BRITISH BIOLOGY OLYMPIAD 2022

Duration: 90 minutes   Total marks: 186

90   186

Instructions

Do not open this booklet until you are told to do.

*Write your answers with **a 2B pencil** on the Scantron Sheet provided.*
        2B

While students are expected to attempt all questions for a complete examination in 90 minutes.
        90

For questions that has more than one answer, partial marks will be given for extra, wrong and missing selection based on the number of options.

The Chinese translation is for reference only. In case of contradictions, please follow the original English text.

British Biology Olympiad 2022 Paper 1

Question 1

Part 1 of 2
Chemical forces cause proteins to fold into their functional shapes via several stages.

在化学作用力下，蛋白质经过多个折叠过程最终形成其功能性结构。

Part 2 of 2
Problem 1. Which structural level of a protein is unaffected by hydrogen bonding?

题目 1：蛋白质的哪种结构不受氢键的影响？

1 mark
Choose ONE 单选
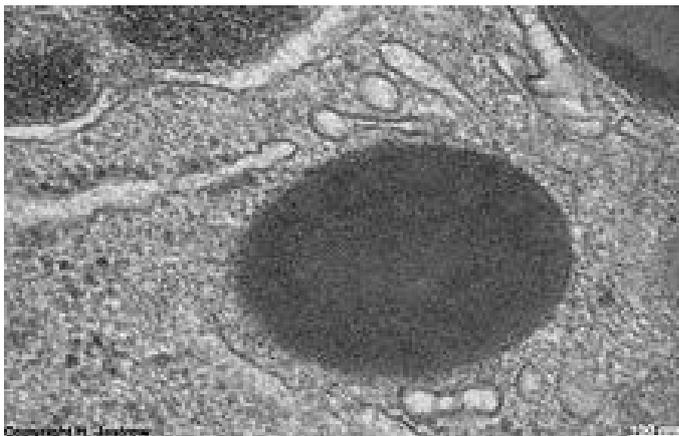A.   Primary   一级结构

B.   Secondary 二级结构

C.   Tertiary   三级结构

D.   Quaternary 四级结构

E.   All levels are affected.   所有结构都受到影响

F.   No levels are affected.   所有结构都不受影响

Question 2

Part 1 of 2
Problem 2. Lysosomes are membrane bound organelles which contain digestive enzymes. Which cell type would be best for studying lysosomes?

题目 2：溶酶体是富含消化酶且具有膜结构的细胞器。哪种细胞最适合用来研究溶酶体？

Human lysosome within cell
人体细胞内的溶酶体

Part 2 of 2

Select the most appropriate answer 请选择最佳答案

1 mark
Choose ONE 单选

A. Fast-twitch muscle cell   快收缩肌肉细胞

B. Neuron   神经细胞

C. Bacterial cell   细菌细胞

D. Phagocytic white blood cell 具有吞噬作用的白细胞

Question 3

Part 1 of 1

Problem 3. Which of the following are passive / facilitated (energetically favourable) processes in cells?

题目 3：以下哪些是细胞中的被动/促进（不消耗能量）过程？

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

A. The establishment of a concentration gradient   建立浓度梯度

B. Osmosis   渗透

C. Diffusion   扩散

D. The hydrolysis of ATP   ATP 水解

E. Synthesising a protein   合成蛋白质

F. Nucleotide polymerisation 核苷酸

Question 4

Part 1 of 2

Mitochondria have very crenated (creased) inner membranes, and the thylakoid membranes of chloroplasts are also highly folded and stacked.

线粒体的内膜呈现锯齿状（高度褶皱），叶绿体的类囊体薄膜也紧密堆积并折叠。

Transmission electron microscope image credit Louisa Howard
透射电子显微镜下的图像 (图像来源：Louisa Howard)

Part 2 of 2

Problem 4. Why are the membranes of mitochondria and chloroplasts folded?

题目 4：线粒体和叶绿体的膜为什么是折叠的？

1 mark

Choose ONE 单选

A.   To maximise the amount of membrane for protons and electrons to diffuse through.

   最大限度增加质子和电子扩散通过的膜层数。

B.   To increase the concentration gradient of protons. 增加质子的浓度梯度。

C.   To maximise the amount membrane-bound of respiratory / photosynthetic proteins which can fit in the cell.
   最大限度增加用于细胞呼吸/光合作用的蛋白质的膜结合量。

D.   To increase the amount of light absorbed by the membranes. 增加膜吸收的光线

E.   To maximise the amount of protons / electrons which can be stored by the membranes.
   最大限度增加膜存储的质子/电子数量

Question 5

Part 1 of 2

The tallest trees, such as giant redwoods, are particularly sensitive to climate change, and many are already dying.

特别高的树木，例如巨红杉，对气候变化特别敏感，许多都已经濒临死亡。

Hyperion, national parks service
亥伯龙神，国家公园管理局

Part 2 of 2

Problem 5. Why are very tall trees vulnerable?

题目 5：为什么特别高的树木易受伤害？

1 mark
Choose ONE 单选

A.   They already require more carbon dioxide to grow very tall
它们需要更多的二氧化碳以长到较高的高度

B.   They are already more exposed to the heat of the sun 它们更容易暴露在阳光下

C.   Their highest leaves are already normally water-stressed and they cannot withstand drought
它们最高处的叶子通常处于缺水状态，无法抵御干旱

D.   They are already more likely to be attacked by pests 它们更容易遭到害虫攻击

E.   Oxygen levels are insufficient for respiration at the tree top
树顶的氧气浓度不足以供其呼吸

Question 6

Part 1 of 1

Problem 6. Ribosomes are responsible for deciphering the genetic code. How do ribosomes ensure the correct amino acids are added to a growing polypeptide (protein)?

题目 6：核糖体负责破译遗传密码。核糖体如何保证向正在合成的多肽（蛋白质）添加正确的氨基酸？

1 mark
Choose ONE 单选

A.   Ribosomes only add amino acids which have similar chemical properties to the rest of the polypeptide
核糖体只添加与多肽剩余部分具有相似化学性质的氨基酸

B.   Ribosomes select amino acids based on the secondary structure of the polypeptide
核糖体根据多肽的二级结构选择氨基酸

C.   Ribosomes only add amino acids if there is proper base-pairing between RNA molecules
核糖体只会在 RNA 分子之间有适当的碱基配对时才会添加氨基酸

D.   Ribosomes only add amino acids which bind to the mRNA
核糖体只添加与 mRNA 结合的氨基酸

E.   Ribosomes select amino acids based on the secondary structure of mRNA
核糖体根据 mRNA 的二级结构选择氨基酸

Question 7

Part 1 of 1

Problem 7. Skeletal muscle can contract and relax much quicker than smooth muscle (which lines the gut *etc*). Which of these could increase the speed of muscle contraction (i.e. are limiting factors on muscle contraction).

题目 7：骨骼肌收缩和放松的速度比平滑肌（肠道的平滑肌等）快得多。

以下哪一项可以提高肌肉收缩的速度（即限制肌肉收缩的因素）？

4 marks
Choose as many as appropriate 选出所有正确的选项
A.　Increasing the temperature of the muscle to 37 degrees Celsius
　　将肌肉的温度提高至 37 摄氏度

B.　Increasing the number of sodium ion channels causing action potentials
　　增加引起动作电位的钠离子通道数量

C.　Increasing the number of mitochondria　　　　增加线粒体的数量

D.　Increasing the rate of anaerobic glycolysis　　提高无氧糖酵解速率

E.　Increasing the number of calcium ion channels　增加钙离子通道数量

F.　Mutations causing myosin to form and break cross-bridges more quickly
　　导致肌球蛋白加速形成与断裂横桥的突变

Question 8

Part 1 of 2
Problem 8. If heart rate increases 4-fold, and stroke volume increases 1.5-fold, how many fold does cardiac output increase?

题目 8：如果心率增加 4 倍，每搏出量增加 1.5 倍，那么心输出量增加多少倍？

1 mark
Choose one. 单选
A.　2.5　2.5 倍

B.　2.7　2.7 倍

C.　5.5　5.5 倍

D.　6　　6 倍

E.　40　40 倍

Part 2 of 2
Problem 9. If cardiac output is 5 l/min, how much blood flows through the pulmonary artery?

题目 9：如果心输出量为 5 升/分钟，请问有多少血液流过肺动脉？

1 mark
Choose one. 单选
A.　1.2 l/min　1.2 升/分钟

B.　2 l/min　　2 升/分钟

C.　3 l/min　　3 升/分钟

D.　5 l/min　　5 升/分钟

E.　51 l/min　51 升/分钟

Question 9

Part 1 of 5
1 mark

Problem 10. Which blood vessel controls blood supply to tissues?

题目 10： 哪条血管控制血液向组织供应？

A. Arteries 动脉

B. Venules 小静脉

C. Pulmonary Veins 肺静脉

D. Arterioles 小动脉

Part 2 of 5
1 mark

Problem 11. Which blood vessel carries oxygenated blood at low pressure?

题目 11： 哪条血管在低压下输送含氧血？

A. Arteries 动脉

B. Venules 小静脉

C. Pulmonary Veins 肺静脉

D. Arterioles 小动脉

Part 3 of 5
1 mark

Problem 12. Which blood vessel is very elastic?

题目 12： 哪条血管的弹性最大？

A. Arteries 动脉

B. Venules 小静脉

C. Pulmonary Veins 肺静脉

D. Arterioles 小动脉

Part 4 of 5
1 mark

Problem 13. Which blood vessel is thin-walled?

题目 13： 哪条血管是薄壁血管？

A. Arteries 动脉

B. Venules 小静脉

C. Pulmonary Veins 肺静脉

D. Arterioles 小动脉

Part 5 of 5

1 mark

Problem 14. Which blood vessel is very muscular?

题目 14： 哪种血管壁肌肉发达？

A.   Arteries   动脉

B.   Venules   小静脉

C.   Pulmonary Veins 肺静脉

D.   Arterioles   小动脉

Question 10

Part 1 of 9

Endosymbiosis is the leading evolutionary theory for the origin of eukaryotic cells. Endosymbiosis states that the ancestors of eukaryotic cells could engulf other cells to establish a symbiotic relationship, which eventually became permanent.

内共生是真核细胞起源的主要进化理论。内共生学说认为真核细胞的祖先可以吞噬其他细胞，以建立共生关系，最终形成永久的共生关系。

Part 2 of 9

Problem 15. Which of the following statements about endosymbiosis are true?

题目 15： 以下关于内共生的说法中，哪些是正确的？

Fill in as many as appropriate. 填写所有的正确答案

2 marks

A.   Chloroplasts have a double membrane due to endosymbiosis.
     由于内共生的缘故，叶绿体具有双层膜。

B.   Bacteria are ancestors of chloroplasts and mitochondria.
     细菌是叶绿体和线粒体的祖先。

C.   Bacteria lost their chlorophyll gene during endosymbiosis.
     细菌在内共生过程中失去了叶绿素基因。

D.   The flagella of some eukaryotic cells are derived from Bacteria.
     一些真核细胞的鞭毛来自细菌。

E.   Plant cell ancestors acquired chloroplasts before mitochondria.
     植物细胞的祖先获得叶绿体早于获得线粒体。

Part 3 of 9

For each organelle, decide whether most scientists believe they arose from endosymbiosis or not.

根据大多数科学家是否认为其来自内共生，选择以下细胞器的来源。

Part 4 of 9

Two thirds of a mark

Problem 16. *Cell nucleus*

题目 16： *细胞核*

A. Endosymbiosis 内共生

B. Other origin   其他来源

Part 5 of 9

Two thirds of a mark

Problem 17. *Plant plastids*

题目 17： *植物质体*

A. Endosymbiosis 内共生

B. Other origin   其他来源

Part 6 of 9

Two thirds of a mark

Problem 18. *Lysosomes*

题目 18： *溶酶体*

A. Endosymbiosis 内共生

B. Other origin   其他来源

Part 7 of 9

Two thirds of a mark

Problem 19. *Vacuole*

题目 19： *液泡*

A.   Endosymbiosis 内共生

B.   Other origin   其他来源

Part 8 of 9

Two thirds of a mark

Problem 20. *Mitochondria*

题目 20： *线粒体*

A.   Endosymbiosis 内共生

B.   Other origin   其他来源

Part 9 of 9

Two thirds of a mark

Problem 21. *Ribosomes*

题目 21： *核糖体*

A. Endosymbiosis 内共生

B. Other origin   其他来源

Question 11

Part 1 of 9
Some groups of life are defined by universal characteristics. For example, *all* mammals can produce milk, but *only* higher mammals give birth to live young.

一部分生命群体是由普遍特征定义的。例如，*所有* 哺乳动物都能产奶，但*只有* 高等哺乳动物才能产下幼崽。

Part 2 of 9
Assign these groups, which start broad and become narrow, universal characteristics which **all** organisms within that group and subsequent groups share.

根据该群体和后续群体中**所有**生物体都具有的普遍特征，对以下生命群体进行分类（特征将从广义到狭义）。

Part 3 of 9
Four sevenths of a mark
Problem 22. *Flowers*

题目 22： *花*

A. All life on Earth   *地球上所有的生命*

B. Eukaryotes   *真核生物*

C. Plants   *植物*

D. Dicot plants   *双子叶植物*

Part 4 of 9
Four sevenths of a mark
Problem 23. *Triplet code*

题目 23： *三联体密码*

A. All life on Earth   *地球上所有的生命*

B. Eukaryotes   *真核生物*

C. Plants   *植物*

D. Dicot plants   *双子叶植物*

Part 5 of 9
Four sevenths of a mark
Problem 24. *Two seed leaves*

题目 24： *双子叶*

A. All life on Earth   *地球上所有的生命*

B. Eukaryotes   *真核生物*

C. Plants   *植物*

D. Dicot plants   *双子叶植物*

Part 6 of 9

Four sevenths of a mark

Problem 25. *Mitochondria*

题目 25：*线粒体*

A.   All life on Earth   *地球上所有的生命*

B.   Eukaryotes   *真核生物*

C.   Plants   *植物*

D.   Dicot plants   *双子叶植物*

Part 7 of 9

Four sevenths of a mark

Problem 26. *Cell membrane*

题目 26：*细胞膜*

A.   All life on Earth   *地球上所有的生命*

B.   Eukaryotes   *真核生物*

C.   Plants   *植物*

D.   Dicot plants   *双子叶植物*

Part 8 of 9

Four sevenths of a mark

Problem 27. *Nucleus*

题目 27：*细胞核*

A.   All life on Earth   *地球上所有的生命*

B.   Eukaryotes   *真核生物*

C.   Plants   *植物*

D.   Dicot plants   *双子叶植物*

Part 9 of 9

Four sevenths of a mark

Problem 28. *Plastids (e.g. Chloroplasts)*

题目 28：*质体（例如叶绿体）*

A.   All life on Earth   *地球上所有的生命*

B.   Eukaryotes   *真核生物*

C.   Plants   *植物*

D.   Dicot plants   *双子叶植物*

Question 12

Part 1 of 2

An action potential in nerve cells is triggered when the potential across its membrane reaches a threshold which causes sodium ion channels to open rapidly.

当神经细胞膜的电位达到阈值，导致钠离子通道迅速打开时，就会触发神经细胞的动作电位。

Part 2 of 2

Problem 29. Which of these may cause an action potential?

题目 29： 以下哪项可能导致动作电位？

3 marks

Choose as many as appropriate 选出所有的正确答案

A. Increased number of sodium/potassium ATPase pumps at the membrane 增加膜上钠/钾 ATP 酶泵的数量

B. Increased number of potassium ion channels at the membrane 增加膜上钾离子通道数量

C. Increased number of leaky sodium ion channels at the membrane 增加膜上泄漏的钠离子通道数量

D. Poison blocking channels allowing chloride ions into the membrane 利用毒素封闭氯离子进入膜的通道

Question 13

Part 1 of 2

Problem 30. In most organisms, in some cells, mitosis occurs without cytokinesis. This may result in...

题目 30：在大多数生物体的某些细胞中，有丝分裂在没有胞质分裂的情况下发生。这可能会导致……

2 marks

Choose ONE 单选

A. cells with more than one nucleus.   细胞的细胞核不止一个

B. cells that are unusually small.   细胞非常小

C. cells lacking nuclei.   细胞没有细胞核

D. cell cycles lacking an S phase.   细胞周期缺少 S 期

Part 2 of 2

Problem 31. What may happen if cytokinesis occurs without mitosis?

题目 31：如果胞质分裂在没有有丝分裂的情况下发生，会发生什么？

2 marks

Choose ONE 单选

A. Cells with more than one nucleus.   细胞的细胞核不止一个

B. Cells lacking nuclei.   细胞没有细胞核

C. Cells that are unusually large.   细胞体积异常大

Question 14

Part 1 of 8

The DNA content of a diploid (2n) cell in the G1 phase of the cell cycle is x.

二倍体（2n）细胞在细胞周期 G1 期的 DNA 含量为 x。

Part 2 of 8

Problem 32. The DNA content of the same cell at the start of meiosis I will be

题目 32：减数分裂 I 开始时，同一细胞的 DNA 含量将是

1 mark
Choose ONE 单选
A.　0.25x

B.　0.5x

C.　x

D.　2x

Part 3 of 8

Problem 33. The DNA content at the start of meiosis II will be

题目 33：减数分裂 II 开始时，DNA 含量将为

1 mark
Choose ONE 单选
A.　0.25x

B.　0.5x

C.　x

D.　2x

Part 4 of 8

Problem 34. The DNA content at the end of meiosis II will be

题目 34：减数分裂 II 结束时，DNA 含量将为

1 mark
Choose ONE 单选
A.　0.25x

B.　0.5x

C.　x

D.　2x

Part 5 of 8

In the oocyte of a young female, a crossover (chiasma) between homologous arms of chromosome 7 occurs 60 million base pairs from one tip. A second chiasma occurs 45 million base pairs from the tip.

在年轻女性的卵母细胞中，7 号染色体同源臂之间的交叉出现在从其顶端开始的 6000 万个碱基对。第二个交叉出现在从其顶端开始的 4500 万个碱基对。

Pair of chromosomes with chiasmata 交叉的一对染色体

Part 6 of 8

Problem 35. How many base pairs are exchanged between the chromosomes?

题目 35：染色体之间交换了多少碱基对？

2 marks

Choose one. 单选

    A. 5

    B. 15

    C. 45

    D. 105

    E. 210

Part 7 of 8

In the same oocyte, a third crossover then forms 10 million bases from the tip.

在同一个卵母细胞中，第三个交叉从其顶端形成了 1000 万个碱基。

Part 8 of 8

Problem 36. Now how many base pairs are exchanged between the chromosomes in total?

题目 36：现在染色体之间总共交换了多少碱基对？

2 marks

Choose one. 单选

    A. 25

    B. 45

    C. 55

    D. 115

    E. 230

Question 15

Part 1 of 6

A population contains 50 rats. 29 are black rats and 21 are white. Coat colour is controlled by a single gene, and the black allele is dominant.

一个种群有 50 只老鼠。29 只是黑老鼠，21 只是白老鼠。毛色由单一基因控制，并且黑色等位基因是显性基因。

White Rat (Rattus norvegicus) - Flickr Tambako The Jaguar CC BY-ND 2.0

白鼠（褐家鼠）- Flickr Tambako The Jaguar CC BY-ND 2.0

Part 2 of 6

Problem 37. Calculate the frequency of the recessive (white) allele.

题目 37：计算隐性（白色）等位基因出现的频率。

2 marks
Choose one. 单选

    A. 0.25

    B. 0.33

    C. 0.42

    D. 0.65

    E. 0.88

Part 3 of 6

Problem 38. Calculate the number of heterozygous rats.

题目 38：计算具有杂合子老鼠的数量。

2 marks
Choose one. 单选

    A. 15

    B. 23

    C. 25

    D. 29

    E. 38

Part 4 of 6

Problem 39. How do you expect this allele frequency to change in the next generation in the absence of selection?

题目 39：不考虑自然选择的影响，下一代的等位基因频率会发生怎样的变化?

1 mark
Choose ONE 单选

A. Higher   变高

B. Lower   变低

C. No change   没有变化

D. Impossible to tell 无法推断

Part 5 of 6

In actual fact, when the researchers came back after twenty generations, they found that all of the rats were black.

事实上，老鼠生长到 20 代后，研究人员发现所有老鼠都是黑色的。

Part 6 of 6

Problem 40. What should the researchers conclude?

题目 40：研究人员可以得出什么结论？

2 marks
Choose ONE   单选

A.   Natural selection most probably favours the black allele. 自然选择对黑色等位基因最为有利。

B.   The alleles have equal fitness and genetic drift most probably fixed the black allele by chance.

这些等位基因具有相同的适应性，遗传漂变极有可能偶然固定了黑色等位基因。

C.   The environment most probably changed, which changed the activity of the alleles so both produce black rats. 环境很可能发生了变化，改变了等位基因的活性，导致这两种基因都会产生黑鼠。

D.   Further study is needed to tell which of these three explanations are most probable.

需要进一步的研究来判断以上三种解释中哪一种最有可能。

E.   None of these explanations is likely.

以上解释都不可能。

Question 16

Part 1 of 9

This question explores primary production in an ecosystem. 这个问题将探讨生态系统中的初级生产。

Part 2 of 9

Problem 41. Which organisms capture energy into an ecosystem (i.e. are the primary producers)?

题目 41：哪些生物体将能量转换到生态系统中（这些生物体是初级生产者）？

2 marks
Choose as many as appropriate 选出所有的正确答案

A.   Photoautotrophs   光能自养生物

B.   Chemoautotrophs   化能自养生物

C.   Heterotrophs   异养生物

D.   Detritovores   食碎屑动物

E.   Omnivores   杂食动物

F.   Saprotrophs   腐生生物

Part 3 of 9

Plants are a primary producer and capture energy from the sun into the ecosystem. The photosynthetic equation contains:

植物是初级生产者，捕获太阳能并转换到生态系统中。光合作用的方程式中包括：

- $C_6H_{12}O_6$

- CO_2

- H_2O

- O_2

Part 4 of 9

Problem 42. Which chemical is the electron donor (is oxidised)?

题目 42：下面哪种化学物质是电子供体（被氧化的化学物质）？

1 mark
Choose ONE 单选
A. $C_6H_{12}O_6$

B. CO_2

C. H_2O

D. O_2

Part 5 of 9

Problem 43. Which chemical stores the solar energy?

题目 43：下面哪种化学物质能贮存太阳能？

1 mark
Choose ONE 单选
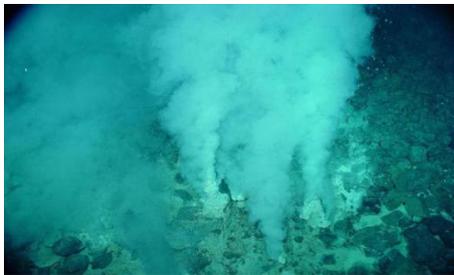A. $C_6H_{12}O_6$

B. CO_2

C. H_2O

D. O_2

Part 6 of 9

Sunlight does not reach deep into the ocean. There are bacteria which can harvest chemical energy from volcanic vents. The chemicals involved in this reaction are:

阳光不能照射至海洋最深处。有些细菌可以从火山口获取化学能。这一反应包含的化学物质有：

- $C_6H_{12}O_6$
- CO_2
- H_2O
- H_2S
- S

In this reaction, sulphur (S) is a product.

在该反应中，硫(S)是其中一种产物。

Bacterial matts around hydrothermal vent, credit NOAA
深海热液喷口周围的细菌垫（图片来源：美国国家海洋和大气管理局 NOAA）

Part 7 of 9

Problem 44. Which chemical is the electron donor (is oxidised)?

题目 44：哪种化学物质是电子供体（被氧化的化学物质）？

1 mark

Choose ONE 单选

A. $C_6H_{12}O_6$

B. CO_2

C. H_2O

D. H_2S

E. S

Part 8 of 9

Problem 45. How many elemental sulphur atoms (S) are generated per $C_6H_{12}O_6$?

题目 45：每个 $C_6H_{12}O_6$ 可以产生多少个硫原子？

2 marks

Choose one. 单选

    A. 2

    B. 3

    C. 4

    D. 6

    E. 12

Part 9 of 9

Problem 46. For **both** photosynthesis and chemical driven energy capture, are these statements *true?*.

题目 46：对于光合作用和化学物质参与的其他能量获取方式，下列哪些说法是**正确**的？

2 marks

Choose as many as appropriate. 选出所有的正确答案

    A. When energy is stored, oxygen is produced   当能量被储存时，将会产生氧气

    B. When energy is stored, CO_2 is used up   当能量被储存时，CO_2 将被耗尽

    C. The energy is stored in a reduced chemical   能量储存于被还原的化学物质中

    D. There is more energy in the products of the reaction than the reagents

        反应产物中的能量比反应物中的能量多

Question 17

Part 1 of 3

Scientists recently discovered seagrasses culture specific bacteria within their roots which are able to fix nitrogen gas from the air into biomolecules which the grass can use.

最近，科学家发现海草在其根部培养的特定细菌能够将空气中的氮气固定到海草自身可以使用的生物分子中。

Neptune's seagrass, credit Frédéric Ducarme
海王星海草，图片来源：Frédéric Ducarme

Part 2 of 3

Problem 47. Which types of biologically important chemical bonds does nitrogen form?

题目 47：氮可以形成哪类对于生物重要的化学键？

3 marks

Choose as many as appropriate 选出所有的正确答案

    A. Glycosidic bonds (sugars)   糖苷键（糖）

    B. Peptide bonds (proteins)   肽键（蛋白质）

    C. Ester bonds (fats)   酯键（脂肪）

    D. Base-pairing (nucleic acids)   碱基配对（核酸）

    E. Phosphodiester bonds (nucleic acids) 磷酸二酯键（核酸）

Part 3 of 3

Problem 48. What other nutrients will seagrass need to source from the external environment to grow?

题目 48：海草还需要从外部环境中获取哪些营养物质用于生长？

3 marks

Choose as many as appropriate 选出所有的正确答案

    A. Fresh water (non-salty)   淡水（不含盐）

    B. Organic carbon (such as sugar or fat) 有机碳（如糖或脂肪）

    C. Protein   蛋白质

    D. Soluble phosphate containing compounds 可溶性含磷化合物

   E. Soluble magnesium containing compounds 可溶性含镁化合物

Question 18

Part 1 of 7

Monophyletic groups can be defined using evolutionary trees, based on which characteristics they share. Below, a simplified evolutionary tree of animals is shown with marked evolutionary events (A-E). The evolutionary events are:

基于单系群共有的特征，可以用进化树来对单系群进行定义。下面是一个简单的动物进化树，标记有 A 到 E 五个进化历程。这些进化历程是：

- I Formation of four legs   I 形成四条腿

- II Formation of milk-producing mammary glands   II 形成产奶乳腺

- III Giving birth to live young   III 生育幼崽

- IV Formation of eggs with amniotic sacks   IV 形成羊膜卵

- V Formation of vertebrae   V 形成椎骨

鱼	青蛙	鳄鱼	鸭嘴兽	大象

Cladogram of animal evolution
动物进化分支图
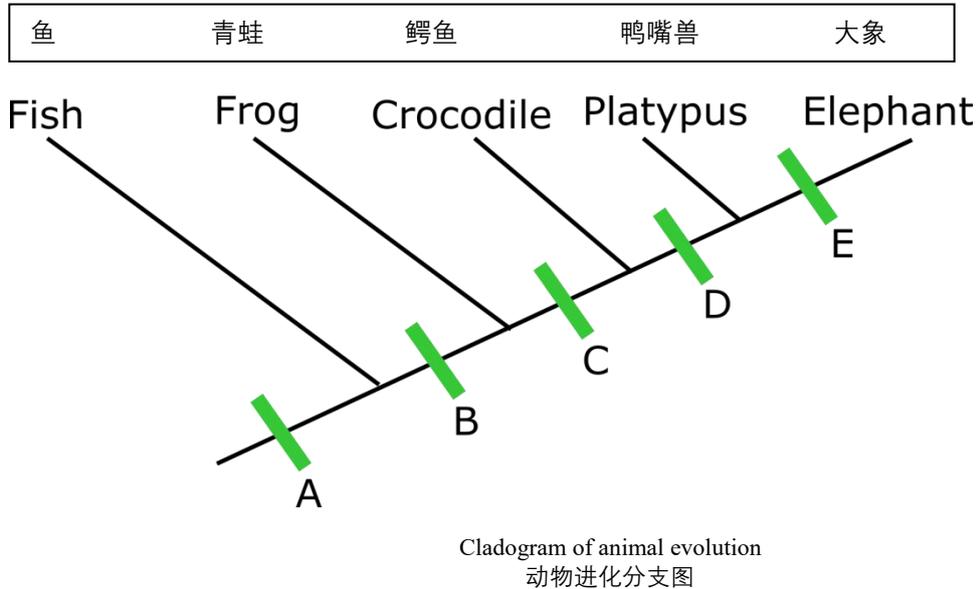
Part 2 of 7
Work out the order of events I-V. 确定进化历程 I-V 在进化树中对应的顺序。

Four fifths of a mark
Problem 49. I
题目 49：I

A.   A

B.   B

C.   C

D.   D

E.   E

Four fifths of a mark
Problem 50. II
题目 50：II

A.   A

B.   B

C.   C

D.   D

E.   E

Four fifths of a mark
Problem 51. III
题目 51：III

A. A

B. B

C. C

D. D

E. E

Four fifths of a mark
Problem 52. IV
题目 52：IV

A. A

B. B

C. C

D. D

E. E

Four fifths of a mark
Problem 53. V
题目 53：V

A. A

B. B

C. C

D. D

E. E

Part 3 of 7

The tree can be used to work out when the last common ancestor of pairs of animals lived. For example, the last common ancestor of frogs and elephants lived at point B. For each pair of animals below, state which point marks when the last common ancestor may have lived.

进化树可以用来推断两种动物的最后一个共同祖先所生活的年代。例如，青蛙和大象的最后一个共同祖先生活在 B 阶段。推断下面各组动物的最后一个共同祖先可能生活的时间点。

Part 4 of 7

Problem 54. Frogs and crocodiles
题目 54：青蛙和鳄鱼

1 mark
Choose ONE　　*单选*

A. A

B. B

C. C

D. D

E. E

Part 5 of 7
Problem 55. Birds and elephants

题目 55：鸟和大象

1 mark
Choose ONE　　*单选*

A.　A

B.　B

C.　C

D.　D

E.　E

Part 6 of 7
Problem 56. Whales and cows

题目 56：鲸鱼和奶牛

1 mark
Choose ONE　　*单选*

A.　A

B.　B

C.　C

D.　D

E.　E

Part 7 of 7
Problem 57. Insects and fish

题目 57：昆虫和鱼

1 mark
Choose ONE　　*单选*

A.　A

B.　B

C.　C

D.　D

E.　E

Question 19

Part 1 of 4
Many flowers which appear uniform in colour to humans, show dark and light patterns when viewed in the ultra-violet spectrum. Usually the dark region is the centre of the flower. These dark areas tend to be larger in flowers growing in regions closer to the equator.

很多人类肉眼看起来颜色相同的花，在紫外线光谱下会呈现出深色和浅色的图案。通常深色区域出现在花的中心。赤道附近生长的花朵往往会呈现出更多的深色区域。

Dandelion in normal light (left) and ultraviolet (right) (Flickr tsaiproject CC BY 2.0)
正常光照下的蒲公英（左）和紫外线光谱下的蒲公英（右）（图片来源：Flickr tsaiproject CC BY 2.0)

Part 2 of 4
2 marks
Problem 58. Which of the following are true?
题目 58：下面哪些选项是正确的?
Choose as many as appropriate 选出所有正确的答案

A. The darker regions of flowers absorb UV radiation and may act as sun protection.
   花的深色区域吸收紫外线辐射，可能起到防晒作用。

B. Many insect pollinators have good vision in the UV region of light, thus the dark region helps attract the pollinators by acting as nectar guide.
   许多传粉昆虫的眼睛对紫外线特别灵敏，因此深色区域的花蜜可以指引并吸引昆虫来传粉。

C. The larger dark area of flowers growing near the equator compensates for the reduced number of pollinating insects near the equator.
   赤道附近生长的花朵拥有较大的深色区域，这解释了赤道附近传粉昆虫的数量有所减少。

D. Larger dark regions are less accurate as nectar guides.
   较大的深色区域用作花蜜向导不太准确。

Part 3 of 4
Many tropical flowers are pollinated by birds or bats rather than insects.
许多热带花卉是由鸟类或蝙蝠来传粉而不是由昆虫来传粉的。

Part 4 of 4

Match the feature of the flower to its most likely pollinator.

将花卉特征与其最可能的传粉者相匹配。

Half a mark
Problem 59. *Large white / pale petals*

题目 59：拥有硕大的淡白色花瓣

A. Insects 昆虫

B. Birds 鸟类

C. Bats 蝙蝠

D. Birds and Bats 鸟类和蝙蝠

Half a mark
Problem 60. *Large strong flowers*

题目 60：*花朵硕大且坚挺*

A. Insects 昆虫

B. Birds 鸟类

C. Bats 蝙蝠

D. Birds and Bats 鸟类和蝙蝠

Half a mark
Problem 61. *Very large amounts of nectar*

题目 61：拥有大量的花蜜

A. Insects 昆虫

B. Birds 鸟类

C. Bats 蝙蝠

D. Birds and Bats 鸟类和蝙蝠

Half a mark
Problem 62. *Flowers turn to face the sun*

题目 62：花朵面向太阳

A. Insects 昆虫

B. Birds 鸟类

C. Bats 蝙蝠

D. Birds and Bats 鸟类和蝙蝠

Half a mark

Problem 63. *Nectar is found at the base of long tube*

题目 63：*花蜜位于花柱的基部*

A. Insects   昆虫

B. Birds   鸟类

C. Bats   蝙蝠

D. Birds and Bats   鸟类和蝙蝠

Half a mark

Problem 64. *Flowers generate warmth to attract pollinators*

题目 64：*花朵会产生热量来吸引传粉昆虫*

A. Insects   昆虫

B. Birds   鸟类

C. Bats   蝙蝠

D. Birds and Bats   鸟类和蝙蝠

Question 20

Part 1 of 3

Problem 65. What makes plants green?

题目 65：为什么植物会呈现出绿色？

1 mark
Choose ONE 单选

A. Diffraction of light through thylakoid membranes 光通过类囊体膜发生了衍射

B. Refraction of light in the epidermis   光在植物表皮进行折射

C. Chemicals in the phloem fluid   韧皮部汁液中的化学物质

D. Chlorophyll   叶绿素

E. Melanin   黑色素

Part 2 of 3

Problem 66. Sunlight contains different colours. Which visible colour is **least** useful for photosynthesis?

题目 66：阳光包含不同颜色的光。哪种可见色光对光合作用的帮助最小？

D-Kuru/Wikimedia Commons   图片来源：D-Kuru/Wikimedia Commons

1 mark
Choose ONE 单选

A. Blue 蓝色

B. Green 绿色

C. Yellow 黄色

D. Red 红色

E. All visible colours are equally useful 所有可见色光的作用都相同

F. No visible colours are useful 所有可见色光都没有作用

Part 3 of 3

Problem 67. Blue light travels further through water than other colours, but any colour light travels less well through water than air. When deep aquatic plants are brought to the surface, what colour are they expected to appear to us compared to mostly green land plants.

题目 67：蓝色的光比其他颜色的光在水中传播得更远，但所有颜色的光在空气中都比在水中传播的远。与大多数绿色陆地植物相比，深海水生植物浮出水面时会呈现出什么颜色？

1 mark
Choose ONE 单选

A. Darker blue 深蓝色

B. Darker red 深红色

C. Lighter green 浅绿色

D. Lighter blue 浅蓝色

E. Lighter red 浅红色

Question 21

Part 1 of 3

No living insects are larger than about 70 g. However, the largest fossil insects are estimated to have weighed 450 g. Scientists have found it is impossible to breed insects larger than about 70 g, except when special manipulations are made. *Note: all insects live on land. The largest and smallest insects can fly*

活昆虫的重量不会超过约 70 克。然而，最大的昆虫化石的重量预计为 450 克。科学家发现，除非进行特殊干预，否则不可能培育出超过 70 克的昆虫。*注：所有昆虫都生活在陆地上，并且最大和最小的昆虫都有飞行能力。*

Elephant beetle 象甲虫

Part 2 of 3

Problem 68. Using this information, select the most likely limiting factor for insect size.

题目 68：运用已知信息，选出最可能限制昆虫大小的因素

1 mark
Choose ONE 单选

A.   Insect exoskeletons cannot support larger bodies 昆虫的外骨骼难以支撑庞大的身体

B.   There is insufficient food for larger insects 大型昆虫没有充足的食物

C.   There is currently insufficient genetic diversity to select on to make larger insects
　　目前没有足够的基因多样性可供选择以形成较大的昆虫

D.   Insect respiratory systems (trachea; air-filled tubes) cannot currently deliver sufficient oxygen to cells far from the surface
　　目前昆虫的呼吸系统（气管；气门）无法向远离地面的细胞输送足够的氧气

E.   Insect circulatory systems (fluid filled sacks) cannot deliver sufficient nutrients to cells far from their heart
　　昆虫的循环系统（如同充满液体的袋子）无法向远离昆虫心脏的细胞输送足够的营养物质

Part 3 of 3

Match the potential limiting factor to the special manipulation which would overcome it.

将限制昆虫大小的可能因素与克服这些限制因素的特殊干预相匹配。

Three fifths of a mark
Problem 69. *Gene-editing*
题目 69：基因编辑

A.   Insect exoskeletons cannot support larger bodies　　昆虫的外骨骼难以支撑庞大的身体

B.   There is insufficient food for larger insects　　　　大型昆虫没有充足的食物

C.   There is currently insufficient genetic diversity to select on to make larger insects

　　目前没有足够的基因多样性可供选择以形成较大的昆虫

D.   Insect respiratory systems (trachea; air-filled tubes) cannot currently deliver sufficient oxygen to cells far from the surface
　　目前昆虫的呼吸系统（气管；气门）无法向远离地面的细胞输送足够的氧气

E.   Insect circulatory systems (fluid filled sacks) cannot deliver sufficient nutrients to cells far from
　　昆虫的循环系统（如同充满液体的袋子）无法向远离昆虫心脏的细胞输送足够的营养物质

Three fifths of a mark
Problem 70. *Microgravity / space-station*
题目 70：*微重力/空间站*

A. Insect exoskeletons cannot support larger bodies 昆虫的外骨骼难以支撑庞大的身体

B. There is insufficient food for larger insects 大型昆虫没有充足的食物

C. There is currently insufficient genetic diversity to select on to make larger insects 目前没有足够的基因多样性可供选择以形成较大的昆虫

D. Insect respiratory systems (trachea; air-filled tubes) cannot currently deliver sufficient oxygen to cells far from the surface 目前昆虫的呼吸系统（气管；气门）无法向远离地面的细胞输送足够的氧气

E. Insect circulatory systems (fluid filled sacks) cannot deliver sufficient nutrients to cells far from 昆虫的循环系统（如同充满液体的袋子）无法向远离昆虫心脏的细胞输送足够的营养物质

Three fifths of a mark
Problem 71. *High-oxygen chambers*
题目 71：*高压氧舱*

A. Insect exoskeletons cannot support larger bodies 昆虫的外骨骼难以支撑庞大的身体

B. There is insufficient food for larger insects 较大的昆虫没有充足的食物

C. There is currently insufficient genetic diversity to select on to make larger insects

目前没有足够的基因多样性可供选择以形成较大的昆虫

D. Insect respiratory systems (trachea; air-filled tubes) cannot currently deliver sufficient oxygen to cells far from the surface 目前昆虫的呼吸系统（气管；气门）无法向远离地面的细胞输送足够的氧气

E. Insect circulatory systems (fluid filled sacks) cannot deliver sufficient nutrients to cells far from 昆虫的循环系统（如同充满液体的袋子）无法向远离昆虫心脏的细胞输送足够的营养物质

Three fifths of a mark
Problem 72. *Remove wings, limit movement*
题目 72：*去掉昆虫的翅膀，限制其移动*

A. Insect exoskeletons cannot support larger bodies   昆虫的外骨骼难以支撑庞大的身体

B. There is insufficient food for larger insects   较大的昆虫没有充足的食物

C. There is currently insufficient genetic diversity to select on to make larger insects
目前没有足够的基因多样性可供选择以形成较大的昆虫

D. Insect respiratory systems (trachea; air-filled tubes) cannot currently deliver sufficient oxygen to cells far from the surface
目前昆虫的呼吸系统（气管；气门）无法向远离地面的细胞输送足够的氧气

E. Insect circulatory systems (fluid filled sacks) cannot deliver sufficient nutrients to cells far from
昆虫的循环系统（如同充满液体的袋子）无法向远离昆虫心脏的细胞输送足够的营养物质

Three fifths of a mark

Problem 73. *Hand feed*

题目 73：*人工投喂*

A.　Insect exoskeletons cannot support larger bodies　昆虫的外骨骼难以支撑庞大的身体

B.　There is insufficient food for larger insects　　　　较大的昆虫没有充足的食物

C.　There is currently insufficient genetic diversity to select on to make larger insects　目前没有足够的基因多样性可供选择以形成较大的昆虫

D.　Insect respiratory systems (trachea; air-filled tubes) cannot currently deliver sufficient oxygen to cells far from the surface　目前昆虫的呼吸系统（气管；气门）无法向远离地面的细胞输送足够的氧气

E.　Insect circulatory systems (fluid filled sacks) cannot deliver sufficient nutrients to cells far from　昆虫的循环系统（如同充满液体的袋子）无法向远离昆虫心脏的细胞输送足够的营养物质

Question 22

Part 1 of 7

Tristerix (*Tristerix aphyllus*) is a plant of the mistletoe family. Tristerix seeds are eaten by Mockingbirds (*Mimidae*), and are deposited on the hedgehog cactus (*Echinopsis chiloensis*) in their faeces. Tristerix seeds germinate to produce a long mobile appendage. At night, the cactus opens its stomata to exchange gasses, and Tristerix enters through them, then grows inside. A year later, tristerix punches through the cactus and produces flowers and their nectar is drunk by the Glowing Puffleg hummingbird (*Eriocnemis vestitA.* 　　　　.

仙钗寄生是一种桑寄生科植物。知更鸟会吃掉仙钗寄生的种子，并将种子随其粪便堆积在锦鸡龙仙人掌上。仙钗寄生的种子发芽长出一个可移动的长附件。到了晚上，仙人掌打开气孔交换气体，仙钗寄生通过气孔进入仙人掌，然后在里面生长。一年后，仙钗寄生穿过仙人掌，开出花朵，花朵的花蜜被紫颏毛腿蜂鸟喝下。

The flowers of Tristerix (Tristerix aphyllus) being pollinated by a hummingbird, Chile. © BBC Studios
仙钗寄生的花朵正在由蜂鸟传粉，图片来源：Chile. © BBC Studios

Part 2 of 7

Problem 74. Which symbiotic relationship do Tristerix (*Tristerix aphyllus*) and Mockingbirds (*Mimidae*) have?

题目 74：仙钗寄生和知更鸟之间的共生关系是什么？

1 mark
Choose ONE 单选

A.　Parasitic　　　　　　　寄生

B.　Commensalist (neutral)　偏利共生（中性）

C.　Mutualist　　　　　　　互利共生

D.　Predatory　　　　　　　偏害共生

Part 3 of 7

Problem 75. Which symbiotic relationship do Tristerix (*Tristerix aphyllus*) and Glowing Pufflegs (*Eriocnemis vestita*) have?

题目 75：仙钗寄生与紫颏毛腿蜂鸟之间的共生关系是什么？

1 mark
Choose ONE 单选

A.　Parasitic　寄生

B.　Commensalist (neutral) 偏利共生（中性）

C.　Mutualist 互利共生

D.　Predatory 偏害共生

Part 4 of 7

Problem 76. Which symbiotic relationship does Tristerix (*Tristerix aphyllus*) and hedgehog cacti (*Echinopsis chiloensis*) have?

题目 76：仙钗寄生与锦鸡龙仙人掌之间的共生关系是什么？

1 mark
Choose ONE

A.　Parasitic　　　　　　寄生

B.　Commensalist (neutral)　偏利共生（中性）

C.　Mutualist　　　　　　互利共生

D.　Predatory　　　　　　偏害共生

Part 5 of 7

Scientists do not know how Tristerix finds open stomata.

科学家们不知道仙钗寄生是如何找到开放的气孔的。

Part 6 of 7

Problem 77. Hypothesise which types of tropism Tristerix seeds may use to enter cacti?

题目 77：仙钗寄生的种子可能会使用哪种类型的向性进入仙人掌？

3 marks

Choose as many as appropriate 选出所有的正确答案

A.　Gravitropism　　　　向重力性

B.　Chemotropism　　　　向化性

C.　Thigmotropism　　　　向触性

D.　Phototropism　　　　向光性

E.　Hydrotropism (hygrotropism) 向水性（向湿性）

Problem 78. Most plant stomata are open during the day time. Why does Tristerix only enter stomata at night?

题目 78：大多数植物的气孔在白天开放。为什么仙钗寄生只在晚上进入气孔呢？

1 mark

Choose ONE 单选

A. The tristerix manipulates the cactus to open stomata during the night.

夜间，仙钗寄生使仙人掌打开气孔。

B. To reduce water loss, the cactus stomata only open at night.

为了减少水分流失，仙人掌只在夜间打开气孔。

C. The cactus keeps stomata open at night to keep cool.

仙人掌在夜间打开气孔以保持低温。

D. Tristerix only grows at night.

仙钗寄生只在夜间生长。

British Biology Olympiad 2022 Paper 2

Question 1

Part 1 of 10

Flower colour is a common trait bred for by gardeners. A flower breeding company wanted a **pure breeding white flower**. The breeders start with a collection of clematis plants. Most have purple flowers. *For this question, assume the purple/white colouring is controlled by a single gene.*

花色是花匠培育的一种常见性状。一家花卉育种公司想要培育一种**纯种白花**。培育人员首先收集了一些铁线莲植株。大多数的铁线莲都开紫色的花朵。在这个问题中，假设花朵的紫色/白色由单一基因控制。

Purple clematis flower 紫色铁线莲

Part 2 of 10

Problem 79. How could you find your first white clematis flower?

题目 79： 如何获得第一朵白色的铁线莲？

3 marks

Choose as many as appropriate 选出所有的正确答案

A. Cross the purple clematis with a white flowering pea (a distant species)
    将紫色铁线莲与开白色花的豌豆（远亲物种）杂交

B. Mutagenise the seed of a purple clematis with x-rays 用 x 射线诱发紫色铁线莲种子发生突变

C. Search collections for clematis which already have white flowers 寻找已经开白花的铁线莲植株

D. Grow the plants on very acidic soil   将植株种在强酸性土壤中

E. Grow purple clematis in high light to bleach away the colour 利用强光照射紫色铁线莲以漂白其颜色

F. Search the wild for a clematis which has white flowers   到野外寻找开白花的铁线莲

Part 3 of 10

The breeders succeeded in finding a white clematis!

培育人员终于找到了白色铁线莲!

White clematis 白色铁线莲

Part 4 of 10

However, when the clematis was selfed (bred with itself) some of its progeny had white flowers but others had purple. Roughly, 3/4 of the progeny had white flowers and 1/4 were purple.

然而，铁线莲自交（同一个体进行繁育）时，一部分后代开白色的花，另一部分后代开紫色的花。后代中大约有 3/4 开白色的花，1/4 开紫色的花。

Part 5 of 10

Problem 80. For the white flower allele, the parent clematis was...

题目 80：对于白花等位基因，亲本铁线莲是……

1 mark

Choose ONE 单选

A.   homozygous.   纯合子

B.   heterozygous. 杂合子

Part 6 of 10

Problem 81. The white colour is...

题目 81：控制白花色的是……

1 mark

Choose ONE 单选

A.   recessive.   隐性基因

B.   dominant.   显性基因

Part 7 of 10

Problem 82. What proportion of the white flowering progeny are expected to be homozygous for the white allele?

题目 82：对于白色等位基因，预计白花后代的纯合子比例是多少？

2 marks

Choose one. 单选

    A.   0.25

    B.   0.33

    C.   0.75

    D.   0.81

    E.   1

Part 8 of 10

Problem 83. How could you identify homozygous white flowers?

题目 83：如何辨别出白色花是纯合子?

2 marks

Choose as many as appropriate 选出所有的正确答案

A. Choosing the tallest plants 选择最高的植株

B. Choosing the whitest flowers 选择花色最白的植株

C. Checking the flower colour of the progeny 观察后代的花色

D. Sequencing the genomes of the white flowers 对白色花的基因组进行测序

E. Crossing the white flowers with a purple flower and checking the flower colour of the progeny
将白色花与一株紫色花进行杂交，并观察后代的花色

Part 9 of 10

The breeders found a plant which was true breeding (homozygous) for the white colour. However, when the breeders sold the seed to farmers, there was a big problem. The seeds germinated, but most of the plants died before they flowered!

培育人员发现了开白色花的纯种植株（纯合子）。但培育人员把种子售卖给农民后，出现了一个严重的问题。植株的种子发芽生长，但大多数植株在开花前就死亡了!

Part 10 of 10

Problem 84. What are likely causes of this?

题目 84：导致这一现象可能的原因是什么?

2 marks

Choose one. 单选

A. The purple pigment of the flower was also a plant defence compound

花的紫色色素也是一种植物防御素

B. The white flowers attracted herbivores

白色花吸引食草动物

C. The purple pigment of the flower is essential for plant growth

花的紫色色素是植株生长的基本要素

Question 2

Part 1 of 5

"Girdling" is the process of removing outer tissues around the branch or trunk of a woody plant.

"环剥"是去除木本植物枝干或主干外部组织的过程。

Girdled Birch Tree - Flickr Dave Bonta CC BY-NC-ND 2.0

环剥后的桦树 图片来源：Flickr Dave Bonta CC BY-NC-ND 2.0

Part 2 of 5

Girdling can be shallow or deep. * 环剥深度可浅可深。

- Shallow girdling removes tissues to the vascular cambium. 浅环剥将植物组织转移到维管形成层

- Deep girdling removes even more tissue.   深环剥会去除更多的植物组织

The top image below shows the cross section of a small plant stem, which you may be familiar with.

下方靠上的图片显示了一个较小植物的茎部横截面，你可能对这个比较熟悉。

- The phloem carries sugars   韧皮部运输糖类
- The xylem carries water   木质部运输水分

The bottom image shows the cross section of a larger woody stem, which contains the same tissues. Work out which tissues are the xylem and phloem.

下方靠下的图片显示了一个较大的木质茎的横截面，其中也包含相同的组织。找找哪些组织是木质部和韧皮部。
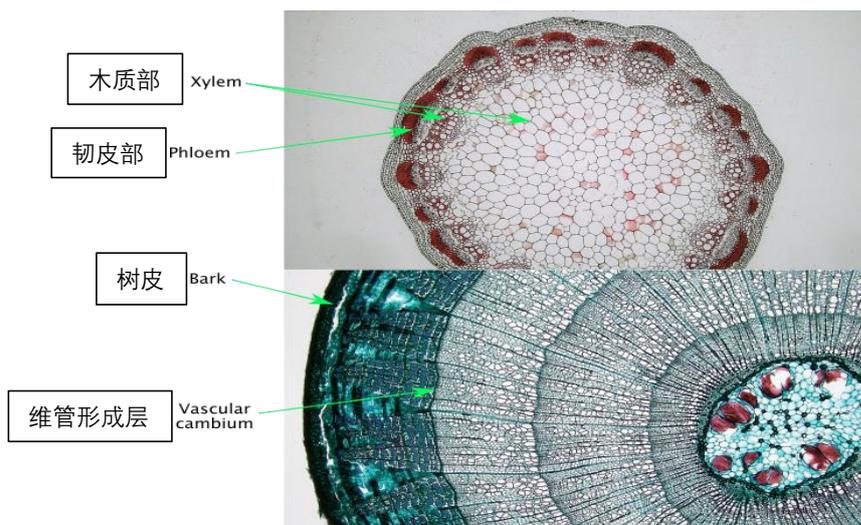
Berkshire Community College Bioscience Image Library

图片来源：Berkshire Community College Bioscience Image Library

Part 3 of 5

Problem 85. What will happen if a **branch** of a grape vine is girdled?

题目 85：如果葡萄藤的一条**枝干**被环剥，将会发生什么呢？

3 marks

Mark all of the correct statements. 选出所有正确的说法

A. If the girdling is shallow, it will not have any effect on the plant
    如果环剥较浅，则不会对葡萄藤产生任何影响

B. If the girdling is shallow, the grapes on the branch will be sweeter
    如果环剥较浅，环剥后枝干上的葡萄会更甜

C. If the girdling is deep, the leaves on the branch will wilt
    如果环剥较深，环剥后枝干上的叶子会枯萎

D. If the girdling is deep, the branch will die   如果环剥较深，环剥后的枝干会死亡

E. If the girdling is deep, the plant will die   如果环剥较深，葡萄藤就会死亡

Part 4 of 5

Problem 86. What will happen if a **trunk** of a grape vine is girdled?

题目 86：如果葡萄藤的**主干**被环剥，将发生什么呢？

2 marks

Mark all of the correct statements. 选出所有正确的说法

A. If the girdling is shallow, it will not have any effect on the plant
    如果环剥较浅，则不会对葡萄藤产生任何影响

B. If the girdling is deep, the leaves will wilt 如果环剥较深，葡萄藤的叶子就会枯萎

C. If the girdling is deep, the plant will die   如果环剥较深，葡萄藤就会死亡

D. If the girdling is shallow, the roots will not grow 如果环剥较浅，葡萄藤的的根将不会生长

Part 5 of 5

Problem 87. The xylem vessels have thick, strong walls. Why?

题目 87：木质部具有厚而坚固的导管壁。这是为什么呢？
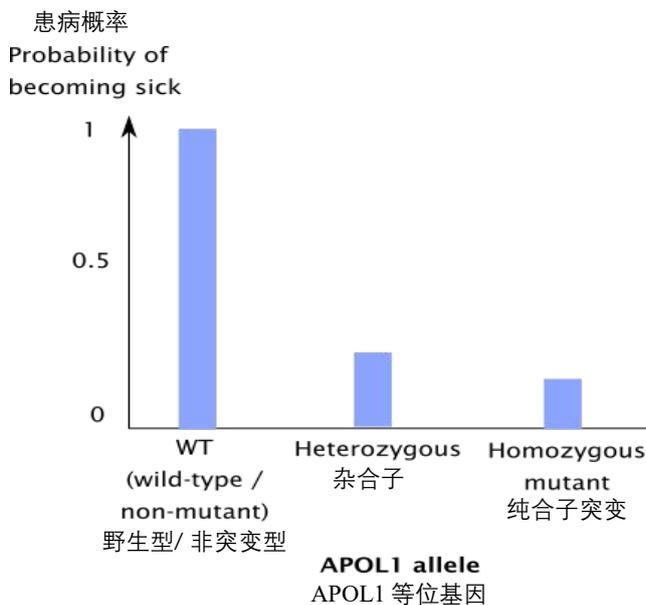
1 mark

Choose ONE 单选

A. The xylem is under high pressure.   木质部处于高压之下。

B. The xylem is under high tension.   木质部处于高拉伸状态。

C. The xylem must be protected from herbivores.   必须保护木质部免受食草动物侵害。

D. To resist the movement of water into the xylem by osmosis. 阻止水分渗透进入木质部。

Question 3

Part 1 of 5

Trypanosomes are single-celled parasites found across Africa. Almost all people are naturally immune to *Trypanosoma brucei brucei* due to a protein in our blood called APOL1 which lyses the cells. However, many people are vulnerable to *Trypanosoma brucei gambiense*. In some African populations, about 60% of people are found to be genetically resistant to *T. gambiense*. To investigate why, scientists measured the likelihood of people with different APOL1 alleles becoming sick with *T. gambiense* after they get infected.

锥虫是在非洲各地发现的单细胞寄生虫。几乎所有人都有对布氏锥虫的自然免疫，这是因为我们血液中有一种称为 APOL1 的蛋白质可以分解细胞。然而，许多人容易感染布氏冈比亚锥虫。在非洲的部分人口中，约 60% 的人被发现对冈比亚锥虫具有抗性遗传。为了研究出现该现象的原因，科学家计算了具有不同 APOL1 等位基因的人感染冈比亚锥虫后的患病概率。

Part 2 of 5

Problem 88. Which of these is correct?

题目 88：以下哪项是正确的？

1 mark

Choose ONE 单选

A. The mutation increases the risk of disease   该突变增加了患病的风险

B. The mutation is recessive   该突变为隐性突变

C. The mutation is dominant   该突变为显性突变

D. Risk of disease is determined by alleles of a different gene 患病的风险是由不同基因的等位基因决定的

Part 3 of 5

Problem 89. Calculate the frequency of the mutant APOL1 alleles in the African population.

题目 89：请计算非洲人群中 APOL1 等位基因发生突变的频率。

3 marks

Choose one. 单选

    A. 0.15

    B. 0.25

    C. 0.37

    D. 0.4

    E. 0.6

Part 4 of 5

Problem 90. The same African populations are found to have high rates of severe kidney disease. Scientists have discovered that homozygous carriers of APOL1 mutations have a high risk of kidney disease, whereas heterozygotes do not.

题目 90：同一批非洲人口被发现具有很高的几率患上严重肾病。科学家发现，APOL1 突变纯合子的携带者患肾病的风险很高，而 APOL1 突变杂合子的携带者则没有该风险。

Part 5 of 5

1 mark

Mark all of the true options. 选出所有的正确答案

A.   The frequency of the mutant allele is probably increasing in Africans over time.
      随着时间的推移，非洲人口携带突变型等位基因的频率可能会增加。

B.   Natural selection is acting to maintain an equilibrium of wild-type and mutant APOL1 alleles in Africa.
      自然选择是为了维持非洲野生型和突变型 APOL1 等位基因之间的平衡。

C.   If a drug to treat *T. gambiense* is widely available, the frequency of mutant alleles will increase.
      如果广泛使用治疗冈比亚锥虫的药物，突变型等位基因的频率将增加。

D.   If a drug to treat the kidney disease is widely available, the frequency of mutant alleles will increase.
      如果广泛使用治疗肾脏疾病的药物，突变型等位基因的频率将增加

E.   The frequency of the mutant allele is likely to be higher in Europeans than Africans.
      欧洲人携带突变型等位基因的频率可能高于非洲人。

Question 4

Part 1 of 4

Ancient Mesopotamians used creatures called Kungas as the first beasts of burden. Kungas were said to be docile and strong like donkeys, but tall and fast like horses. Only recently, scientists discovered what Kungas were by genetic sequencing of equine remains found in tombs. Kungas are a hybrid of female donkeys (*Equus africanus*) crossed with male Tibetan asses (*Equus hemionus*). They were bred specially by ancient people and were very valuable.

古代美索不达米亚人将一种名为昆加斯的生物作为第一批驮畜。据说，昆加斯像驴子一样温顺而强壮，同时像马一样高大敏捷。直到最近，科学家通过对墓穴中发现的马科动物遗骸进行基因测序，才发现了昆加斯的真实面目。昆加斯是雌性驴（非洲野驴）与雄性藏驴（蒙古野驴）杂交的后代。由古代人专门培育，极其珍贵。

Depiction of an equid, thought to be the kungas. Detail from the War panel of the 3rd millennium BC 'Standard of Ur' mosaic, in the British Museum - Agricolae, Wikimedia, CC BY-SA 3.0
一种马科动物，据说是昆加斯的图片。

Part 2 of 4

Problem 91. What are some possible reasons why Kungas have to be artificially bred?

题目 91：昆加斯必须由人工培育的可能原因有哪些？

3 marks

Choose as many as appropriate 选出所有正确答案

A.   The parent species have incompatible genetic codes   亲本物种的遗传密码不相容

B.   The parent species are not sexually attracted to one another   亲本物种之间没有性吸引力

C.   The parent species live far apart   亲本物种生活区域距离太远

D.   Kungas are badly adapted in the wild, so die   昆加斯难以适应野外环境，所以会死亡

Part 3 of 4

Problem 92. Kungas were said to be sterile. Why might this be?

题目 92：据说昆加斯无法生育。这是为什么呢？

2 marks

Choose as many as appropriate 选出所有的正确答案

A.   Kungas are all the same sex   昆加斯都是同一性别

B.   Historians are mistaken and Kungas probably were not sterile
     历史学家记载有误，昆加斯很可能可以繁育后代

C.   The parent species may have different numbers of chromosomes 亲本物种的染色体数量可能不同

D.   There may be some genes in the parent species which are lethal to Kungas if homozygous
     如果是纯合子，亲本物种中可能有部分基因对于昆加斯而言是致命的

Part 4 of 4

Problem 93. What are possible reasons that the sex of the Kunga's parent species matters?

题目 93: 昆加斯亲本物种的性别至关重要的可能原因有哪些?

4 marks

Choose as many as appropriate 选出所有的正确答案

A. The Kunga requires one X chromosome from each species 昆加斯需要每个亲本的一条 X 染色体

B. The Kunga requires one Y chromosome from each species 昆加斯需要每个亲本的一条 Y 染色体

C. The hormones of the developing Kunga and its mother must interact correctly
    发育中的昆加斯与其母本的激素必须正确地相互作用

D. The autosomes (non-sex chromosomes) that the Kunga inherits depends on the sex of each parent
    昆加斯遗传的常染色体(非性染色体)取决于每个亲本的性别

E. Each sex of each parent species may leave different epigenetic imprints which alter gene expression in the Kunga
    每个亲本物种的每一性别可能会产生不同的表观遗传印记,这会改变昆加斯的基因表达

F. The Kunga may need mitochondrial genes found only in *Equus africanus*
    昆加斯可能需要只在非洲野驴体内发现的线粒体基因*

Question 5

Part 1 of 6

A researcher is working on a DNA plasmid. The plasmid contains 5000 nucleotides (5 kBp). The plasmid has restriction (cut) sites for nuclease enzymes *EcoRI* and *BamHI*. The plasmid contains 2 *EcoRI* sites and *x BamHI* sites. Both enzymes are used by the researcher to cut the plasmid. The researcher observed 3 bands when the product was run on an agarose gel.

一名研究人员正在研究 DNA 质粒。质粒中含有 5000 个核苷酸(5 kBp)。该质粒具有核酸酶 EcoRI 和 BamHI 的限制(切割)位点。该质粒包含 2 个 EcoRI 位点和 x 个 BamHI 位点。这两种酶都被研究人员用来切割质粒。当该产物在琼脂糖凝胶上运作时,研究人员观察到 3 个条带。

Part 2 of 6

Problem 94. What is the value of *x*?
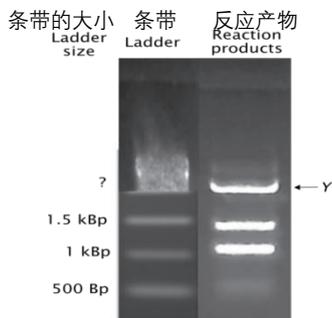
题目 94: x 的值是多少?

1 marks

Choose one. 单选

    A. 0

    B. 1

    C. 2

    D. 3

    E. 4

Part 3 of 6

The researcher compared the size of the bands to a ladder of nucleic acids of known length, as shown in the image. However, there was a problem with the ladder, so the size of one band could not be measured directly.
研究人员将这些条带的大小与已知长度的核酸条带进行了比较，如图所示。然而，该核酸条带存在问题，因此无法直接测量单一条带的大小。

Part 4 of 6

Problem 95. Determine the size of the unknown band (*y*) using the available information.

题目 95：运用已知信息来确定未知条带（y）的大小。

2 marks

Choose one. 单选

    A. 1 kBp

    B. 1.5 kBp

    C. 2 kBp

    D. 2.5 kBp

    E. 3 kBp

Part 5 of 6

This researcher's experiment is similar to the process of 'DNA fingerprinting'.
这名研究人员的实验类似于"DNA 指纹鉴定"的过程。

Part 6 of 6

Problem 96. How does DNA fingerprinting distinguish between different people?

题目 96：DNA 指纹如何区别不同的人呢？

3 marks

Choose as many as appropriate 选出所有的正确答案

    A. Mutations in some people may create or destroy cut sites
       有些人的基因突变可能会产生或破坏切割位点

    B. Mutations in some people may increase or decrease the distance between cut sites
       有些人的基因突变可能会增加或减少切割位点之间的距离

    C. Different people express different nuclease enzymes
       不同的人表达不同的核酸酶

    D. Some people express more or less nuclease enzymes
       有些人表达的核酸酶数量有多有少

    E. Many sequences are tested to see differences between close relatives
       测试很多基因序列，可以发现近亲之间的差异

Question 6

Part 1 of 12

The polymerase chain reaction (PCR) is a method invented to amplify nucleotide sequences.The technique works by:

聚合酶链式反应（PCR）是一种用于扩增核苷酸序列的方法。这项技术的工作原理是：

- Primers made of DNA bind (anneal) to the sequence to be amplified.
  由 DNA 组成的引物结合（退火）到要扩增的序列。

- DNA polymerase extends the primers along the sequence.
  DNA 聚合酶沿序列延伸引物。

- The sequence is 'melted' so the new double strand sequence dissociates into single strands.
  该序列被"解离"，因此新的双链序列分解成单链。

- The process repeats. 重复该过程。

Part 2 of 12

The reaction is primarily controlled by changing the temperature of the reaction in a machine called a *thermocycler*.This is because temperature controls the melting of the sequences.

该反应主要是由名为*热循环仪*的机器改变反应的温度来控制的。这是因为温度控制序列的解离。

G-STORM GS4 thermal cycler
G-STORM GS4 热循环仪

Part 3 of 12

Rank the following steps by the temperature at which they take place.

根据下列步骤发生的温度，对下列步骤进行排序。

Mark the highest temperature step as A, the mid temperature as B, and the lowest temperature as C.

将温度最高的步骤标记为 A，温度中间的步骤标记为 B，温度最低的步骤标记为 C。

Two thirds of a mark

Problem 97. *Primer annealing to the sequences*

题目 97： *对序列进行引物退火*

A. Highest temperature step   温度最高的步骤

B. Mid-temperature step   温度中间的步骤

C. Lowest temperature step   温度最低的步骤

Two thirds of a mark

Problem 98. *Melting the extended sequences*

题目 98： *解离扩展的序列*

A.　Highest temperature step　　温度最高的步骤

B.　Mid-temperature step　　　温度中间的步骤

C.　Lowest temperature step　　温度最低的步骤

Two thirds of a mark

Problem 99. *Extending the primers*

题目 99： 延伸引物

A.　Highest temperature step　　温度最高的步骤

B.　Mid-temperature step　　　温度中间的步骤

C.　Lowest temperature step　　温度最低的步骤

Part 4 of 12

Different primers have different binding (annealing) temperatures depending on the energy it takes to overcome the base-pairing.

不同的引物具有不同的结合（退火）温度，这取决于其克服碱基配对所需的能量。

Part 5 of 12

Rank the following primers by the temperature at which they anneal.

根据退火温度对以下引物进行排序。

One half of a mark

Problem 100. *Short primer with lots of A/T bases.*

题目 100： *具有大量 A/T 碱基的短引物*

A.　Highest temperature step　　　温度最高的步骤

B.　Mid-upper temperature step　　中高温度中间的步骤

C.　Mid-lower temperature step　　中低温度的步骤

D.　Lowest temperature step　　　温度最低的步骤

One half of a mark

Problem 101. *Short primer with lots of G/C bases*

题目 101： *具有大量 G/C 碱基的短引物*

A.　Highest temperature step　　　温度最高的步骤

B.　Mid-upper temperature step　　中高温度的步骤

C.　Mid-lower temperature step　　中低温度的步骤

D.　Lowest temperature step　　　温度最低的步骤

One half of a mark

Problem 102. *Long primer with lots of G/C bases.*

题目 102： *具有大量 G/C 碱基的长引物*

A.   Highest temperature step   温度最高的步骤

B.   Mid-upper temperature step   中高温度的步骤

C.   Mid-lower temperature step   中低温度的步骤

D.   Lowest temperature step   温度最低的步骤

One half of a mark

Problem 103. *A short primer with a sequence which does not match the target sequence very closely*

题目 103： *与靶标序列不匹配的短引物*

A.   Highest temperature step   温度最高的步骤

B.   Mid-upper temperature step   中高温度的步骤

C.   Mid-lower temperature step   中低温度的步骤

D.   Lowest temperature step   温度最低的步骤

Part 6 of 12

PCR usually uses a *Taq* DNA polymerase. Taq polymerase was originally taken from a thermophilic (heat loving) bacterium that lives in hot springs.

聚合酶链式反应通常使用 Taq DNA 聚合酶。Taq 聚合酶最初取自于生活在温泉中的嗜热细菌。

Part 7 of 12

Problem 104. What are the reasons that Taq polymerase is suitable for PCR?

题目 104： Taq 聚合酶适合用于聚合酶链式反应的原因是什么呢？

4 marks

Choose as many as appropriate 选出所有正确答案

A.   Nucleotides are universal, so Taq can replicate sequences from any organism.
      因为核苷酸是通用的，所以 Taq 可以复制任何生物体的序列。

B.   High temperatures used for melting sequences denture Taq. 高温可用于解离义齿 Taq 的序列。

C.   The amplification is quicker if it can take place at a higher temperature.
      如果能在更高的温度下进行，扩增速度会更快。

D.   Bacterial polymerases are very error prone.   细菌聚合酶非常容易出错。

E.   Taq polymerase can amplify mRNA.   Taq 聚合酶可以扩增信使核糖核酸。

qPCR is used in diagnostic testing, and to detect the presence of sequences in the environment. In qPCR:

qPCR（实时荧光定量聚合酶链式反应）用于诊断的测试，并检测环境中是否存在序列。在 qPCR 中：

- Primers which are *specific* to a sequence of interest are used to amplify the sequence.
  用特定于序列的引物来扩增该序列。

- A dye is included in the reaction which is fluorescent when it binds double-stranded DNA.
  反应中的染料与双链 DNA 结合时，产生荧光。

- The amount of fluorescence is measured at the end of each thermocycle.
  每个热循环结束时测量荧光的量。

Modern qPCR reactions can be extremely specific as they only detect the sequence the researcher chooses. They can also be extremely sensitive as they can amplify the sequence a billion fold.

现代的 qPCR 可以有非常高的特异性，因为它们只检测研究人员选择的序列。也可以非常灵敏，因为它们可以将序列扩增 10 亿倍。

For each of these features, state whether they improve qPCR specificity or sensitivity, or do not directly impact specificity and sensitivity. *Think about qPCR, as described above, and not PCR in general*

对于这些特征，判断它们是否提高了 qPCR 的特异性或灵敏度，或者间接影响其特异性和灵敏度。根据如上所述而非通常提到的 PCR（聚合酶链式反应），对 *qPCR* 进行思考。

Four fifths of a mark

Problem 105. *The products of primer extension become targets for primer binding*

题目 105：引物延伸的产物成为引物结合的靶标

A. Improve specificity　提高特异性

B. Improve sensitivity　提高灵敏度

C. Not directly relevant　不直接相关

Four fifths of a mark

Problem 106. *'Hot start' Taq (only works on primers binding at high temperatures)*

题目 106："热启动" Taq（仅适用于高温下引物的结合）

A. Improve specificity　提高特异性

B. Improve sensitivity　提高灵敏度

C. Not directly relevant　不直接相关

Four fifths of a mark

Problem 107. *Taq engineered to have improved 'proofreading' Taq*

题目 107：经过 Taq 设计改进了 Taq 的"校对"

A. Improve specificity　提高特异性

B. Improve sensitivity　提高灵敏度

C. Not directly relevant　不直接相关

Four fifths of a mark

Problem 108. *Primers assessed against databases of all genomes to identify potential targets*

题目 108：根据所有基因组数据库评估引物，以确定潜在靶标

A. Improve specificity   提高特异性

B. Improve sensitivity   提高灵敏度

C. Not directly relevant   不直接相关

Four fifths of a mark

Problem 109. *The amount of target approximately double every thermocycle*

题目 109：靶标的数量在每次热循环后大约会变成原来的两倍。

A. Improve specificity 提高特异性

B. Improve sensitivity 提高灵敏度

C. Not directly relevant 不直接相关

Part 10 of 12

Problem 110. Which of these applications require very high specificity and sensitivity, as opposed to methods with normal sensitivity and specificity?

题目 110：与具有正常灵敏度和特异性的方法相比，下列哪些应用场景需要非常高的特异性和灵敏度？

2 marks

Choose as many as appropriate 选出所有的正确答案

A. Detecting the presence of very endangered species from water / air samples taken from a habitat.
从栖息地采集的水/空气样本中检测是否存在极其濒危的物种。

B. Diagnosing a common virus which has a high viral-load in infected people.
检测一种在受感染人群中具有较高病毒载量的常见病毒。

C. Diagnosing mutant DNA coming from tumor cells in blood samples.
检测血液样本中肿瘤细胞的突变 DNA。

D. Determining which organisms are male from cell samples.
根据细胞样本确定哪些生物体是雄性的。

Part 11 of 12

A qPCR test was carried out for some genetic material in two people.
对两个人的某些遗传物质进行了 qPCR 检测。

In **Sample A**, the measurements of fluorescence began increasing at the 18th cycle of heating and cooling.
在**样品 A** 中，荧光测量值在第 18 次加热和冷却循环时开始增加。

In **Sample B**, the measurements of fluorescence began increasing at the 16th cycle.
在**样品 B** 中，荧光测量值在第 16 次循环时开始增加。

Problem 111. Which of these are correct?

题目 111： 下面哪些是正确的？
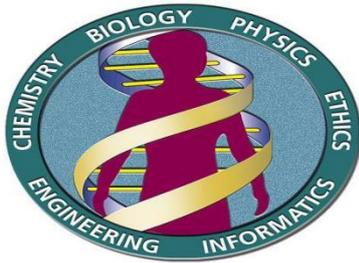
2 marks

Choose as many as appropriate 选出所有的正确答案

A. There was twice as much of the target material in one sample vs the other.
   一个样品中靶标物质的含量是另一个样品的两倍。

B. Sample B has more of the target material than sample A. 样品 B 比样品 A 含有更多的靶标物质。

C. One person may have been heterozygous for the target allele, and the other homozygous.
   一个人可能是靶标等位基因的杂合子，另一个人可能是纯合子。

D. The DNA extraction to prepare the samples may have been more efficient for person B than for person A.
   为 B 提取 DNA 来准备样本可能比为 A 准备会更高效。

Question 7

Part 1 of 13

When the human genome was first sequenced in 2003, scientists were very surprised to only identify about 20,000 genes. However, the human proteome contains 80,000 - 400,000 proteins.

人类基因组在 2003 年首次测序时，科学家们发现只有大约 20000 个基因，这让科学家们很惊讶。然而，人类蛋白质组包含 80000 至 400000 种蛋白质。

Logo of the human genome project
人类基因组计划的标志

Part 2 of 13

Problem 112. Why were so many fewer genes found than expected?

题目 112： 为什么发现的基因比预期的基因的数量少了很多？

4 marks

Mark all of the true options. 选出所有正确的答案

A. The sequencing methods in 2003 missed large coding sections of the genome.
   2003 年的基因测序方法遗漏了基因组大量的编码片段。

B. Many genes undergo alternative splicing to generate a greater variety of proteins.
   许多基因经过选择性剪接以产生更多种类的蛋白质。

C. The bioinformatic tools at the time failed to annotate most of the genes.
   当时的生物信息学工具未能对大多数基因进行注释。

D. The human nucleus contains only 1/10th of DNA within the cell.

人类细胞核中只有十分之一的 DNA。

E. Many proteins are chemically modified in various ways after translation.

许多蛋白质在翻译后以各种方式进行化学修饰。

F. Most of the proteins in our cells are produced by microorganisms living in our guts.

我们细胞中的大多数蛋白质是由生活在肠道中的微生物产生的。

Part 3 of 13

The human genome project revealed that the haploid human genome contains 3.3 billion (3 300 000 000) nucleotides. The average length of a human protein is 480 amino acids.

人类基因组计划显示，单倍体人类基因组包含 33 亿（3 300 000 000）个核苷酸。人类蛋白质的平均长度是 480 个氨基酸。

Part 4 of 13

Problem 113. Using the information given in this question, calculate the proportion of the human genome which is protein coding (is transcribed to an exon).

题目 113：运用提供的信息，计算蛋白质编码（转录到外显子）的人类基因组的比例。

3 marks

Choose one. 单选

    A. 0.21%

    B. 0.29%

    C. 0.87%

    D. 1.45%

    E. 4.36%

Part 5 of 13

Problem 114. What is contained in the rest of the genome which is not protein coding?

题目 114：基因组的其余部分中，哪些不是蛋白质编码的？

3 marks

Choose as many as appropriate 选出所有的正确答案

A. DNA which folds into specific shapes to catalyse reactions like an enzyme.

折叠成特定形状以像酶一样催化反应的 DNA。

B. Sequences which form centromeres and telomeres. 形成着丝粒和端粒的序列。

C. Much unused DNA is deleted from cells as they specialise (differentiate).

细胞特化（分化）时，许多未利用的 DNA 从细胞中被去除。

D. Much of the genome is remnants of viruses and parasitic sequences.

病毒和寄生者序列的剩余部分的大部分基因组。

E. Sequences which help control the rate of transcription.

有助于控制转录速率的序列。

Part 6 of 13

The simplest organisms, such as some bacteria, tend to have very short genomes, whereas animals and plants have very large genomes. Moreover, a much greater proportion of bacterial genomes tends to be protein coding.

最简单的有机体，例如一部分细菌，通常拥有非常短的基因组，而动物和植物则拥有非常大的基因组。此外，更大比例的细菌基因组往往是蛋白质编码。

Part 7 of 13

Problem 115. What are sensible hypotheses to explain this observation?

题目 115：哪些是解释这一现象合理的推测？

3 marks

Choose as many as appropriate 选出所有正确的答案

A. Bacterial genomes need to be replicated quicker.
    细菌基因组需要的复制速度更快。

B. Animals and plants need more complicated promoters and enhancers.
    动植物需要更复杂的启动子和增强子。

C. Animals and plants produce a wider variety of proteins.
    动植物产生的蛋白质种类繁多。

D. Replicating the genome consumes a larger proportion of the energy of bacteria.
    复制基因组会消耗细菌更多的能量。

Part 8 of 13

The largest human gene by far is *dystrophin*, which is mutated in muscular dystrophy. *Dystrophin* is approximately 2 200 000 bases long (including introns). *Dystrophin* is **not** the largest human protein, having 3684 amino acids. Titin contains 34350 amino acids.

到目前为止，最大的人类基因是肌营养不良蛋白，它会在肌营养不良症中发生突变。肌营养不良蛋白大约有 2 200 000 个碱基那么长（包括内含子）。肌营养不良蛋白**不是**人类最大的蛋白质，含有 3684 个氨基酸。肌联蛋白含有 34350 个氨基酸。
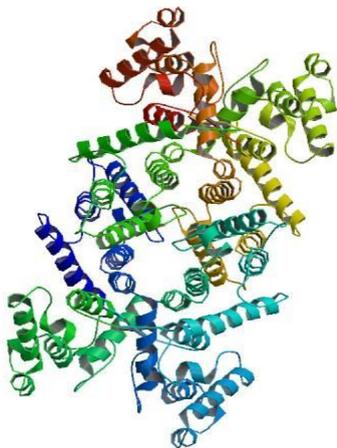
Dystrophin structure
肌营养不良蛋白的结构

Part 9 of 13

Problem 116. Which of these is correct?

题目 116： 下面哪项是正确的？

1 mark

Choose ONE 单选

A. *Dystrophin* contains more exon sequence than *Titin*.
肌营养不良蛋白比肌联蛋白包含更多的外显子序列。

B. *Titin* contains more exon sequence than *Dystrophin*.
肌联蛋白比肌营养不良蛋白包含更多的外显子序列。

C. It is not possible to say which gene has more exon sequence.
不能判断哪个基因的外显子序列更多。

D. Dystrophin is a heavier protein than titin.
肌营养不良蛋白是比肌联蛋白质量更重的蛋白质。

Part 10 of 13

Human RNA polymerase II moves at an average speed of 3 200 bases per minute.
人类 RNA 聚合酶 II 以每分钟 3200 个碱基的平均速度移动。

Human DNA polymerase delta moves at an average speed of 2 000 bases per minute.
人类 DNA 聚合酶 δ 以每分钟 2000 个碱基的平均速度移动。

Part 11 of 13

Problem 117. Which of these is correct?

题目 117： 下面哪项是正确的？

1 mark

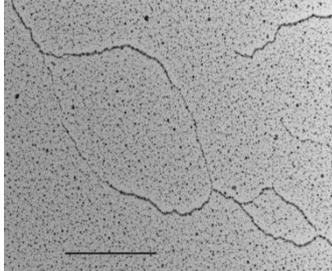*Choose ONE 单选*

A. *Dystrophin* is transcribed quicker than *Titin*.
肌营养不良蛋白的转录速度比肌联蛋白快。

B. It is not possible to say which gene is transcribed quicker.
无法判断哪个基因转录得更快。

C. *Titin* is replicated quicker than *Dystrophin*.
肌联蛋白的复制速度比肌营养不良蛋白快。

D. It is not possible to say which gene is replicated quicker.
无法判断哪个基因复制得更快。

E. Both genes are replicated quicker than they are transcribed.
这两种基因的复制速度都快于转录速度。

Human genome replication begins from 'initiation sites' which have special properties. Replication forks usually move in both directions along DNA, outwards from an initiation site, and stop when they reach another fork moving towards them.In human cell cycles, S-phase takes 9 hours on average.

人类基因组复制始于具有特殊性质的"起始位点"。复制叉通常沿着 DNA 向两个方向移动，从起始点向外移动，当移动到另一个向它们移动的复制叉时停止。在人类细胞周期中，S 期（DNA 复制期）平均需要 9 小时。

DNA being replicated

DNA 正在被复制

Problem 118. Estimate the *minimum* number of replication initiation sites used in a human cell.

题目 118： 估算人类细胞中所用的复制起始位点的*最小* 数量。

4 marks

Choose one. 单选

    A. 1197

    B. 2000

    C. 3056

    D. 20000

    E. 1080000

Question 8

Part 1 of 5

The beaches of Northern Cyprus are home to two species of marine turtle: the loggerhead turtle (*Caretta caretta*) and the green turtle (*Chelonian mydas*). Both are endangered and protected species. Female loggerhead turtles visit the beach to lay eggs from late May every year.

北塞浦路斯的海滩是两种海龟的家园：红海龟（Caretta Caretta）和绿海龟（Chelonian mydas）。两者都是濒危保护物种。雌性红海龟每年 5 月下旬都会到海滩产卵。

Loggerhead sea turtle hatchlings make their way to the ocean 红海龟孵化的小海龟正朝着大海走去

Part 2 of 5

A group of researchers tried to estimate how many loggerhead turtles visit the beach (A), and so used the mark-release-recapture method. In 2019, they marked and released 54 turtles. In 2020, they captured only 30 turtles and 12 of them were previously marked.

一队研究人员试图估算有多少只红海龟会来到海滩（A），因此采用标记重捕法进行。2019 年，他们标记并放回 54 只海龟。2020 年，他们只捕获了 30 只海龟，其中 12 只是之前标记的海龟。

Part 3 of 5

Problem 119. How many turtles do the researchers estimate visit the beach (A) every year?

题目 119：研究人员估算每年会有多少只海龟会来海滩（A）？

2 marks

Choose one. 单选

     A. 12

     B. 22

     C. 42

     D. 120

     E. 135

Part 4 of 5

Unfortunately, quite a few things went wrong with this experiment!

糟糕的是这个实验出现了不少问题!

- The researchers captured turtles for two weeks in 2019, but for 2 months in 2020.
  研究人员在 2019 年捕获海龟用了两周时间，但在 2020 年捕获海龟用了两个月的时间。

- Marked turtles were much more likely to be eaten by predators.
  有标记的海龟更容易被捕食者吃掉。

- The team accidentally counted some green turtles in 2020, but did not in 2019.
  该团队在 2020 年偶然统计了一部分绿海龟，但在 2019 年没有统计绿海龟。

- A neighbouring beach (B) was created January 2020, so some turtles did not return to beach (A).
  附近的海滩（B）于 2020 年 1 月建成，因此一部分海龟没有返回海滩（A）。

- The researchers found it easier to spot and count marked turtles than unmarked turtles.
  研究人员发现，有标记的海龟比没有标记的海龟更易识别和计数。

Part 5 of 5

For each error, sort them into whether this will have no effect, cause an underestimate) or overestimate in loggerhead turtle numbers **who visit beach A.**

对于所出现的问题，将它们分为不会影响、低估或高估**回到海滩（A）**的红海龟数量。

Four fifths of a mark

Problem 120. *Counting green turtles*

题目 120：统计了绿海龟

A.   No effect   不会影响

B.   Underestimate   低估

C.   Overestimate   高估

Four fifths of a mark

Problem 121. *Differing lengths of capture periods*

题目 121：捕获海龟的时间不同

A.   No effect   不会影响

B.   Underestimate   低估

C.   Overestimate   高估

Four fifths of a mark

Problem 122. *Increased predation of marked turtles*

题目 122：有标记的海龟被捕食的数量增加

A.   No effect   不会影响

B.   Underestimate   低估

C.   Overestimate   高估

Four fifths of a mark

Problem 123. *Marked turtles are easier to find*

题目 123：有标记的   更容易被发现

A.   No effect   不会影响

B.   Underestimate   低估

C.   Overestimate   高估

Four fifths of a mark

Problem 124. *Creation of beach B*

题目 124：海滩（B）的建成

A.   No effect   不会影响

B.   Underestimate   低估

C.   Overestimate   高估

Question 9

Part 1 of 10

- DNA polymerases and RNA polymerases do not require a high-energy co-factor (such as ATP) to function.

  DNA 聚合酶和 RNA 聚合酶不需要高能辅因子（如 ATP（腺嘌呤核苷三磷酸）发挥作用。

- Ribosomes require GTP to function.

  核糖体需要 GTP（三磷酸鸟苷）才能发挥作用。

- Glycogen synthase requires ATP to function.

  糖原合酶需要 ATP（腺嘌呤核苷三磷酸）才能发挥作用。

- ATP, GTP and UTP are approximately equal as energy sources.

  ATP（腺嘌呤核苷三磷酸）、GTP（三磷酸鸟苷）和 UTP（尿苷三磷酸）作为能量来源具有大致相等的能量。

Part 2 of 10

Problem 125. Why do DNA / RNA polymerases not require an additional source of energy?

题目 125： 为什么 DNA/RNA 聚合酶不需要额外的能量来源？

1 mark

Choose ONE 单选

A. Nucleotide polymerisation is an exothermic reaction. 核苷酸聚合是放热反应。

B. Nucleotide polymers have a lower free energy than free nucleotides.

   核苷酸聚合物的自由能低于游离核苷酸的自由能。

C. Formation of phosphodiester bonds between free nucleotides is energetically favourable.

   游离核苷酸之间形成磷酸二酯键是不消耗能量的。

D. DNA/RNA polymerases cleave high energy phosphate bonds in their substrates which releases energy.

   DNA/RNA 聚合酶在其基质中切割高能磷酸键，释放能量。

E. Base-pairing between nucleotides provides energy for polymer synthesis.

   核苷酸之间的碱基配对为聚合物合成提供能量。

Part 3 of 10

In anaerobic glycolysis, 1 ATP is consumed to turn glucose into glucose-6-P. A second ATP is then consumed in the next step. In the final steps, 4 ATP are produced. Thus anaerobic glycolysis of glucose has a net yield of 2 (4 ATP produced - 2 ATP consumed).

在厌氧糖酵解中，葡萄糖转化为葡萄糖-6-P 会消耗 1 个 ATP（腺嘌呤核苷三磷酸）。然后在下一步消耗第二个 ATP。在最后的步骤中，产生 4 个 ATP。因此，葡萄糖的厌氧糖酵解净产量为 2ATP（产生 4 个 ATP，消耗 2 个 ATP）。

Part 4 of 10

Addition of one glucose monomer to glycogen consumes 1 ATP molecule to phosphorylate glucose and then 1 UTP molecule to power glycogen synthase.Phosphorylated glucose (glucose-6-P) can be released from glycogen in an energetically favourable reaction which does not produce or consume ATP. Glucose-6-P can be turned back into glucose in a second energetically favourable reaction which does not produce or consume ATP.

向糖原中添加一个葡萄糖单体需要消耗 1 个 ATP 分子以磷酸化葡萄糖，然后消耗 1 个 UTP 分子来为糖原合成酶提供能量。磷酸化葡萄糖（葡萄糖-6-P）可以通过不消耗能量的反应从糖原中释放出来，该反应不产生或消耗 ATP。葡萄糖-6-P 可以在第二个不消耗能量的的反应中转化为葡萄糖，该反应不产生或消耗 ATP。

- Glucose-6-P can be released into the cytoplasm of muscle cells and used directly in glycolysis.

  葡萄糖-6-P 可以释放到肌肉细胞的细胞质中，并直接用于糖酵解。

- Only glucose can be released from liver cells into the blood, for use by muscle cells.

  只有葡萄糖可以从肝细胞释放到血液中，供肌肉细胞使用。

Part 5 of 10

Problem 126. What is the net energy yield when glucose from food is first stored as glycogen in **muscles**, then used in **anaerobic** respiration?

题目 126： 食物中的葡萄糖先作为糖原储存在**肌肉**中，然后用于无氧呼吸时，所产生的净能量是多少？

Give your answer as a number in terms of ATP molecules.

答案以 ATP 分子为单位。

2 marks

Choose one. 单选

- A.   1
- B.   2
- C.   3
- D.   4
- E.   6

Part 6 of 10

Problem 127. What is the net ATP yield when glucose from food is first stored as glycogen in the **liver**, then used in **anaerobic** respiration?

题目 127： 食物中的葡萄糖首先作为糖原储存在**肝脏**中，然后用于**无氧呼**吸时，所产生的净 ATP 分子的数量是多少？

Give your answer as a number in terms of ATP molecules.

答案以 ATP 分子为单位。

1 mark

Choose one. 单选

- A.   0
- B.   1
- C.   2
- D.   3
- E.   6

Part 7 of 10

Problem 128. What are the main purposes of glycogen stored in the liver?

题目 128：糖原储存在肝脏的主要目的是什么？

2 marks

Choose as many as appropriate 选出所有的正确答案

A. As an energy source for anaerobically respiring muscles.　作为肌肉无氧呼吸的能量来源。

B. As an energy source for aerobic respiration.　　　　　作为有氧呼吸的能量来源。

C. To supply glucose to the brain between meals.　　　　在两餐之间为大脑提供葡萄糖。

D. To balance the osmolarity (water potential) of blood.　　平衡血液的渗透压（水势）。

Part 8 of 10

Protein synthesis requires at least 2 ATP to charge tRNA, 1 GTP to bind ribosomes, and 1/3 GTP to move a ribosome 1 base along an mRNA molecule.
蛋白质合成需要至少 2 个 ATP 为 tRNA 提供能量，1 个 GTP 用于结合核糖体，1/3 个 GTP 用于沿着 mRNA 分子让核糖体移动 1 碱基。

Part 9 of 10

Problem 129. What is the minimum energy cost of synthesising a peptide bond?

题目 129：合成肽键的最低能耗是多少？

Give your answer as a number in terms of ATP molecules. 答案以 ATP 分子为单位。

2 marks

Choose one. 单选

    A. 2

    B. 3

    C. 4

    D. 5

    E. 6

Part 10 of 10

Problem 130. Why don't our bodies use proteins to store excess energy?

题目 130：为什么我们的身体不使用蛋白质来储存多余的能量？

2 marks

Choose as many as appropriate 选出所有的正确答案

A. Synthesising proteins consumes lots of energy, making them inefficient.
合成蛋白质会消耗大量能量，使其效率低下。

B. Proteins attract lots of water, increasing the weight of energy stores.
蛋白质会吸引大量水分，增加能量储存的重量。

C. Respiration of peptides is energetically unfavourable.
以多肽为底物进行呼吸作用是耗能的。

D. We do not have enzymes which can respire amino acids.
我们没有通过氨基酸进行呼吸作用的酶。

Question 10

Part 1 of 7

A woman is suspected of having an *E. coli* infection. The hospital needs to work out how severe the infection is and which antibiotic to give the patient.

一名妇女疑似感染大肠杆菌。医院需要判断出患者感染的严重程度以及给患者使用哪种抗生素。

- 2 mL of blood from the patient was diluted 98 mL of buffer solution.
  将患者的 2 毫升血液稀释到 98 毫升缓冲溶液中。

- 1 mL of this solution was then diluted into 99 mL of buffer.
  然后将 1 毫升该溶液稀释到 99 毫升缓冲液中。

- This was repeated twice more.
  将以上过程重复两次。

- For each dilution, 1 mL and 0.1 mL of solution was plated on an agar plate.
  每稀释一次，都将 1 毫升和 0.1 毫升溶液涂抹在琼脂平板上。

After 24h, the number of bacterial colonies (colony forming units; CFU) were counted.

24 小时后，计算菌落数（菌落形成单位；CFU）。

CFU counts are only reliable between 5 and 250 CFU.

CFU 计数的结果仅在 5 到 250 CFU 之间是可靠的。
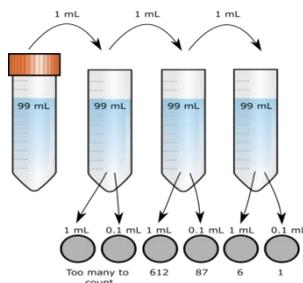
A dilution series of liquids, which are subsequently plated.
随后涂抹在琼脂平板上的一系列稀释溶液。

Part 2 of 7

Problem 131. Which CFU count should doctors use to calculate the severity of this infection?

题目 131：医生应该使用哪种 CFU 计数来判断患者感染的严重程度？

1 mark

Choose ONE 单选

A. Too many to count 不计其数

B. 612

C. 87

D. 6

E. 1

Part 3 of 7

Problem 132. What is the number of CFU per mL of blood?

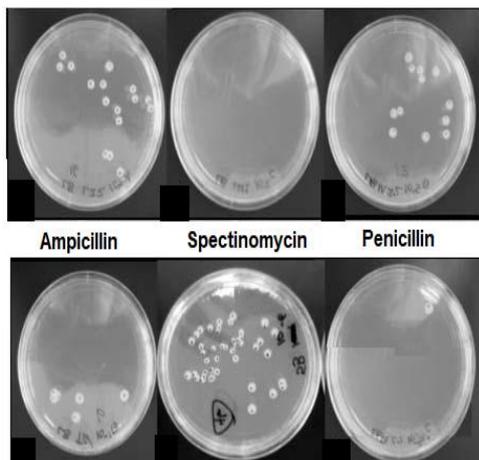**题目 132：**每毫升血液的 CFU 数量是多少？

3 marks

Choose one 单选

    A. 612

    B. 870

    C. 6120000

    D. 435000000

    E. 4350000000

Part 4 of 7

The doctors thought this infection was severe enough to need antibiotics. However, many *E. coli* strains have antibiotic resistance. Therefore, some of the patients *E. coli* was streaked onto agar plates containing antibiotics, as shown below.

医生们认为患者感染非常严重，需要使用抗生素。然而，许多大肠杆菌菌株具有抗生素耐药性。因此，部分患者的大肠杆菌被接种到含有抗生素的琼脂平板上，如下图所示。

Ampicillin	Spectinomycin	Penicillin

氨苄西林　大观霉素　青霉素

Gentamicin	Positive Control	Negative Control

庆大霉素　阳性对照的琼脂平板　阴性对照的琼脂平板

Part 5 of 7

Problem 133. Which antibiotic should the doctor prescribe?

题目 133：医生应该开哪种抗生素？

1 mark

Choose ONE 单选

A. Ampicillin   氨苄西林

B. Spectinomycin   大观霉素

C. Penicillin   青霉素

D. Gentamicin   庆大霉素

E. All of them   以上所有

Part 6 of 7

Problem 134. What causes **this patient's** bacteria to be resistant to the antibiotics?

题目 134：什么会导致**这位患者**的大肠杆菌对抗生素产生耐药性？

1 mark

Choose ONE 单选

A.   In response to the antibiotic, her *E. coli* evolved a resistance gene
     为应对抗生素，患者的大肠杆菌产生了一个耐药基因

B.   All *E. coli* are resistant to antibiotics by default
     正常情况下，所有大肠杆菌都对抗生素有耐药性

C.   Her *E. coli* already had antibiotic resistance genes in its genome
     患者的大肠杆菌基因组中已经有抗生素抗性基因

Part 7 of 7

Problem 135. What should the negative control plate contain?

题目 135：阴性对照的琼脂平板应该包含什么？

1 mark

Choose ONE 单选

A.   A mix of all the antibiotics   所有抗生素的混合物

B.   *E. coli* which are resistant to all antibiotics   对所有抗生素都有耐药性的大肠杆菌

C.   No antibiotic   不含抗生素

D.   Agar which does not have all the nutrients *E. coli* needs   不含有大肠杆菌所需全部营养的琼脂

E.   None of the patient's *E. coli*   不含患者的大肠杆菌