

Theoretical Assessment Test Questions for the **2023** Republic of

China Biology Olympiad

National Team Selection Camp

Part One

Student Code



Precautions:

1. This section of the test consists of 9 pages (including the cover) and is worth 100 points.
2. Please check for missing pages. If any pages are missing, please inform the test administrator immediately.
3. When answering the questions, please make sure that the cover of the exam paper matches your exam number.
4. Please answer the questions on the test paper using a blue (black) pen, and please keep the test paper clean.
5. You may write your answers on the back of the questions, but please indicate the question number.

Part 1: (100 points)

I. Multiple Choice Questions

_____ 1. Normal cells must attach to a suitable surface to grow; they struggle to grow when suspended in a liquid or semi-solid state.

Good. However, cells that can grow in a liquid or semi-solid state are considered by us to be cellular...

What factors caused this? (3 points)

- (A) Infected with a virus
- (B) Immortalization
- (C) Apoptotic
- (D) Anchorage-independent
- (E) Density-dependent

_____ 2. The incidence of cancer in organ transplant patients is generally higher than in the general population. Which of the following factors is this related to? (3 points)

- (A) Anchorage-independence of growth
- (B) Evasion of immune surveillance
- (C) Multistep mutations
- (D) Angiogenesis
- (E) Increased motility of cancer cells

_____ 3. Which of the following is NOT a type of protein encoded by an oncogene? (3 points)

- (A) Growth factor
- (B) Signal receptor
- (C) Plasma membrane-associated GTP-binding protein
- (D) Cell cycle regulator
- (E) P-450 cytochrome

II. Short Answer Questions

1. What is a G protein? (3 points)

2. What is a G protein-coupled receptor (GPCR)? (4 points)

3. To function, cyclin-dependent kinases (CDKs) must interact with cyclins.

(Cyclin) interactions. Whether the same cyclin interacts with other cyclins throughout the cell cycle.

Type I kinase interactions? (2 points) Why? (2 points)

4. Is the content of cyclin constant throughout the cell cycle? (2 points) Why? (2 points)

Answer:

III. Fill in the blanks

1. Please select the most appropriate answer from the following options (A - O) and fill it in the blank. 2 points for each blank, 10 points in total.

While hiking, Da Dan encountered a black bear charging at him. This activated his sympathetic nervous system, causing vasodilation.

Zhang, this process is caused by a series of reactions: first, sympathetic nerve cells release (1), and this substance can react with blood

(2) The receptors on the surface of the tube bind, leading to extravascular (3) reflux into the cell; this process can activate ceNOS and

(4) is produced, and this substance diffuses into nearby smooth muscle cells, activating (5), thereby converting GTP into...

cGTP. cGTP then relaxes smooth muscle cells, thus ultimately causing vasodilation.

A. Ca⁺F. Na⁺

K. guanylate cyclase

B. N₂OG. H₂O₂

L. endothelial cells

C. NO

H. smooth muscle cells

M. fibroblasts

D. K⁺

I. Nicotinic acid

N. adenylate cyclase

E. NO₃ -

J. Adrenaline

O. Acetylcholine

Cell cycle	(1)	(2)	(3)	(4)	(5)
Answer					

2. Please select the most appropriate answer from the following options (AP) to fill in each blank. Each blank may have more than one option.

2 points per blank, 16 points in total.

A. Sucrose

Glycerin

M. FADH₂

B. Glucose

H. lactic acid

N. O₂

C. Lactose

I. H₂O

O. ATP

D. Pyruvic acid

J. CO₂

P. glyceraldehyde-3-phosphate

E. Acetyl-CoA

K. NADPH

F. Fatty acids

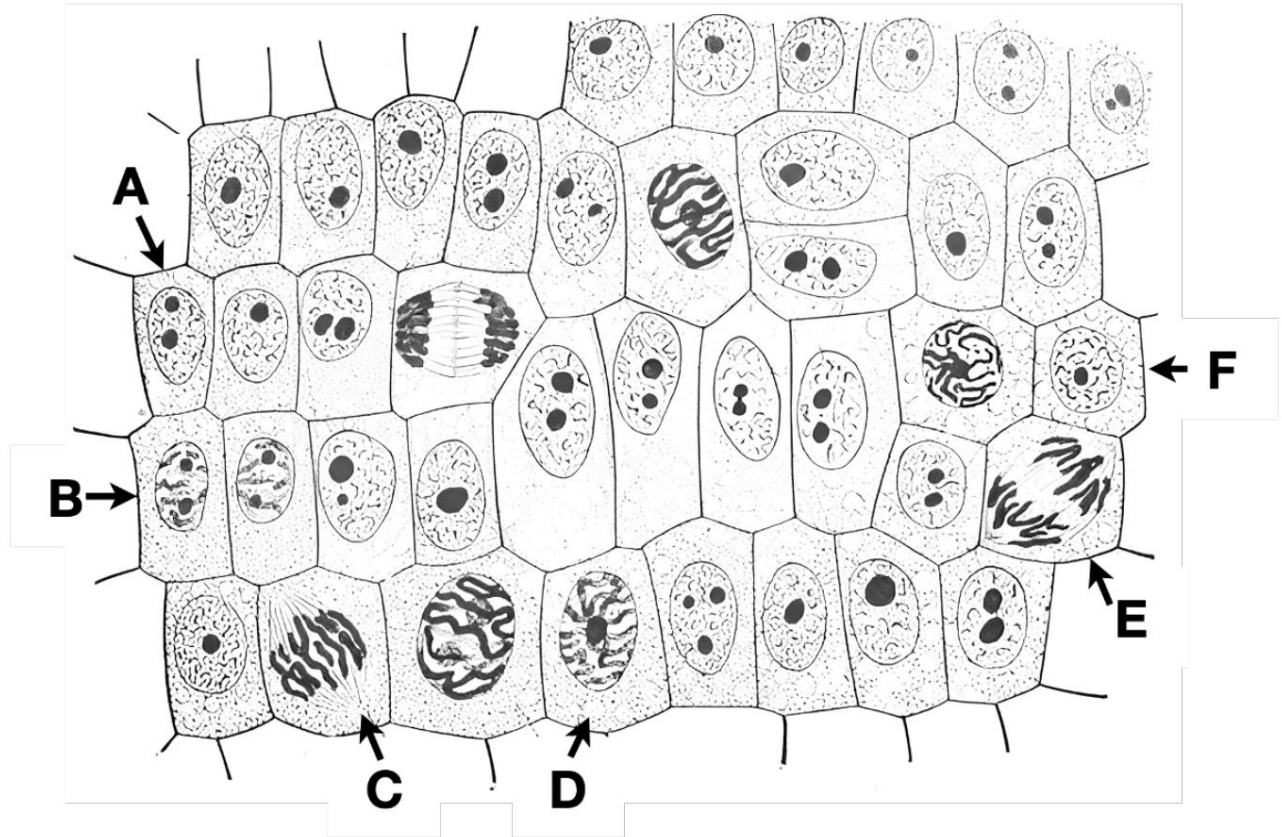
L. NADH

Metabolic pathways	Directly subject to mass	direct products
Glycolysis		
Kreb cycle		
The light reaction of photosynthesis		
Carbon fixation reaction in photosynthesis		

IV. Fill in the blanks

1. The image above is a hand-drawn diagram of an onion root tip cell section. Please fill in the correct letters for each cell type (AF) in the correct order.

Fill in the blanks with the correct sequence of cell mitosis: (1.5 points per blank, 9 points in total)



Mitosis order	Interphase, early-middle-middle-late-late phase					
	INTERPHASE	PROPHASE	PROMETAPHASE	METAPHASE	ANAPHASE	TELOPHASE
Answer						

2. Following the hand-drawn diagram of onion root tip cell sections above, please fill in the cells labeled with the letters (AF) in order.

The most accurate position of the cell cycle: (2 points per square, 10 points in total)

Cell cycle G0		G1	S	G2	M
Answer					

V. Multiple Choice Questions

_____ 1. Which of the following phenomena is most likely to occur in the later stages of cell mitosis? (2 points each)

- (A) Centriole separation
- (B) Chromosomal division
- (C) Spindle formation
- (D) Nuclear membrane reformation
- (E) The cell membrane begins to contract.

_____ 2. Which of the following phenomena is most likely to occur during the G2 phase of the cell cycle? (2 points each)

- (A) DNA replication
- (B) Chromosomal division
- (C) Chromosome replication
- (D) Spindle formation
- (E) Cell membrane contraction

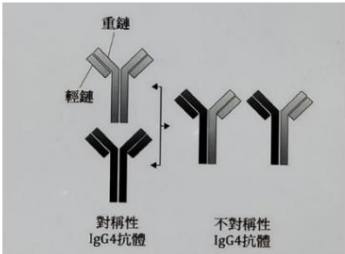
_____ 3. Which of the following phenomena is most likely to occur during the S phase of the cell cycle? (2 points each)

- (A) Increased cell size
- (B) Cellular DNA Synthesis
- (C) The cell membrane begins to contract.
- (D) The cell nucleus divides into two daughter nuclei.
- (E) The cell divides into two daughter cells.

VI. International Competition

Question: γ Report

1: IgG immunoglobulin is the most abundant antibody component in body fluids. Human IgG can be divided into four subtypes. Compared to the three subtypes IgG1, IgG2, and IgG3, the concentration of IgG4 varies greatly in the serum of different healthy individuals, ranging from 0.01 to 1.4 mg/ml. However, the concentration of IgG4 in each individual's serum is relatively stable. The constant domains of the IgG4 heavy chain are more than 95% similar to other IgG subtypes, but the difference in the amino acids on the second constant domain (CH2) limits the ability of IgG4 to bind to C1q and Fc γ receptors. The amino acid composition of the IgG4 hinge region differs from other trisubtypes, allowing for disulfide rearrangement between the two heavy chains to form half-molecule structures. Two half-molecules can then bind non-covalently through the third invariant region (CH3), enabling them to undergo Fab-arm exchange (FAE) or half-antibody exchange reactions with other IgG4 molecules, forming asymmetric antibody molecules (see diagram below). Therefore, the separation and rearrangement of two different IgG4 half-molecules can form FAE bispecific antibodies. Modification of the IgG4 hinge region sequence can reduce the occurrence of FAE. For example, modifying the hinge region sequence, or mutating the arginine (Arg) at position 409 in the CH3 region to a lysine (Lys) sequence similar to that of IgG1, can stabilize the IgG4 framework.



1. Determine whether the following six statements (AF) are true or false. Fill in the corresponding column in the answer sheet with **T** (for true) or **F** (for false).

(Incorrect). 0 points for all wrong answers. 1, 2, 4, 7, 10.5, and 15 points for correct answers to items one, two, three, four, five, and six respectively.

- (A) Among the four IgG subtypes, IgG4 had the lowest serum concentration.
- (B) IgG4 antibodies primarily combat protein antigens, such as common bacterial or viral infections.
- (C) All IgG subtypes can effectively activate complement, but their complement activation ability is not as strong as that of IgM.
- (D) Bispecific antibodies made from monoclonal antibodies can be used to identify differences in cell surface molecules and carry specific toxins to kill cells.
- On cancer cells
- (E) After Fab-arm exchange, bivalent IgG4 molecules become monovalent and cannot cross-link with antigens to form [the desired structure].
- Stable immune complexes
- (F) IgG4 antibody drugs may reduce efficacy by exchanging Fab arms with existing IgG4 in the body. If the hinge region...
- Amino acid sequence modification can prevent fecal efflux (FAE) in IgG4 therapeutic antibody drugs.

Narrative (A)		(B)	(C)	(D)	(AND)	(F)
Answer						

Report 2:

Since the monkeypox outbreak in the UK last May, at least 109 countries have reported more than 86,000 confirmed cases.

Primarily distributed in the Americas and Europe, but in March of this year, the Centers for Disease Control (CDC) announced one locally acquired case of monkeypox each in Hsinchu and Kaohsiung.

These are the 6th and 7th confirmed cases in China. Monkeypox virus is mainly transmitted to humans from rodents and primates through contact with the blood of infected individuals.

Fluids, bodily fluids, respiratory secretions, damaged skin or mucous membranes, consumption of infected meat, or prolonged contact with droplets can all cause infection.

Monkeypox can be transmitted to the fetus via placental vertical transmission. The incubation period for monkeypox is 5–21 days. Symptoms after infection include fever, chills, and shortness of breath.

Symptoms include chills, sweating, headache, muscle aches, swollen lymph nodes, and extreme fatigue. Skin lesions typically appear one to three days after the fever begins, usually on their own.

It spreads from the face to the body, and is more common on the limbs than the trunk. The skin lesions progress through stages from macules, papules, vesicles, to pustules.

The rash eventually scabs over and falls off; in severe cases, the rash can number in the thousands. Symptoms last 14 to 21 days, with a mortality rate of less than 10%.

Most cases recover within a few weeks. Children and those with weakened immune systems are more prone to severe illness, with complications including secondary bacterial infections.

Pneumonia, sepsis, etc. Prevention includes avoiding contact with rodents and primates in endemic areas, not eating raw food, and avoiding contact with infected individuals.

Close contact with infected individuals, especially sexual activity. Currently, there are two vaccines available: the JYNNEOS vaccine contains a weakened form of vaccinia virus and is suitable for...

Used for high-risk groups aged 18 and older who are infected with monkeypox; the ACAM2000 vaccine is a smallpox vaccine containing live virus and is used to treat monkeypox.

Those at high risk of contracting smallpox, such as laboratory personnel who handle the smallpox virus.

2. Determine whether the following five statements (AE) are true or false, and fill in **T** (true) or **F** (false) in the corresponding column of the table below.

(Incorrect). 0 points for all wrong answers; 1, 2, 4, 7, and 10 points for correct answers to items one, two, three, four, and five respectively.

- (A) Monkeypox is a zoonotic infectious disease.
- (B) Monkeypox is the most serious poxviral disease in human history.
- (C) The emergence of two local cases in Hsinchu and Kaohsiung indicates that a monkeypox transmission chain already exists in the country.
- (D) JYNNEOS vaccine is used to prevent monkeypox and smallpox. People who have been vaccinated against smallpox do not need to be vaccinated again.
- (E) The sudden increase in monkeypox cases is due to the virus mutating rapidly, similar to coronaviruses or influenza viruses, causing monkeypox to be more virulent than other viruses.
- It was easier to transmit in the past.

Narrative	(A)	(B)	(C)	(D)	(AND)
Answer					

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Part Two

Student Code



Precautions:

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Part Two: (100 points) I. True or

False and Short Answer Questions:

1. Inflammatory responses activate various immune cells, such as macrophages and microglia.

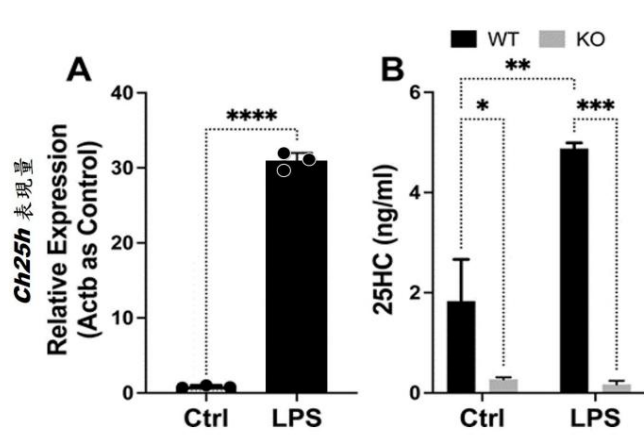
These immune cells synthesize and release 25-hydroxycholesterol, an oxosterol with antiviral and immunomodulatory properties.

(25HC). Lipopolysaccharide (LPS) is an immune activator, generally induced by TLR4.

This paper aims to investigate whether lipopolysaccharide (LPS) affects the response of immune cells.

Glial cells produce 25HC, and this study investigates the effects of LPS and 25HC on neural plasticity and learning and memory at CA1 in the hippocampus (long-term).

The function of long-term potentiation (LTP) (Izumi et al., J. Neurosci. 2021)



Ctrl: Control Group

LPS: Administered to the LPS group (100 ng/ml)

Figure A: Microglial cells (WT) measured by qPCR

Performance of Ch25h after LPS treatment

Figure B: Wild-type (WT) and KO (Ch25h gene knockout)

After adding LPS to mouse microglial cells

The expression level of 25HC in its culture medium

(1) Based on the image above, please determine whether the following options are correct or incorrect (6%).

- _____ (A) LPS administration can stimulate the expression of the Ch25h gene in mice. (1%)
- _____ (B) Wild-type mice's microglial cells themselves exhibit 25HC. (1%)
- _____ (C) LPS stimulates microglial cells in wild-type mice to express large amounts of 25HC. (1%)

(2) Please describe the relationship between Ch25h and 25HC in one precise sentence. (3%)

(Within 15 characters, English codes (e.g., LPS, Ch25h, 25HC count as one character) should be written after the answer.)

Answer:

Total of characters

2. Please explain the meaning of the diagram below.

(Within 20 characters, English codes (e.g., LPS, LTP, HFS) count as one character. Write the character count after the answer.) (3%)

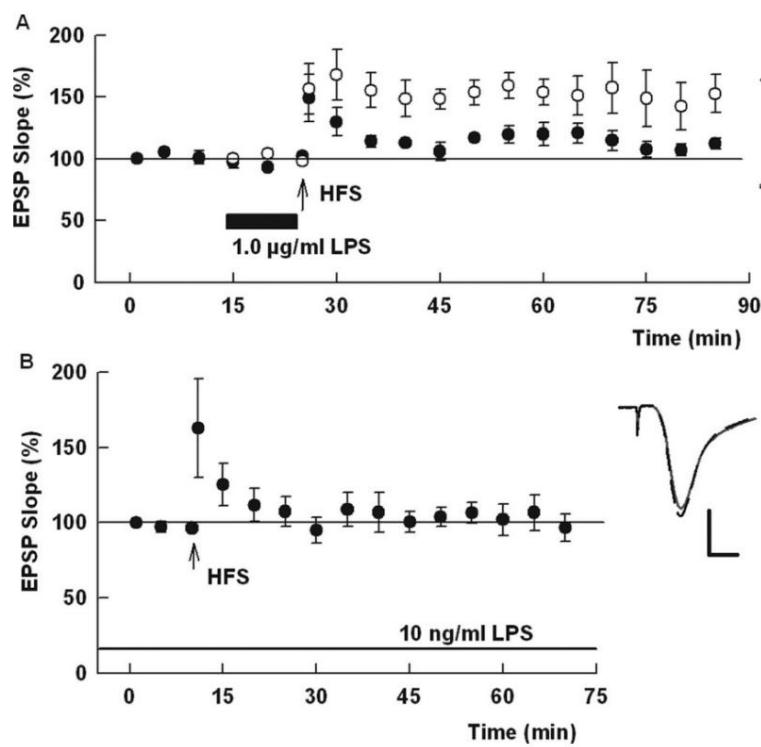


Figure A: EPSP for processing LPS

HFS: High-frequency stimulation of 100 Hz × 1 s (used to generate LTP)

EPSP: Excitatory Postsynaptic Potential

The black horizontal bar indicates the time when LPS processing was added.

Treatment site: Hippocampal gyrus CA1

• LPS Investment Group

• Control Group

Figure B: EPSP with continuous LPS processing

• LPS Investment Group

Answer:

Total of characters

3. Please explain the meaning of Figures 3A, 3B, 3C, and Figure 3 based on the following diagram.

(Within 20 characters, English codes (e.g., LPS, LTP, NMDA-EPSP, HFS) count as one character. Write the character count after the answer.) (11%)

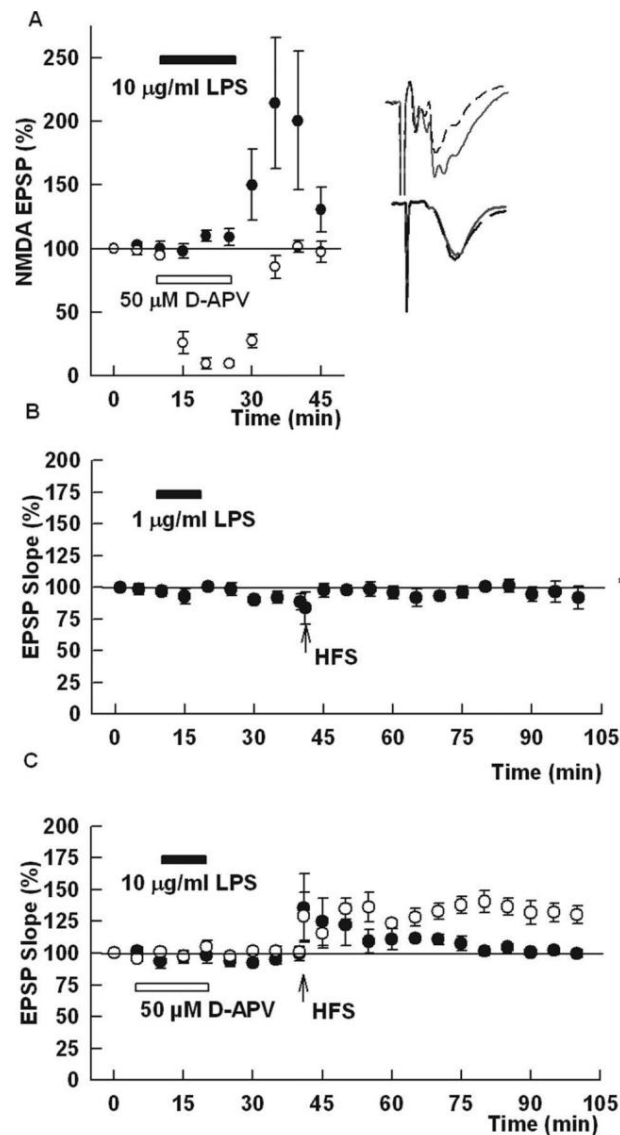


Figure A:

Black horizontal bars: NMDA EPSP pretreatment of LPS (black horizontal bars indicate the time of LPS addition treatment)

White horizontal bars: Pretreatment of LPS and D-APV reagents

NMDA EPSP (the white horizontal bar indicates the time of treatment with LPS and D-APV agents)

D-APV: NMDA receptor antagonist

EPSP: Excitatory Postsynaptic Potential

NMDA EPSP: EPSP mediated by NMDA receptors

HFS: High-frequency stimulation used to generate

LTP. Black and white bars indicate the time of drug treatment.

• LPS administration group (10 µg/ml)

• LPS (10 µg/ml) + D-APV (50 µM) administration group

Figure B: LPS investment group provides EPSP for short-term HFS

• LPS administration group (1 µg/ml)

Figure C: Pretreated LPS group vs. merged LPS and D-APV group

EPSP for short-term HFS

• LPS administration group (10 µg/ml)

• LPS (10 µg/ml) + D-APV (50 µM) administration group

(1) 3A: (2%)

Answer:

Total of characters

(2) 3B: (2%)

Answer:

Total of characters

(3) 3C (2%)

Answer:

Total of characters

(4) Please explain the meaning of Figure 3 precisely. (5%)

Answer:

Total of characters

4. Please explain the meaning of Figures 4A, 4B, 4C, and Figure 4 based on the following diagram.

(Within 25 characters, English codes or nouns (e.g., minocycline, LPS, LTP, HFS) count as one character. Write the number of characters after the answer.)

number)(10%)

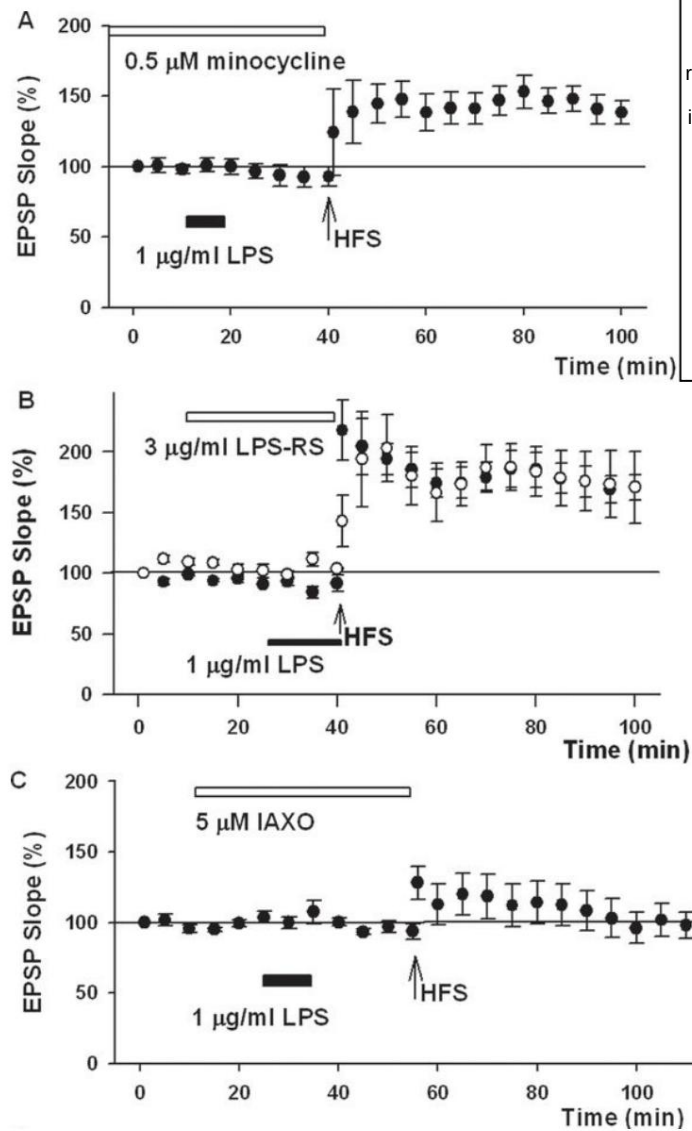


Figure A: EPSP with pretreatment of LPS and minocycline to induce short-term HFS (Black bars represent the time of LPS addition, white bars represent the time of minocycline addition.) The black and white bars indicate the time of reagent addition.

minocycline: a microglial cell inhibitor

HFS: High-frequency stimulation used to generate LTP

EPSP: Excitatory Postsynaptic Potential

γ LPS (1 μg/ml)+ minocycline(0.5 μM)γ

Figure B: EPSP with pretreated LPS and pretreated LPS-RS reagent followed by LPS and then a short HFS (black bars indicate the time of LPS addition, white bars indicate the time of LPS-RS addition). The black and white bars represent the time of reagent addition.

LPS-RS: LPS inhibitors

γ LPS administration group (1 μg/ml)

LPS (1 μg/ml) + LPS-RS (3 μg/ml) administration group

Figure C: EPSP with brief HFS after pretreatment with LPS and IAXO (black bars represent the time of LPS addition, white bars represent the time of IAXO addition.) The black and white bars indicate the time of reagent addition.

IAXO: Selective TLR4 Inhibitor

γ LPS (1 μg/ml)+IAXOγ

Part Two

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(1) 4A: (2%)

Answer:

Total of characters

(2) 4B: (2%)

Answer:

Total of characters

(3) 4C (2%)

Answer:

Total of characters

(4) Please explain the meaning of Figure 4 precisely. (4%)

Answer:

Total of characters

II. Multiple Choice and Short Answer Questions:

1. Tail autotomy is an escape method used by many lizard species when facing predators. The following are well-known native or special species of the Formosan lizard.

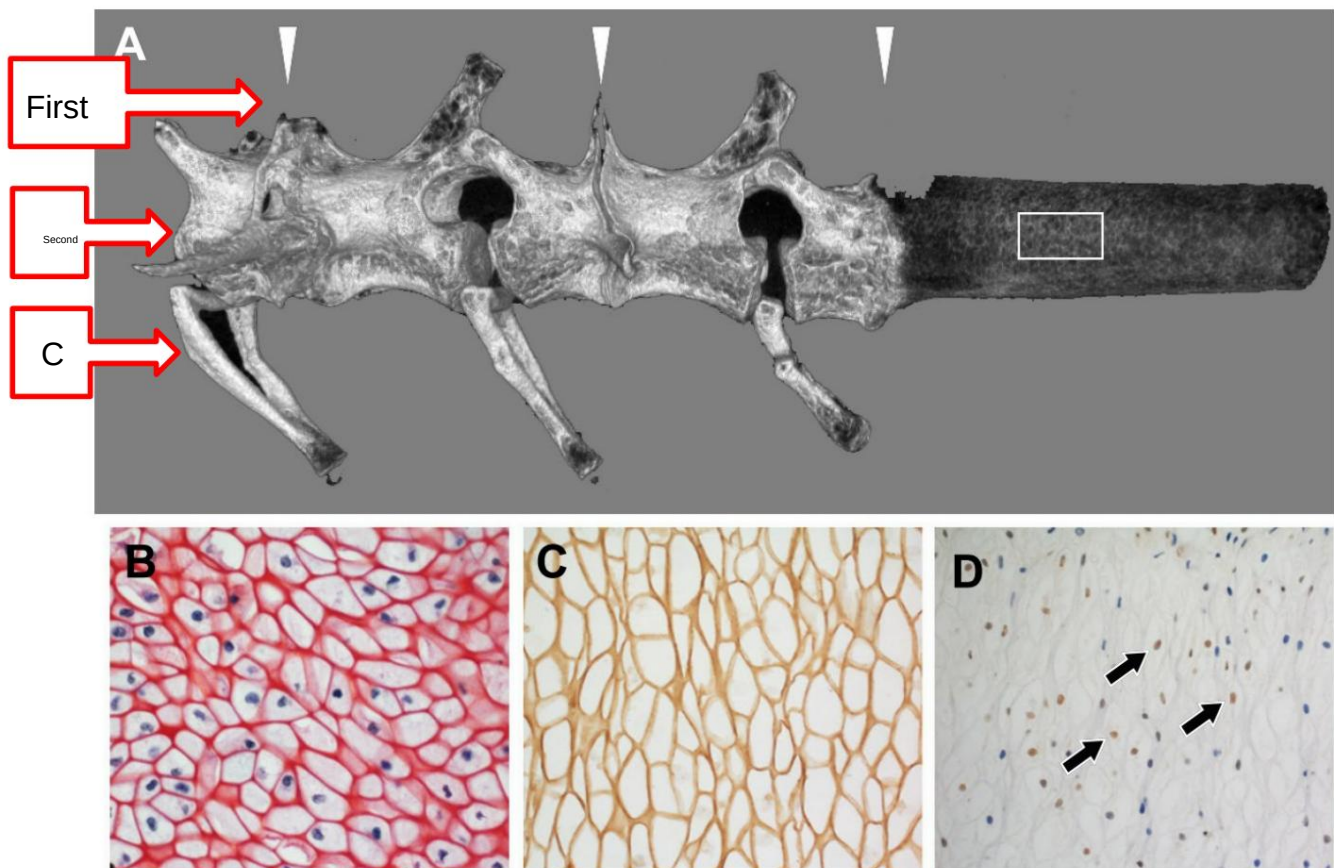
Which pets have the ability to self-cut their tails? (1 point for each option) (Multiple choice question)

- | | |
|-------------------------|--------------------------|
| (A) Qianshan gecko | (F) Bearded Dragon |
| (B) Liwen skink | (G) Leopard Gecko |
| (C) Scylla styrax | (H) Swamp Monitor Lizard |
| (D) Green iguana | (I) Green Water Dragon |
| (E) Taiwan Grass Lizard | (J) Taiwan snake lizard |

2. Figure A below shows a computed tomography (CT) reconstruction of the skeletal system of a lizard's tail after regeneration. The left side shows the original tail bones.

The skeleton, the darker area on the right is the regenerated part, and the inverted triangle arrow points to the location where autotomy can occur. BD

The tissue sections enclosed in Figure A are treated with different staining agents.



(1) According to the above figure, the location of the lizard's tail self-cutting is located between/within the segment of the tail vertebrae (circle the correct option, 2 points)

(2) What type of tissue should the skeleton of the regenerated tail be made of? (4 points)

(3) The spinal cord in the tail passes through A/B/C, while the major blood vessels pass through A/B/C. (Circle the correct option, 3 points each)

(4) After a lizard has cut off its own tail, will it cut off its tail again closer to or further away from its torso? Why? (8 points)

Answer:

III. Fill in the blanks and answer questions:

1. The image below is a hand-drawn evolutionary tree of various organisms by naturalist Ernst Haeckel in 1866. Please refer to this image and modern scientists' understanding of...

Based on your knowledge of the relationships between organisms on Earth, answer the following questions:

(1) Fill in the blanks: Please find the names of the following taxa in the diagram and fill them in the blanks. Please be sure to use the spelling shown in the diagram (2 points per blank).

(Total 20 points)

Amniotic membranes: _____

Flagellates: _____

Siliceous algae: _____

Ulva: _____

Gymnosperms: _____

Echinoderms: _____

Arthropods: _____

Sponges: _____

Mollusks: _____

Annelids: _____

Part Two

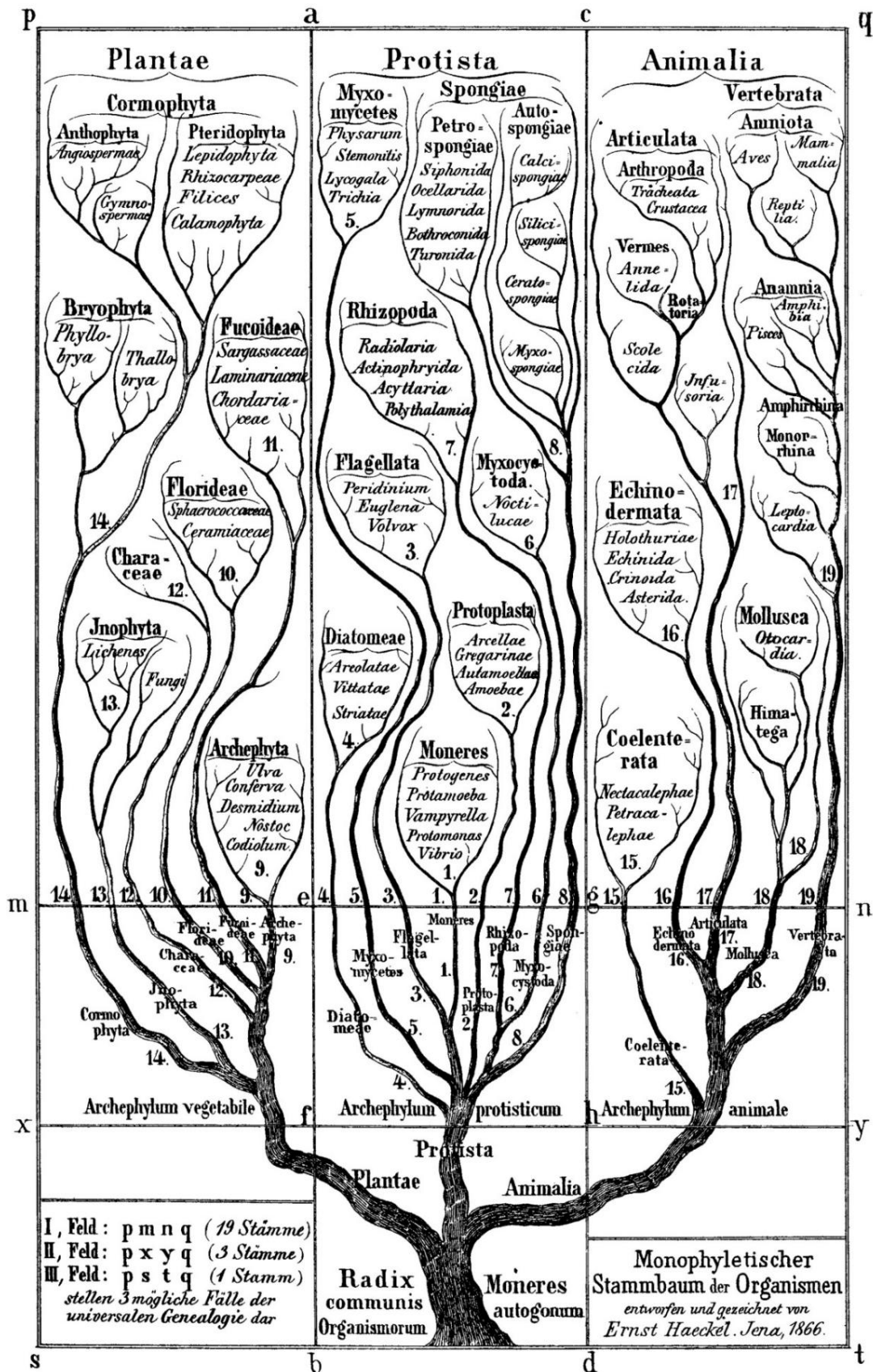
2023 Selection Camp Theory Student Code:

(2) Based on modern hypotheses, please comment on the differences between the evolutionary relationships shown in this diagram and modern scientific knowledge. Comment format:

Please first draw the currently known hypotheses (based on the Campbell Biology version), and then explain where they differ from this diagram.

Similarly, please identify four points in this diagram that contradict modern knowledge, and explain how these differences in evolutionary hypotheses affect our understanding of those organisms.

Knowledge of physics? (5 points each, 20 points total)



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Part Three

Student Code



Precautions:

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Part Three: (100 points)

I. An Investigation into the Photoreversibility of Phytochrome: Phytochrome is a pigment found in plants.

Phytochrome proteins exist in two forms: Pr and Pfr. Phytochrome proteins are composed of proteins and chromophores, with the chromophores possessing...

It consists of a structure with four rings: ABCD. The two forms, Pr and Pfr, are formed by the cis and trans configurations of the CD rings of the chromophore.

The difference lies in their structure: Pr has a cis structure, while Pfr has a trans structure. Changes in the cis-trans structure can trigger phosphorylation of phytochrome.

Acidification leads to differences in physiological activity. In addition, plant physiologists often use the individual contents of Pr and Pfr and their...

The changes in the total amount of both (P_{tot}) are used to study the photoequilibrium ($\bar{y}$) state of plants and its corresponding physiological state.

The reaction, where $\bar{y} = P_{fr}/P_{tot}$. The following are questions related to the photomorphogenesis of phenanthrene; please answer them based on your knowledge/experience.

Answer the following questions based on scientific knowledge related to plant physiology and the information in the diagram below (40 points).

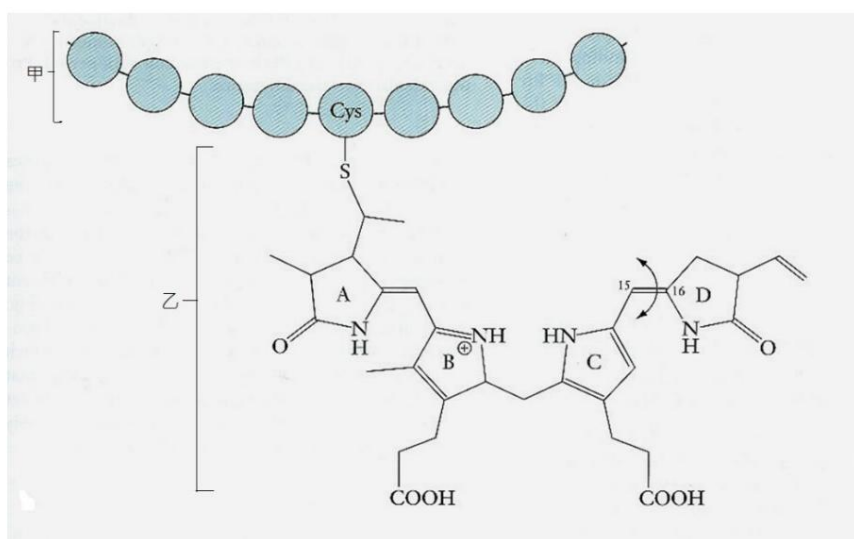


Figure 1: Chemical structural formula of plant phytochrome Pr

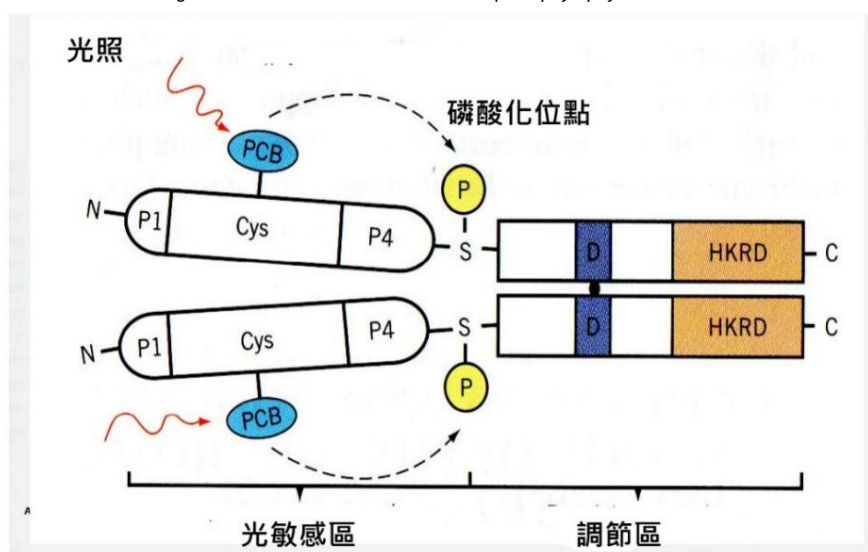


Figure 2: Schematic diagram of phosphorylation of phytochrome (PCB: phytyl chain, a type of plant phytochemical).

Phytochromophore

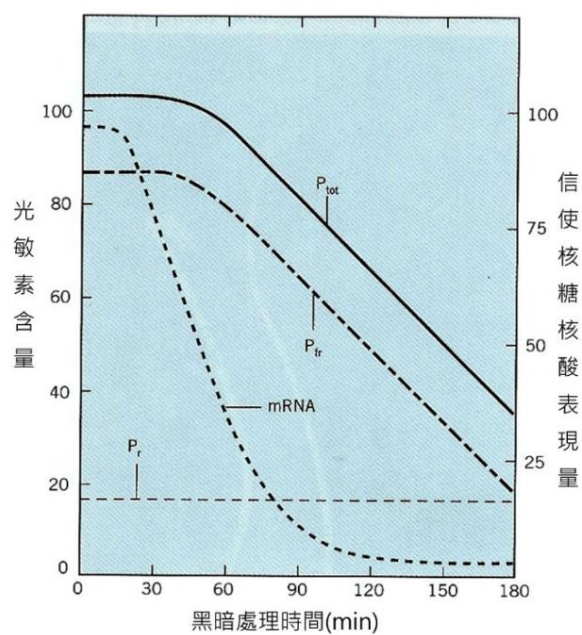


Figure 3: Relationship between total phytochrome (Ptot), messenger RNA (mRNA) expression levels, and darkness treatment time in plants.

Table 1: Relationship between light wavelength (λ) and the light balance (Φ) of plant phytophytes

λ (nm)	Φ
450	0.4
660	0.8
720	0.03
756	0.01

Question 1. Corresponding to the chemical structure of the plant phytophyte molecule in Figure 1, this structure is divided into two parts, A and B, located at the top of the figure.

The A part is _____ The part corresponding to section B in the lower part of the diagram is then... _____ (5 points)

Question 2. Draw the configuration of Pfr corresponding to the chemical structure of the phytophyte molecule in Figure 1 (Note: Draw part of the CD ring).

(5 points)

Configuration diagram of Pfr (CD ring portion)

Question 3. Figure 2 shows another manifestation of phytochrome, which can be compared with the structural formula in Figure 1. This is due to the phosphorylation of phytochrome.

In the schematic diagram, the PCB corresponds to parts A and B in Figure 1.

The PCB receives the following light at certain locations.

Among the wavelengths (590, 660, 730 nm)

A wavelength of nm light can induce a configurational change in Pfr. (6 points)

Question 4. Based on the phosphorylation diagram of phytochrome, deduce at what wavelengths the N-terminus and C-terminus will produce phosphorylation during light exposure.

Physical activity: N-terminus _____ nm light wavelength, C-terminal _____ nm light wavelength. (4 points)

Question 5. Relationship between total phytochrome (Ptot), phytochrome messenger RNA (mRNA) expression levels, and dark treatment time in plants.

The figure suggests possible reasons for the decrease in total phytochrome (Ptot).

yes _____ The physiological significance of this change is _____

(10 points)

Question 6. Based on the relationship between light wavelength (λ) and the light balance ($\bar{y}$) of plant phytochromes, what is its physiological significance? (5 points)

Answer:

Question 7. Plant physiologists have identified that the overall conformation of phototropin is similar to that of phytochrome, both being composed of proteins and chromosomes.

Okay, do you think that phototropin and phytochrome are (same protein, different chromosome; different protein, same chromosome)?

Which is correct: protein or chromosome?

The reason is:

(5 points)

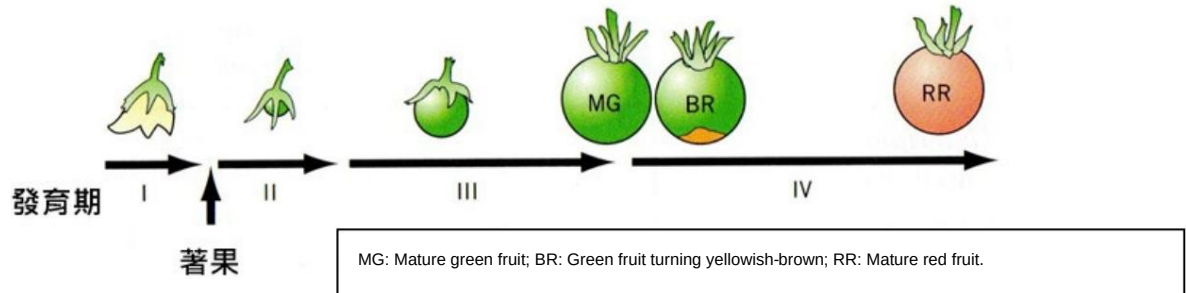
II. Investigation of Physiological Activities in Fruit Development: Crop scientists classify the fruit development process of tomato plants into five stages, including IV.

The developmental stage, in which the flowering and fruit setting period occurs after the end of developmental stage I, is shown in the diagram below. The developmental stage is...

Stage V represents the fruit drop period (stage V of the developmental stage is not shown in the diagram). This relates to the effects of hormones on plant fruit development and growth.

For questions regarding the role of plant bioactivity, please answer based on your/your knowledge of plant physiology and the information in the image below.

Answer (10 points)



Question 1. What are the two periods when plant auxin content increases? Please select from the four periods: I, II, III, and IV.

Please answer in two different time periods, and explain your reasoning. (5 points)

Answer:

Question 2. Fruits are distinguished as climacteric fruits based on whether there are significant changes in physiological activity during late development.

In the two main categories of fruits (both male and female) and non-climacteric fruits, which type of significant physiological change is the most easily detected? (Tomato genus)

Which type of fruit is it? Which plant hormone primarily regulates its growth? (5 points)

Answer:

III. Multiple Choice Questions:

Plant adaptations and reproductive isolation are almost always caused by single, small-scale mutations. In 1999, Schemske and...

Bradshaw's team conducted genetic studies on the divergence in the relationships between *Mimulus* species and their pollinators across species.

The study investigated the relationships between species of the genus **Mimulus** and their pollinators in the field, as shown in Figure 1. A total of eight species in this genus were investigated.

After constructing the phylogenetic relationships of the species using molecular sequences, five of these eight species were pollinated by hummingbirds, and three were pollinated by hummingbirds.

The species is pollinated by bumblebees.

Afterwards, Schemske and Bradshaw's team selected two *Mimulus* species for research, one of which was pollinated by hummingbirds.

Mimulus cardinalis and *Mimulus lewisii*, pollinated by bumblebees, were studied using quantitative trait loci (QTL) methods to investigate the flowers.

The study investigated genetic traits, using molecular marker loci methods to study quantitative trait loci; the results are shown in Figure 2.

The quantitative trait loci associated with flower traits were classified into three groups: those that are attractive to pollinators, and those that are not.

A total of 31 traits were found in **Mimulus lewisii**, including traits that reward pollinators and traits that increase pollination efficiency.

Quantitative trait loci (attractiveness: 19, reward: 2, efficiency: 10) were found in *Mimulus cardinalis*, totaling 34.

Trait locus (attractiveness: 17, reward: 1, efficiency: 16).

Schemske and Bradshaw's team then used artificial pollination to pollinate *Mimulus cardinalis* and bumblebees pollinated by hummingbirds.

Two species of *Mimulus lewisii*, both pollinated, were artificially hybridized to produce F1 hybrid offspring. These F1 offspring were then self-pollinated to produce offspring.

The F2 hybrid offspring were produced, and the results are shown in Figure 3.

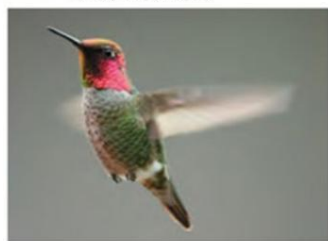
Based on data from hybridization experiments, the contribution of F2 flower traits to pollinator visits was statistically analyzed, and multiple regression analysis was used to determine the contribution of four different types of pollinators.

Flower characteristics: anthocyanin concentration in petals (antho.), carotenoid concentration in petals (carot.), nectar content per flower, and

The projected area of the petals (proj. area) is presented in a bar chart, as shown in Figure 4. A total of 228 F2 plants were used.

The substance is used in this analysis.

蜂鳥授粉(H)



熊蜂授粉(B)

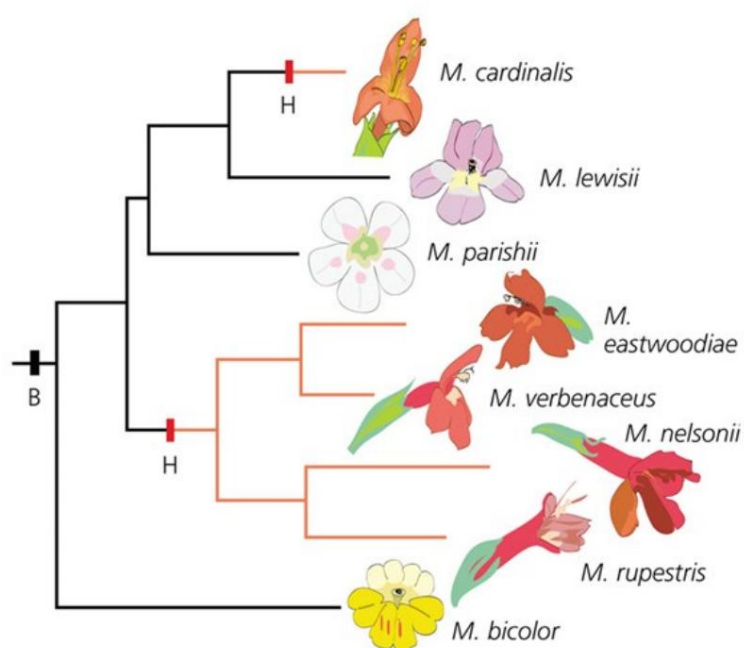
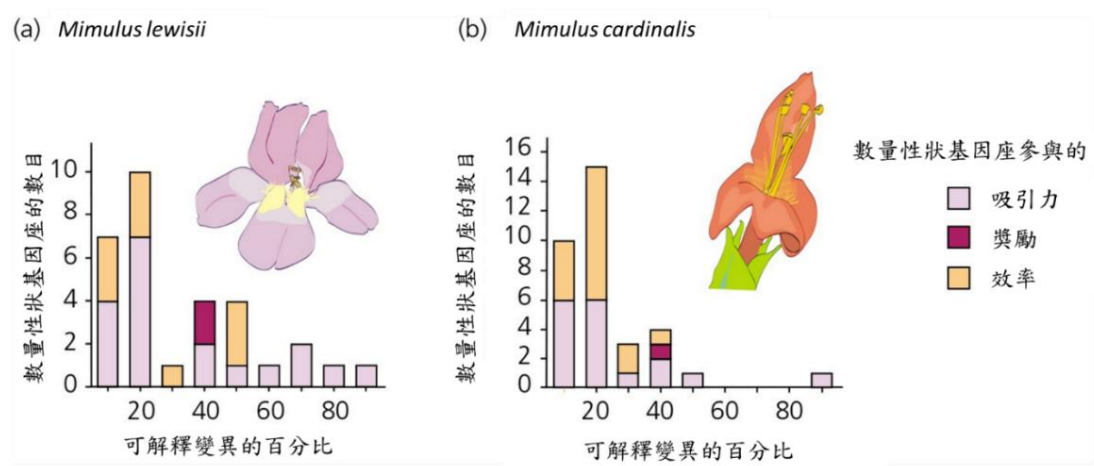


Figure 1. Relationships between *Mimulus* species and their pollinators during field investigations.



(rate), and its distribution.

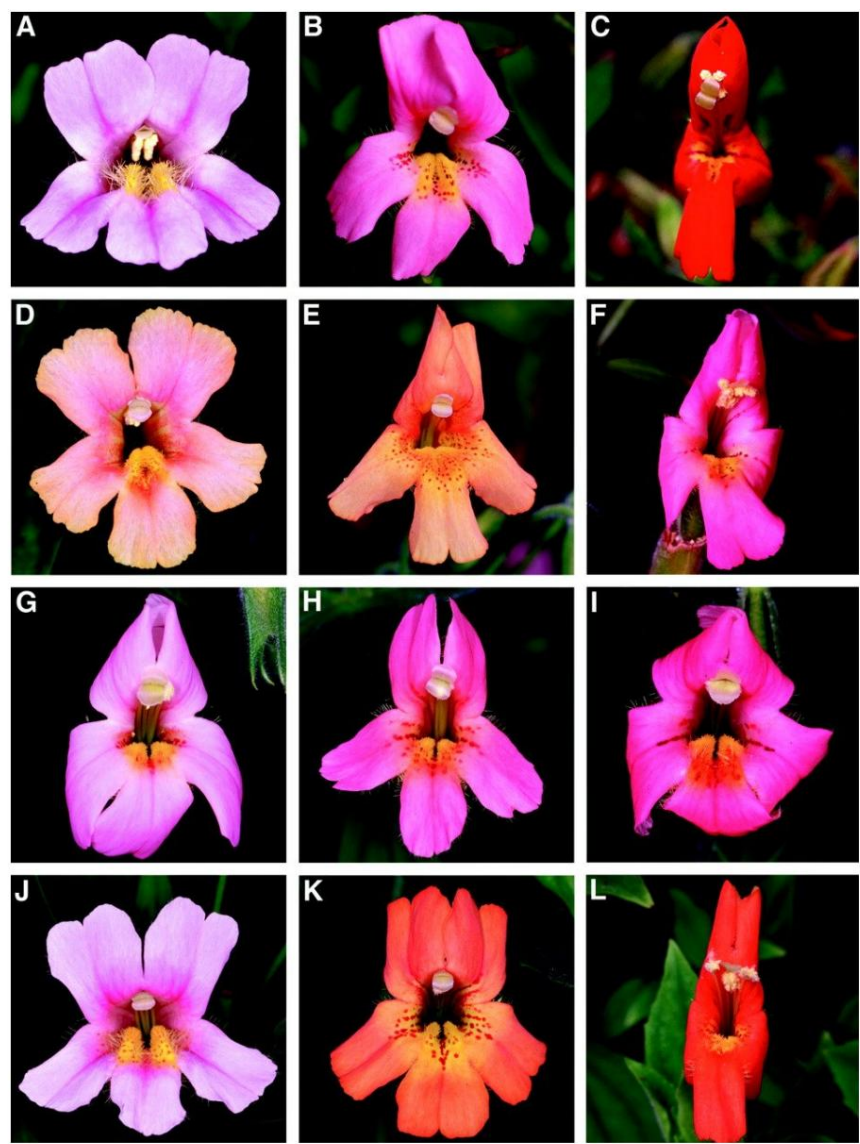


Figure 3. Results of artificial hybridization experiments: A: *Mimulus lewisii*; C: *Mimulus cardinalis*; B: *Mimulus lewisii* x

DL is the F1 offspring of the *Mimulus cardinalis* hybrid, and is the flower morphology of the F2 offspring of the F1 hybrid that is self-pollinated.

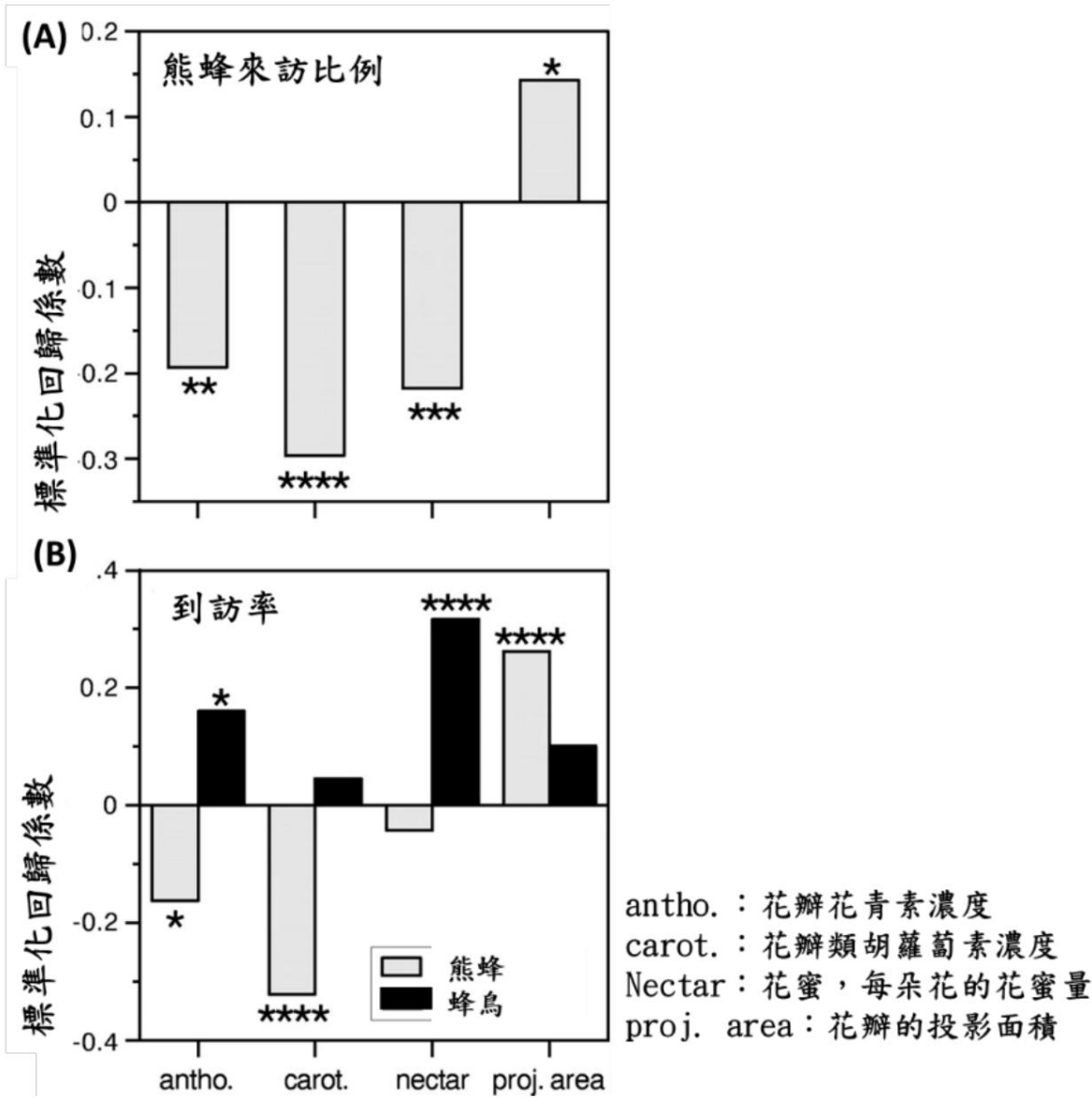


Figure 4. Statistical analysis of the contribution of flower traits in F2 pollinator visits. (A) Results of flower traits on the proportion of bumblebee visits. (B) Flower...

Results of the flower feature on the average daily visitation rate of bumblebees and hummingbirds.

Based on the above research, answer the following questions and fill in the appropriate options in the answer table following this section. (Answers may be optional.)

(1-5 options)

1. Based on the phylogenetic information of species in the genus *Mimulus* in Figure 1, which of the following statements is correct?

- (A) The common ancestor of this group of plants was pollinated by bumblebees.
- (B) This taxa evolved three times due to pollination by hummingbirds.
- (C) Species of the genus *Mimulus* attract hummingbirds with their red tubular corollas.
- (D) The common ancestor of species pollinated by hummingbirds was pollinated by bumblebees.
- (E) Species pollinated by bumblebees exhibit convergent evolution.

Part Three

2023 Selection Camp Theory Student Code:

2. Based on the results of the quantitative trait loci in Figure 2, which of the following statements is correct?

- (A) Most quantitative trait loci can only explain a small amount of variation in the floral morphology of these two species.
- (B) A small number of quantitative trait loci have a significant impact on the phenotypic variation of flowers.
- (C) At least one quantitative trait locus in two species can explain 90% of phenotypic variation.
- (D) Bumblebees are more susceptible to the attraction of flowers.
- (E) Hummingbirds are more susceptible to flowers, which increases the pollination efficiency of pollinators.

3. Based on the information in Figures 3 and 4, which of the following statements is correct?

- (A) Bumblebees prefer flowers with high anthocyanin content.
- (B) Hummingbirds prefer flowers rich in nectar and high in anthocyanins.
- (C) The trait of increasing nectar production will increase the number of hummingbird visits.
- (D) Both bumblebees and hummingbirds are affected by flower size.
- (E) The main factor influencing bumblebee visits is most related to flower size.

4. Based on the information in this study, which of the following statements is correct?

- (A) The pollination of bumblebees and hummingbirds is primarily affected by the availability of nectar.
- (B) Bumblebee visits are influenced by flower size and flower color.
- (C) Hummingbirds of the genus **Mimulus** are mostly pollinated by brightly colored flowers and high-nectar content.
- (D) The change in flower traits is presumed to be gradual rather than discontinuous.
- (E) Species that are changed to be pollinated by hummingbirds first exhibit altered corolla color and shape characteristics.

Multiple choice answer table (5 points each, 20 points in total)

Question Number	1	2	3	4
Answer				

IV. Matching Questions:

Xiao Ming discovered that the bamboo plants in the bamboo forest had thorns that intertwined to form a thorny net. He learned that this type of bamboo is called a thorny bamboo.

The shape of bamboo thorns is shown in the picture below.



The image shows the shape of the spiny bamboo and the form of its spines.

So Xiaoming collected information about the morphology and structure of bamboo and compiled it into the table below.

1. Please complete the morphological construction matching from the provided options, and fill in the option numbers in the blanks to the right of the description. (Total)

20 points. 3 points for each correct answer, maximum 20 points; 3 points are deducted for each incorrect answer, up to a maximum of 0 points.

Option list (options can be matched repeatedly; not all options can be matched).

A. Annual to biennial E. Can flower multiple times in its lifetime I. Monocotyledonous	M. Hard tissue originates from secondary growth (wood).
B. Perennial F. Flowering only once in its lifetime. J. Dicotyledonous. N. Hard tissue derived from primary growth (fibers).	
C. Modified stem G. Rhizome K. stalk O. creeping stem	
D. Modified Leaf H. adventitious roots L. bamboo shoots P. Bamboo pole	

Characteristics of thorny bamboo	Describe the form and fill in the corresponding option number (1 to multiple options).
Belongs to <u>annual cotyledonous plants</u>	
The texture of the stem	
The origin of "thorn"	
asexual reproduction	
Sexual reproduction	
flowering	

2. Short Answer Questions: (10 points)

Xiaoming discovered that almost all the scattered bamboo groves in a mountainous area had died. What are the possible causes? Please explain your reasoning.

The basis for the test or how to prove your inference.

Answer:

Possible reasons	Based on speculation / How to verify the inference

Theoretical Assessment Test Questions for the **2023** Republic of

China Biology Olympiad

National Team Selection Camp

Part Four

Student Code



Precautions:

1. This section of the test consists of 6 pages (including the cover) and is worth 100 points.
2. Please check for missing pages. If any pages are missing, please inform the test administrator immediately.
3. When answering the questions, please make sure the number on the cover of the test paper matches your test number.
4. Please answer the questions on the test paper using a blue (black) pen, and please keep the test paper clean.
5. You may write your answers on the back of the questions, but please indicate the question number.

Part Four

2023 Selection Camp Theory Student Code:

Part Four: **(100 points)** • Short

Answer Questions

1. Two rice varieties: one resistant to rice blast disease but intolerant of herbicides; the other intolerant of rice blast disease but tolerant of herbicides. [The text abruptly ends here.]

When two rice varieties are crossed, all F1 plants are not resistant to rice blast, but are tolerant to herbicides. The 328 F2 plants resulting from self-pollination of the F1 plants...

Of the offspring, 178 plants were not resistant to rice blast but were tolerant to herbicides; 63 plants were neither resistant to rice blast nor tolerant to herbicides; and 62 plants were resistant to rice blast.

It is resistant to disease and herbicides; 25 plants are resistant to rice blast disease, but not resistant to herbicides.

- 1A. Based on the above experimental data, a hypothesis is proposed regarding the genetic relationship between the two traits of rice resistance to rice blast disease and herbicide tolerance.

(10%)

1B. The chi-square value (χ^2) of hypothesis 1A was calculated using the chi-square test . **(10%)**

Note: Chi-square analysis is often used to test the suitability of genetic hypotheses. Based on the hypothesis, there will be expected values for the number of individuals exhibiting various characteristics.

The difference between the expected value (E) and the actual observed value (O) is calculated as $(O-E)^2/E$, where various representations of the expected value and the actual observed value (O) are expressed as $(O-E)^2/E$.

The sum of the differences between the actual observations is the chi-square value:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

The larger the chi-square value, the greater the difference between the expected value and the actual observed value. In this case, the statistical distribution of the chi-square value will be used.

As a basis for determining whether a hypothesis is appropriate, the statistical distribution of chi-square values is often presented in a chi-square table.

1C. Referring to the following chi-square table, explain the significance of the chi-square value of 1B for hypothesis 1A. (10%)

Note: When using a chi-square table, you must first determine the applicable degrees of freedom (DF). Degrees of freedom represent a set of real...

The number of independently variable categories in experimental data. For example, an experiment may have only two categories because individuals in two categories have a total number of categories.

With a fixed number of individuals, when the number of individuals in one category changes, the number of individuals in the other category must change accordingly.

The DF for this experiment is $2 - 1 = 1$.

Chi-Square Right-Tail Probability ($\geq \chi^2$)										
DF	0.995	0.99	0.975	0.95	0.9	0.1	0.05	0.025	0.01	0.005
1	---	---	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188

Part Four

2023 Selection Camp Theory Student Code:

2. Genes A, B, and C are located on the same chromosome, and their relative positions are ACB. In a question concerning genes A, B, and C...

In a hybridization experiment involving two genes, one parent has the genotype ABC/abc, and the other parent has the genotype abc/abc. The resulting offspring...

The genotypes and number of individuals in each generation are shown in the table below:

Genotypes ABC/abc abc/abc Abc/abc aBC/abc AbC/abc aBc/abc abC/abc ABc/abc								
Number of individuals: 1680	1650	220	230	100	110	6	4	

2A. Among these genotype categories, those originating from the simultaneous development of the same chromatid in the AC and CB regions during gamete production by the parents...

Which offspring undergo a single chromosome exchange? **(5%)** What percentage of all offspring are offspring that have undergone this process? Round to four decimal places.

Rounded down to the nearest whole number: **(5%)**

Part Four

2023 Selection Camp Theory Student Code:

2B. If chromosome exchanges occurring in the AC and CB regions are independent of each other, then in this experimental genotype category, the one originating from...

The expected ratio of chromosome crossing over to simultaneous occurrences in the AC and CB regions on the same chromatid during gamete production by the parents is [missing information].

For example, round to four decimal places. (10%)

Part Four

2023 Selection Camp Theory Student Code:

2C. In the two questions above (2A, 2B), the ratio of the same chromatid undergoing one chromosome exchange simultaneously in regions AC and CB is...

Are the examples the same? (5%) Please explain their meaning? **(10%)**

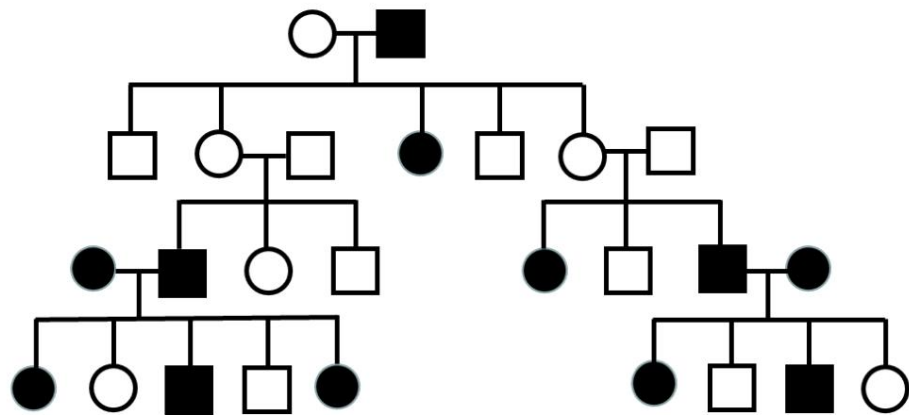
3. The following pedigree chart illustrates the occurrence of panda eyes in a family, where solid circles and squares represent individuals with panda eyes.

Based on this pedigree chart, discuss whether this panda eye conforms to the following various inheritance patterns:

- A. Autosomal dominant inheritance;
- B. Somatic recessive inheritance;
- C. Y-chromosome inheritance;
- D. X-chromosome dominant inheritance;
- E. X-chromosome recessive inheritance.

In the discussion, please use I-1 and I-2 to represent the first and second individuals from the left in generation I, respectively, and the individuals in the remaining generations.

All forms are referred to in this format. (25%)



4. A beetle has two alleles for the gene A: A and a, where allele A is dominant over allele a. Analyze this...

The following table shows the genotypic changes of gene A in populations in closed regions A and B. Based on the data in the table, infer the influence of gene A on populations in closed regions B and B.

What are the main factors contributing to the genotypic changes in the beetle population in area B? **(10%)**

	Genotype	1st generation	2nd generation	3rd generation	4th generation	5th generation	6th generation	
A local ethnic group	AA		308	334	327	350	390	425
	Aa		593	576	596	586	587	570
	aa		299	290	277	264	223	205
Ethnic Group in Area B	AA		296	269	299	319	330	298
	Aa		597	615	600	605	584	606
	aa		307	316	301	276	286	296

Theoretical Assessment Test Questions for the **2023** Republic of

China Biology Olympiad

National Team Selection Camp

Part Five

Student Code



Precautions:

1. This section of the test consists of 10 pages (including the cover) and is worth 100 points.
2. Please check for missing pages. If any pages are missing, please inform the test administrator immediately.
3. When answering the questions, please make sure that the cover of the exam paper matches your exam number.
4. Please answer the questions on the test paper using a blue (black) pen, and please keep the test paper clean.
5. You may write your answers on the back of the questions, but please indicate the question number.

Part Five: (100 points)

I. Selection and Fill

- _____ 1. Eusocial insects refer to insects that possess the following three characteristics: (1) Reproductive specialization: the group can be divided into different groups. (1) Classes that exclusively reproduce, and classes that reproduce less or not at all; (2) Generational overlap: the adult population in the group Mature individuals can be divided into two or more generations; (3) They cooperate in caring for immature individuals. Which of the following insect species...?
- Is it a eusocial insect? (Multiple choice) (5 points)
- (A) *Destruction of Monomorium ants*
- (B) *Formosan subterranean termite (Odontotermes formosanus)*
- (C) *Apis florea (a small honeybee)*
- (D) *Australian house cockroach (Periplaneta australasiae)*
- (E) Yellow-rumped hornet (*Vespa affinis*)
2. Following on from the previous question, the most commonly kept bee species is the Italian bee (*Apis mellifera ligustica*), whose colonies can be divided into queen bees, etc., according to their functions. Worker bees and drones. Which of these three types of bees, with their distinct roles, are haploid (containing only one set of chromosomes from the mother)? body)? (2 points)
- Answer:
3. Following on from the previous question, among the three types of bees—queen bees, worker bees, and drones—which two have the same sex? (2 points)
- Answer:
4. Following on from the previous question, what percentage of the chromosomes possessed by the queen bee, worker bees, and drones—the three types of bees with different roles—are similar to those of the mother bee? Are they related? (6 points)
- Answer: Queen bee _____%, worker bee _____%, drone _____%

5. The colonies of eusocial insects are often considered superorganisms, which consist of many...

A group of individuals who move freely but have different roles and responsibilities. In cold regions, bees stop being when the temperature drops below 10°C.

They fly and crowd into the center of the hive, forming a "wintering colony." The queen bee is located at the center of the colony, with worker bees clustered around her.

Around the queen bee, the body constantly trembles to maintain the core temperature at 27-34°C, while worker bees take turns...

The bees moved from the periphery to the interior of the colony to prevent each bee from getting too cold. During this time, they will not go out to forage.

Bees obtain energy from the honey stored in their hives. Which of the following statements are true? (Multiple choice) (5 points)

- (A) The winter colony still has three types of bees with different roles: queen bee, worker bee, and drone.
- (B) The more worker bees a colony has, the less likely it is to perish during a long winter.
- (C) The more queen bees a colony has, the less likely the colony is to perish during the long winter.
- (D) If a region experiences a long-term and significant winter warming trend, the average size of bee colonies in that region can be expected to increase.
- (E) The more worker bees there are in the cluster, the lower the average total time each worker bee has to take turns going to the periphery of the cluster.

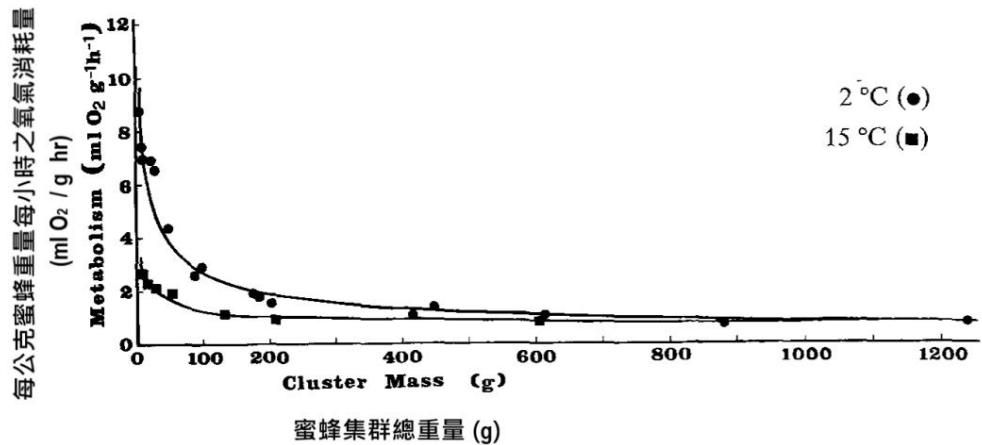
6. Following on from the previous question, scientists (Southwick 1985) conducted experiments on bees, continuously...

18-48 hours, exploring different overwintering bee colony sizes (total weight of all individual bees in the colony, weight of each worker bee).

The relationship between approximately 0.1 grams and the energy expenditure of bees is shown in the following graph. The energy expenditure of bees is calculated based on the specific energy expenditure of each bee.

The average oxygen consumption per gram of a swarm per hour represents [the value of oxygen]. Which of the following statements are true? (Multiple choice)

(8 points)



- (A) If the bee colony is less than 5,000, each worker bee expends more energy in an environment with a temperature of 2°C than in an environment with a temperature of 15°C.
- (B) At the same low temperature, the fewer individuals in the colony, the more energy each bee will consume.
- (C) At the same low temperature, the fewer individuals in the bee colony, the more total energy the colony consumes.
- (D) From the perspective of winter energy consumption, the larger the bee colony, the more nectar needs to be stored.

7. Following on from the previous question, the following are four different combinations of bee colony size and winter temperature. Please determine the combination of this bee colony and its environment.

List the average amount of nectar each worker bee must store before winter, in order of size, and briefly explain your reasoning.

By. (5 points)

A: Temperature 2°C, 500 birds;

B: Temperature 2°C, 5000 birds;

C: Temperature 15°C, 500 birds;

Ding: Temperature 15°C, 5000 birds.

Answer:

two,

Many organisms spread beyond their native habitats due to human activities, becoming alien or invasive species in other regions.

Some of the exotic horticultural plants cultivated by humans will escape from the artificially cultivated environment and regenerate and reproduce on their own in the wild.

They have become naturalized alien plants. In recent years, with the progress of globalization, naturalized alien plants have become a common feature of the flora in many regions.

As an important component, the number of naturalized plant species has also increased rapidly in many regions. Although some alien plants were introduced with the help of humans...

While some exotic plants are introduced unintentionally through human activity, most invasive plants enter their native habitats only through deliberate cultivation by humans.

To understand which characteristics among these plants used and cultivated by humans are more likely to become naturalized plants,

Researchers integrated two major databases for analysis: the global economic plants database and the database of introduced naturalized plants databases.

The collection includes a total of 11,685 plant species, categorized into 12 economic uses (Figure 1), with each plant species having at least one species.

Economic uses. The Global Database of Naturalized Alien Plants contains the geographical origins and regional distributions of 12,013 plant species.

The naturalization status (excerpted from van Kleunen et al. 2020 Nature Communications). Please refer to Figures 1–3 for the information and answer the question.

The following questions:

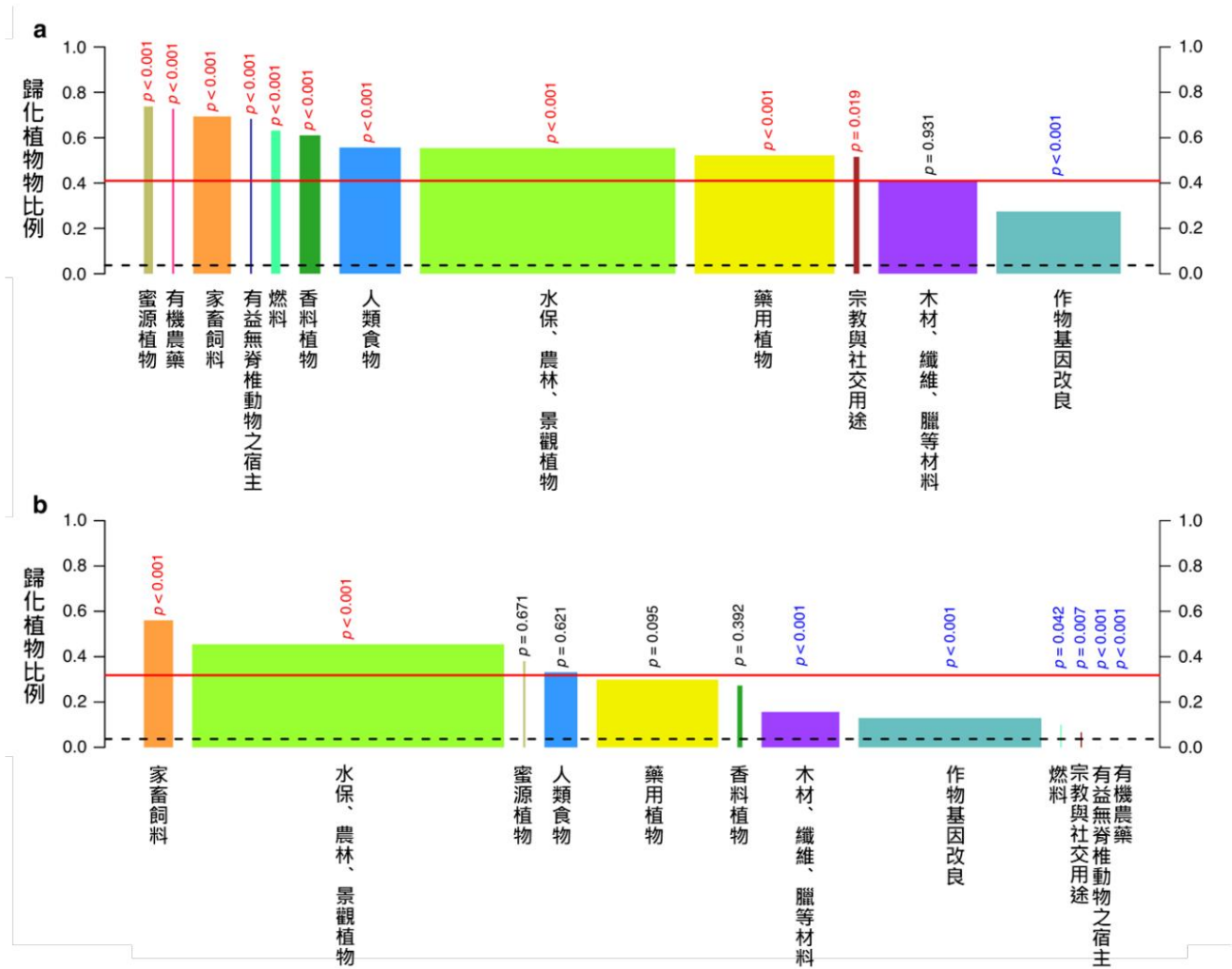


Figure 1. Proportion of 12 economically valuable plant species that have become naturalized. (a) All plants with economic uses (n = 11,685) (b) Plants with a single economic use (n = 8,246).

The width of each square in the figure is proportional to the number of plant species.

Plants by use are sorted according to the proportion of their naturalized species to the total number of species. The red solid lines represent (a) all plants with economic uses.

(a) Among plants with only a single economic use, regardless of their use, the proportion of naturalized plants. (Black dashed line)

This represents the proportion of naturalized plants among all extant global seed plant species (economic and non-economic plants combined). (Figure)

The p -value indicates whether the proportion of naturalized plant species in each economically used plant species is significantly higher (red) or lower (blue) than the expected value.

Or it will not deviate from the (black) expected value.

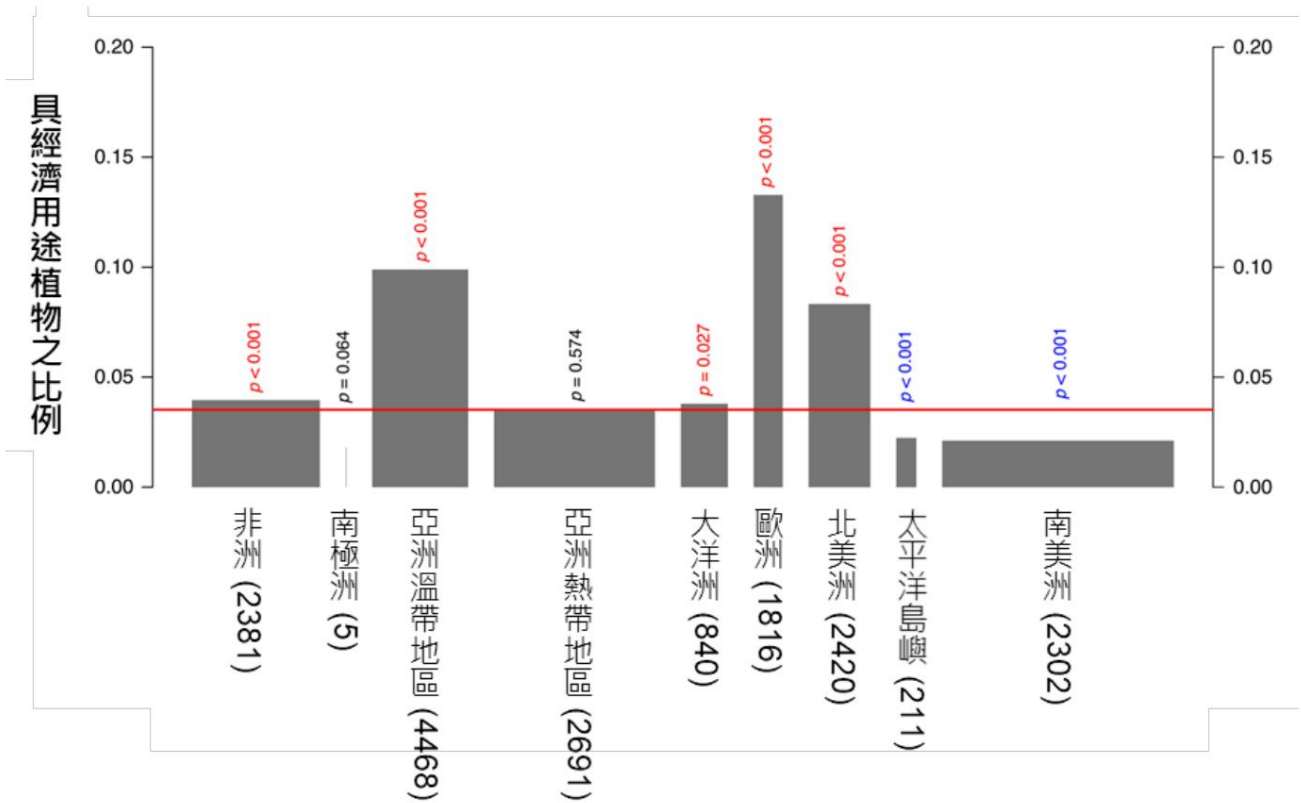


Figure 2. Proportion of native plant species with economic value in nine geographical regions worldwide. (Data in the figure represents...)

All plants with economic value (n = 11,485; excluding plant species known to be cultivated only). The width of each square is related to the...

The number of native plant species is directly proportional to the geographical region. The red horizontal line represents the proportion of economically valuable plants in the global plant population.

The percentage of species is indicated by the p-value on each square, representing whether the percentage of economically important plants is significantly higher (red) or lower (blue).

(Color) Expected or not deviating from (Black) Expected value. The numbers in parentheses next to the text for each geographic region indicate the economic use of each region.

Number of plant species.

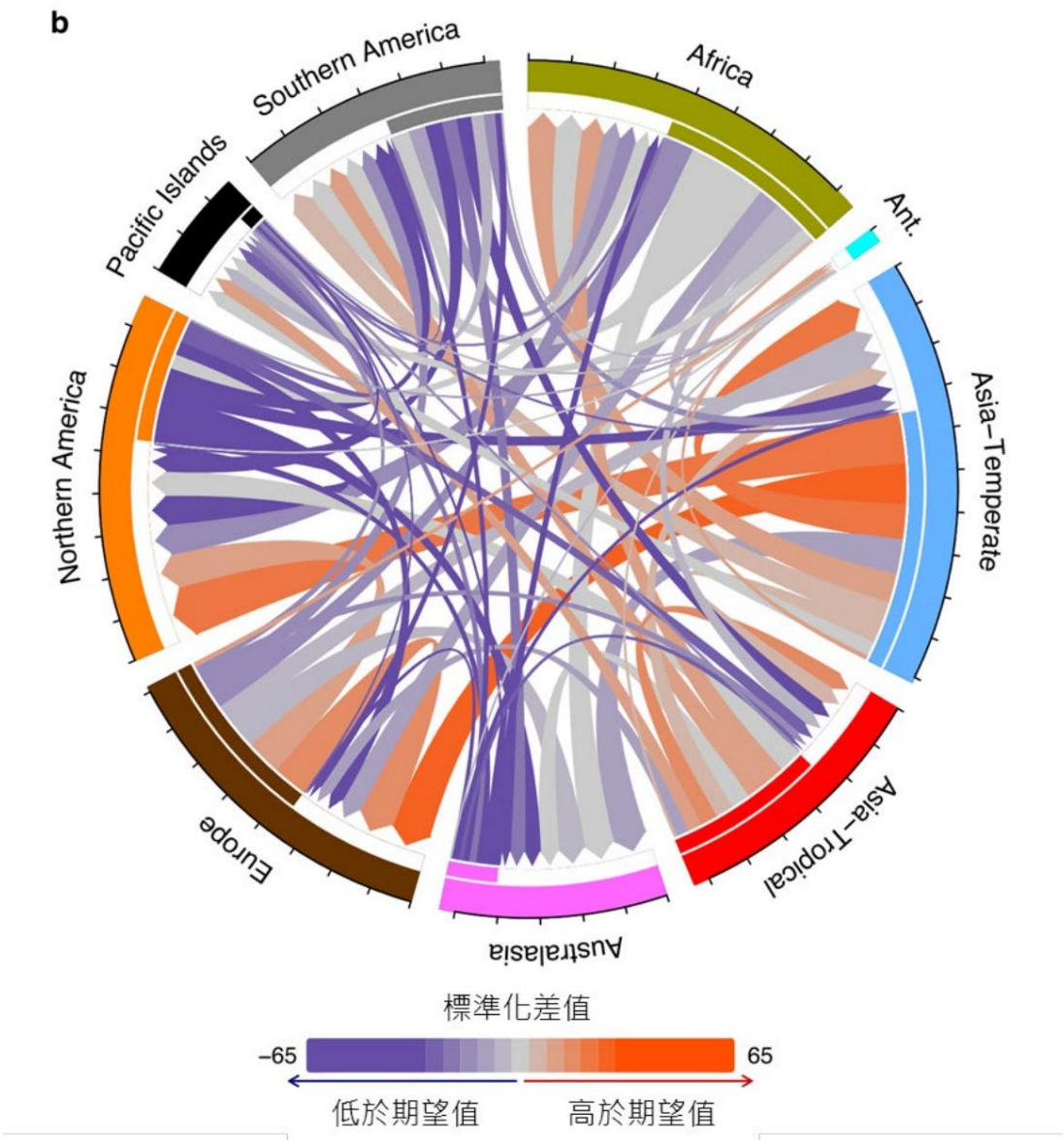


Figure 3. Flow direction of naturalized economic plants across geographical regions. The outer circle shows the flow from one region. The cumulative number of naturalized economic plants flowing to other regions (or flowing back to their own region) and received from other regions. Each of the outer rings... Each scale interval corresponds to 1000 species. Arrows indicate naturalized economic plants that originated in one region and migrated to another. (Or flow back to its own region), the arrow color indicates whether the flow is greater than (red series) or less than (purple series) based on species. The expected value of random sampling; the width of the arrow represents the number of species flowing out (or in); each outflow (or inflow) arrow will be... The number of species is arranged clockwise from highest to lowest. Africa; Antarctica; Asia-Temperate. Regions; Asia-Tropical; Australasia; Europe; Northern America: North America; Pacific Islands: Pacific Islands; Southern America: South America

Multiple choice questions: (5 points)

_____ 1. Based on the analysis results of Figures 1 and 2, which of the following characteristics would give a plant a higher probability of becoming a naturalized plant?

- (A) Its planting area is very large.
- (B) Often planted in semi-natural environments
- (C) Plants from the Southern Hemisphere
- (D) Human use began relatively early
- (E) Has multiple economic uses

Short answer questions: (12 points)

1. Both of those economically valuable plants, regardless of whether they have other economic uses, have a high rate of naturalization.

Answer:

2. Which geographical region is the primary source of introduced naturalized economic plants in tropical Asia?

Answer:

3. In which geographical region of the world are there the most species of introduced economic plants originating from Africa?

Answer:

4. Besides Antarctica, in which two geographical regions are there the highest proportions of introduced and naturalized economic plants among all plant species?

Highest?

Answer:

True or False Questions: (16 points, 4 points deducted for each incorrect answer)

- _____ 1. Among plants used for various economic purposes, those used as nectar sources have the largest number of species.
- _____ 2. Economically important plants used for crop genetic improvement have a lower rate of naturalization than the global rate of naturalization of seed plants.
- _____ 3. Apart from Antarctica, South America has the most native plant species, but the proportion of plant species with economic value is the lowest.
- _____ 4. Compared to Europe, temperate regions of Asia have more native plants with economic value.
- _____ 5. North America has the largest number of introduced and naturalized economic plant species, and these introduced plants mainly come from tropical Asia.
- _____ 6. African economic plants exhibit high species diversity, but the proportion of naturalized plants in other geographic regions is significantly lower than that in randomized areas.
- _____ 7. During the Age of Discovery in the 15th-17th centuries, European countries actively explored various parts of the world, which led to global...
Among the introduced and naturalized economic plants in each geographical region, the largest number of plant species originated from Europe.
- _____ 8. The more economically useful a plant is, the higher the probability that it will be distributed to different regions of the world.

III. Questions and Answers

Sea urchins are often observed to pile small stones or empty shells on the sides of their bodies (a behavior known as covering).

Scientists provided sea urchins with red and transparent plastic sheets to test whether the sea urchins' covering behavior was associated with reduced [something related to behavior].

The hypothesis is related to the harmful effects of UV light. Design an experiment to test this hypothesis. Please fully explain the hypothesis (4 points) and the research steps (10 points).

And what are the conclusions corresponding to the different experimental results? (4 points) (Total 18 points)

IV. Questions and Answers

Scientists use a variety of methods to conduct ecological research, the most common of which include observation and hands-on experiments to illustrate the effects of these two methods.

In what situations are each method applicable? (6 points) List the advantages and disadvantages of each method. (10 points) (Total 16 points)