

※ 注意：請於試卷內之「非選擇題作答區」依序作答，並應註明作答之大題及小題題號。

1. Please translate the following paragraph into Chinese (10%)

The molecular diversity of dissolved organic matter (DOM) in soil depends on the stage of plant litter decomposition and microbial metabolism. Yet the contributions of catabolic and anabolic processes on DOM molecular diversity, and their consequences for organic carbon mineralization, remain unclear. To address this question, we used an  $^{18}\text{O}$ - $\text{H}_2\text{O}$  isotope-labelling approach to track microbial transformation of DOM during plant litter decomposition and determine how these processes alter molecular diversity. Here, we show that microbially produced DOM increases functional molecular diversity during early decomposition but not at later stages. Furthermore, carbon mineralization from DOM is most strongly correlated with molecular weight, highlighting the role of chemical properties in regulating microbial decomposition.

(Adapted from *Nature Communications*, 2025, 16: 11155)

2. Please translate the following paragraph into Chinese (20%)

Soil organic matter is a complex mixture originating from the residues and metabolic products of plants and soil organisms. These plant residues undergo microbial decomposition, thereby contributing to the overall soil carbon pool. Microorganisms play a critical role in soil carbon sequestration processes. Indeed, shifts in the composition of key soil microbial communities directly influence carbon balance and total carbon stocks in soil. Primary producers, such as plants, convert  $\text{CO}_2$  and water into organic matter through photosynthesis. Besides plants, autotrophic microbes are also primary producers, capable of assimilating  $\text{CO}_2$  through various pathways. The underlying mechanism of the microbial carbon pump involves microbial activities that transform labile organic matter into recalcitrant forms. After death, microbial biomass is accumulated as microbial necromass. Due to its relative recalcitrance to decomposition, microbial necromass represents a significant component of stable organic matter in soil. These findings indicate that an abundant and active population of decomposers is a critical determinant of soil carbon sequestration capacity.

(Adapted from *Environmental Chemistry Letters*, 2025, 23: 1145-1151)

3. Choose the correct answer for each question after reading the paragraphs below (20%)

Plants host taxonomically diverse microbial communities, which colonize different below- and above-ground plant parts. The most important reservoir of plant-associated microbiota is the soil and the rhizosphere environment. Owing to the presence of nutrients for microorganisms, such as root exudates and decaying plant material, the rhizosphere is considered a hot spot of microbial activity. Root exudation chemistry and bacterial substrate preferences determine microbiome assembly to a great extent in the rhizosphere. Above-ground plant tissues, including vegetative foliar tissues and flowers, also host endophytes as well as epiphytes.

Harnessing the plant microbiome has led to various microbial applications to improve crop productivity in the face of challenges like climate change and declining soil properties. Microorganisms, particularly nitrogen-fixing rhizobia as well as mycorrhizae and biocontrol agents, have been applied for decades. Still, there are limitations regarding efficacy and consistency under field conditions. The first generation of microbial inoculants consists mostly of single microbial strains, whereas second-generation approaches involve more advanced methods such as the application of complex consortia or microbiome modulation. For example, *Bacillus thuringiensis* is widely used as a powerful insecticide, accounting for 90% of all biopesticides used. These microbial interactions can be further classed into several types, such as mutualism, where all species involved benefit from their interactions.

(Adapted from *Nature Review Microbiology*, 2025, 23: 9-23)

- (1) According to the text, why is the **rhizosphere** considered a "hot spot" of microbial activity? (A) Because of the high temperature within the soil reservoir. (B) Because of the presence of nutrients like root exudates. (C) Because it is the only part of the plant that lacks microorganisms. (D) Because it is protected from decaying plant material.
- (2) Which factor is primarily responsible for determining how the microbiome **assembles** in the rhizosphere? (A) The physical height and leaf shape of the plant. (B) Root exudation chemistry and bacterial substrate preferences. (C) The color of the flowers and the density of seeds. (D) The local atmospheric pressure and wind speed.
- (3) Based on the passage, where can **endophytes** and **epiphytes** be found? (A) Exclusively in the bulk soil far from any roots. (B) Only within the decaying plant material in the subsoil. (C) In above-ground plant tissues such as leaves and flowers. (D) Only in nitrogen-fixing nodules of legumes.

見背面

- (4) What is the main objective of "**harnessing the plant microbiome**" as mentioned in the text? (A) To replace all biological processes with chemical alternatives. (B) To reduce the overall nutritional quality of agricultural crops. (C) To improve crop productivity against environmental challenges. (D) To increase the reliance on traditional chemical pesticides.
- (5) Which group of microorganisms has a **long history (decades)** of application for plant nitrogen nutrition? (A) *Bacillus thuringiensis*. (B) Nitrogen-fixing rhizobia. (C) Predatory soil protists. (D) Newly discovered archaea.
- (6) What is a significant **limitation** of current microbial applications in real-world farming? (A) They are too simple to be understood by researchers. (B) They often show inconsistent efficacy under field conditions. (C) They prevent plants from absorbing any soil nutrients. (D) They are only effective for wild plants, not for modern crops.
- (7) How does the "**second generation**" of microbial approaches differ from the first? (A) It relies on inorganic fertilizers instead of live microbes. (B) It focuses exclusively on using single microbial strains. (C) It utilizes advanced methods like complex consortia and modulation. (D) It ignores the role of climate change and soil properties.
- (8) According to the passage, which organism dominates the current **biopesticide** market? (A) *Rhizobium leguminosarum*. (B) *Glomus intraradices*. (C) *Bacillus thuringiensis*. (D) *Pseudomonas fluorescens*.
- (9) The term "**mutualism**" is used in the text to describe an interaction where: (A) One organism benefits by causing harm to another. (B) All involved species benefit from the interaction. (C) Organisms compete intensely for limited space and nutrients. (D) One organism is killed and eaten by another.
- (10) What can be **inferred** about the future of sustainable agriculture from this text? (A) Microbial applications are likely to become more complex to improve field results. (B) Chemical fertilizers are the only way to solve declining soil properties. (C) Microbes are only relevant for protecting plants from insect pests. (D) Plant breeding will eventually make soil microorganisms unnecessary.

4. Please translate the following paragraph into Chinese.

- (a) Organophosphate pesticides (OPs), characterized by phosphoester bonds, the general formula  $(RO)_2P(X)$  (where R = alkoxy/aryloxy and X = a labile leaving group), and neurotoxic efficacy through acetylcholinesterase (AChE) inhibition, remain indispensable in modern agriculture. Since the 1930s discovery of tetraethyl pyrophosphate as a dual-use insecticide and nerve agent, OPs have revolutionized pest control, particularly in resource-limited regions. Their molecular design, which combines thiophosphate or halogen leaving groups with targeted AChE inhibition, ensures high insecticidal specificity and cost-effectiveness. (12%) (Adapted from *Journal of Agricultural and Food Chemistry*, 2025, 73(29), 18047-18062.)
- (b) Aflatoxins represent the most prevalent and hazardous category of mycotoxins. These toxins are primarily produced by *Aspergillus* species and are commonly detected in agricultural products, nuts, and intermediate products. The United Nations Food and Agriculture Organization estimates that approximately 25 % of food crops are contaminated with mycotoxins, with aflatoxins constituting the primary source of contamination. (8%) (Adapted from *Food Chemistry*, 2026, 147853.)
- (c) Flavonoids are phenolic compounds that act as strong scavengers of reactive oxygen species, potentially mitigating the effect of abiotic stresses on plants. The accretion of flavonoids in plants is intricately linked to light conditions, with blue light being particularly effective in promoting the growth and flavonoid accumulation in various plant species. The transcriptome study showed that light, especially blue light, plays a dynamic role in regulating flavonoid biosynthesis in plants like mango and safflower. (10%) (Adapted from *Critical Reviews in Food Science and Nutrition*, 2025, 1-18.)
- (d) Resistant starch (RS) is essentially a sort of starch that escapes from host enzyme digestion, and basically consists of amylose and amylopectin. These two starch chains can self-assemble to form multi-level structures and endow RS with hierarchical structures, including fine structures, chain structures, short-range ordered structures, helical structures, crystalline structures, aggregation structures, and granular morphology. (8%) (Adapted from *Trends in Food Science & Technology*, 105245.)

接次頁

5. Choose the correct answer for each question after reading the paragraph below. (12%)

Single-cell proteins (SCPs) have been explored since the early 20th century as a versatile protein source. Their production leverages diverse microorganisms tailored to specific applications: in aquaculture, microalgae provide protein and essential fatty acids, while bacteria like *Lactococcus lactis* (probiotics) and *Clostridium autoethanogenum* enhance fish and shrimp nutrition; livestock benefit from yeast-improved digestion and methanotroph-derived SCPs from methane; for human consumption, yeast supports plant-based meats, and spirulina offers anti-inflammatory benefits. Despite these advancements, SCP production remains constrained by its scalability and sustainability. Current yields are insufficient for global demand, and reliance on first-generation (1G) substrates (food crops) competes with agriculture for land/water. While second-generation (2G) lignocellulosic biomass uses nonfood feedstocks, both generations face high costs: 1G from volatile crop prices and 2G from complex pretreatment. Replacing just 20% of global meat with SCPs by 2050 could halve deforestation-related CO<sub>2</sub> emissions and cut livestock methane. Achieving this requires transitioning to third-generation (3G) feedstocks, which utilize renewable C1 sources (e.g., CO<sub>2</sub>, methane, and methanol). By converting industrial emissions into protein, 3G systems align SCP production with carbon neutrality, resolving the “food vs. feed” dilemma while enhancing climate resilience. (Adapted from *Journal of Agricultural and Food Chemistry*, 2025, 73, 52, 32957–32969.)

- (a) Which of the following best summarizes the main focus of the paragraph?
- A. The historical emergence of microbial technologies for protein production.
  - B. The applications, limitations, and future trajectory of SCP production.
  - C. The nutritional comparison between microbial and animal proteins.
  - D. The biochemical mechanisms underlying microbial protein synthesis.
  - E. The economic implications of replacing livestock with microbial systems.
- (b) Which of the following can be most reasonably inferred about first-generation (1G) substrates?
- A. Their use creates competition with conventional agriculture.
  - B. They are no longer used in SCP production.
  - C. They are unsuitable for human consumption.
  - D. They are environmentally harmful because they emit large amounts of CO<sub>2</sub>.
  - E. They are more expensive than second-generation substrates.
- (c) Which option best paraphrases the following sentence?  
“By converting industrial emissions into protein, 3G systems align SCP production with carbon neutrality.”
- A. 3G systems utilize agricultural byproducts to replace conventional protein sources.
  - B. 3G systems rely on livestock-based processes to maintain carbon balance.
  - C. 3G systems eliminate carbon release during all stages of protein synthesis.
  - D. 3G systems reduce overall protein demand by shifting to alternative energy inputs.
  - E. 3G systems transform gaseous carbon inputs into more sustainable biomass.
- (d) What is most strongly implied by the statement that replacing 20% of global meat with SCPs could reduce deforestation-related CO<sub>2</sub> emissions and livestock methane?
- A. SCPs offer a nutritionally leaner alternative to animal-derived proteins.
  - B. SCPs are expected to replace most conventional meat products.
  - C. Livestock production contributes substantially to environmental pressures.
  - D. SCP production relies primarily on forest-derived raw materials.
  - E. Meat consumption is projected to decline sharply by 2050.

試題隨卷繳回