

2023 年度日本政府(文部科学省)奨学金留学生選考試験

QUALIFYING EXAMINATION FOR APPLICANTS FOR THE JAPANESE
GOVERNMENT (MEXT) SCHOLARSHIP 2023

学科試験 問題

EXAMINATION QUESTIONS

(学部留学生)

UNDERGRADUATE STUDENTS

生 物

BIOLOGY

注意 ☆試験時間は **60 分**。

PLEASE NOTE: THE TEST PERIOD IS **60 MINUTES**.

(2023)

Biology	Nationality		No.		Marks	
	Name	(Please print your name, underlining your family name)				

Answer the subsequent questions (I–IV) using the answer sheet.

I. Read the following two passages, (A) and (B), and write down your answers to the subsequent questions on the answer sheet.

(A) A gene can be defined as a DNA region carrying information for one [1] strand or a region on DNA carrying information on one or more functional RNA molecules. In the former case, the first step expressing genetic information is the transcription of a template strand of DNA by [2]. [2] is directed to the appropriate position on the DNA by binding to the [3] region. The [2] moves in the 3' to 5' direction along the template strand of DNA, assembling a complementary, antiparallel strand of RNA that grows from its 5' terminus to the 3' terminus.

There are three types of RNA that are directly involved in the translation of genetic information into proteins. Those are rRNA, mRNA, and [4]. rRNA is a major component of the two large and small [5] of the ribosome. Amino acids are transported to the ribosome by [4], where they form [6] and are arranged based on the information of mRNA. mRNA is the transcription product of a base sequence containing protein information from a DNA template. mRNA consists of a [7] region that contains the information that determines the amino acid sequence and a non-[7] region that is involved in the initiation and regulation of translation.

[4] is responsible for binding to a specific amino acid and transporting it to the ribosome. Amino acids form [6] based on the information of DNA transcribed into mRNA to [8] proteins.

(B) 1) Each cell of an individual organism has a different set of genes, depending on the required function. The body maintains relatively constant blood pressure, blood sugar, electrolytes, energy, hormones, oxygen, proteins, temperature, etc. All body systems

need to respond well to a variety of environmental stimuli in order for the body to function properly and survive. They also need to be maintained at the same level at all times under various signals. Therefore, 2) gene expression is always kept constant under various conditions. This phenomenon is called “homeostasis.” Such gene expression begins with the transcription of DNA, then is translated into a protein. 3) A series of basic processes, such as intracellular DNA replication, transcription of genetic information, and translation into proteins, is called "metabolism."

1. Choose the most suitable term from the list given below to answer ([1] to [8]) on the paragraph above and write down the appropriate letter (A–W) in the designated spaces (I-1 (1) to (8)) on the answer sheet.

- | | | |
|--------------|-------------------|-------------------|
| A. cDNA | B .coding | C. digest |
| D. DNA | E. DNA polymerase | F. double |
| G. enzyme | H. ester bonds | I. ether bonds |
| J. examine | K. ligase | L. lipid |
| M. lysosomes | N. peptide bonds | O. polypeptide |
| P. promoter | Q. RNA | R. RNA polymerase |
| S. sRNA | T. subunits | U. synthesize |
| V. triple | W. tRNA | |

2. Which of the above sentences from 1) to 3) is/are incorrect? Write down the letter “T” for the correct sentence and the letter “F” for the incorrect sentence in the designated spaces (I-2 (1) to (3)) on the answer sheet.

II. Read the following passage and answer the subsequent questions (1–4).

In the living cells, various substances are being synthesized and degraded. The overall process of these biological reactions is termed metabolism, and many metabolic pathways, a series of consecutive chemical reactions, proceed in an integrated manner to maintain the activities of living cells.

Metabolic pathways are divided into two categories: one is called [1], in which 1)cell constituents and nutrients are broken down into their components and inorganic substances, and the other is called [2], in which 2)complex biomolecules are synthesized from simpler constituents and compounds.

The chemical reactions in [2] are thermodynamic processes that [3] energy. Therefore, an external energy supply is required for the reaction to proceed. Conversely, the chemical reactions in [1] are the processes to [4] energy, and the resulting energy is conserved through the synthesis of [5] and NADPH (NADH), which are often utilized to drive the chemical reactions in [2]. The processes of two metabolic categories are thus coupled through [5], which is called the biological energy currency.

Most reactions in metabolic pathways are mediated by corresponding enzymes. Enzymes are known as biological catalysts and can function efficiently under conditions preferable for the cell's biological performance. They differ from chemical catalysts, which often function under non-biological conditions such as high temperature and high pressure. The catalytic activities of many enzymes are well regulated in response to the internal environment of the cell to maintain the homeostasis of metabolism as a whole. In recent years, 3)many studies on the functions and structures of enzymes in the atomic and molecular levels have been carried out, and several important achievements have been obtained.

1. Fill in the blank ([1]-[5]) in the above passage using the most suitable term from the list given below and record the corresponding letters (A-I).

- | | | |
|--------------|-------------------------|--------------------------|
| A catabolism | B anabolism | C conversion |
| D store | E transform | F extract |
| G adenosine | H adenosine diphosphate | I adenosine triphosphate |

2. Metabolic pathways (1) to (5) given below are the main examples for metabolic pathways. Determine whether each of them belongs to the underlined sentence 1) or sentence 2) of the above passage. Write down X if it belongs to sentence 1) or Y if it belongs to sentence 2) in the designated spaces (II-2(1) – (5)) on the answer sheet.

- (1) Calvin-Benson cycle
- (2) Krebs cycle (TCA cycle, Citric acid cycle)
- (3) Urea cycle
- (4) Alcoholic fermentation
- (5) Glycolysis

3. Judge whether the following sentences concerning enzyme functions are correct or wrong, and write down “T” for the correct sentence and “F” for the incorrect one in the designated spaces (II-3(1) – (5)) on the answer sheet.

(1) The rates of enzymatically-catalyzed reactions are greater by the factors of 10^6 to 10^{12} than those of the corresponding reactions without a catalyst. This is due to the shift of the equilibrium constant of the reaction toward product formation.

(2) Enzymes have greater efficiency in the catalytic reaction for a certain substrate. Such a substrate specificity is due to the presence of the enzyme’s active site with a structure complementary to that of the substrate.

(3) There are substances that reduce an enzyme’s activity. Such substances, known as inhibitors, can act with mainly two different mechanisms: one is to bind to the enzyme’s active site in a competitive manner with a normal substrate, and the other is to bind to the region other than the active site in a non-competitive manner.

(4) All enzymes consist of single or multiple polypeptides. Some enzymes play a catalytic role in association with vitamins or metal ions.

(5) Enzymes are generally inactivated when the enzyme solution is heated. This is due to the low conformational stability of proteins. However, certain species of organisms known as hyperthermophiles that grow in hot springs have special enzymes that can function at temperatures higher than 80°C . Such enzymes consist of heat-stable macromolecules that are not proteins.

4. Judge whether the following sentences concerning research achievements for the underlined part 3 in the above passage are correct or wrong, and write down “T” for the correct sentence and “F” for the incorrect one in the designated spaces (II-4(1) – (5)) on the answer sheet.

(1) In order to obtain an enzyme

of a certain animal, we can extract the enzyme from the tissues of the animal biochemically, or we can prepare the enzyme by a genetic recombination method from a heterologous organism such as *E. coli*.

(2) The 3D structures of many substances can be determined by X-ray crystallographic analysis. However, this method is hardly applied for the structural determination of enzymes since it is difficult to crystalize enzymes.

(3) Several metabolic disorders are caused by the dysfunction of certain enzymes. Many mutations of the genes encoding the corresponding enzymes have been elucidated by the tailor-made genomic analysis of the corresponding patients.

(4) Studies of enzyme functions have been carried out using new methods, such as by rapid analysis of millisecond-order reactions and direct observation of enzyme molecules labeled with visualization probes.

(5) The genomes of many organisms contain multiple open reading frames encoding nonidentified proteins that are homologous with a certain enzyme of known function. These homologs can be considered to have the same function as the enzyme.

III. Read the following passage and answer the subsequent questions (1–4).

Mass extinctions occurred several times in geological history. In the Precambrian age, [1] started to appear 3.5 billion years ago and left layered rocks known as [2]. They produced oxygen that exterminated most of [3]. The accumulated oxygen oxidized iron ion soluble in seawater into [4], which became sediments of [5] in shallow waters.

The extremely cold climate had frozen the lands and sea waters of the earth three times during the Precambrian age. After the last age of snowball earth, fossils of [6] appeared, and they were known as the 1)Ediacaran biota from Australia. The fossils of many animals from multiple phyla appeared in the Cambrian period of the Paleozoic era. This event is known as [7]. The 2)Burgess shale fauna are the famous Cambrian fossils found in the Canadian Rockies.

Photosynthetic organisms such as algae, plants, and euglena became abundant and oxygen accumulated in the atmosphere. Then, [8] was formed in the stratosphere and absorbed [9] rays. As the [9] rays that reached land were reduced, plants started colonizing land in the Silurian period, followed by 3)the colonization of land by animals in the Silurian and Devon periods. A group of fishes developed lungs, legs, and fingers and evolved to [10].

4)The mass extinction in the late Permian era, which is the boundary of Paleozoic and Mesozoic eras, destroyed most members of fauna and flora in lands and waters caused by large-scale [11].

1. Fill in the blank ([1]–[11]) in the above passage with the most suitable term from the list given below and record the corresponding letters (A–Q).

- | | | |
|----------------------------|------------------------|-----------------------|
| A. aerobic bacteria | B. anaerobic bacteria | C. amphibians |
| D. banded iron formation | E. cyanobacteria | F. Cambrian explosion |
| G. collision of meteorite | H. infrared | I. iron oxide |
| J. multicellular organisms | K. ozone layer | L. reptiles |
| M. snowball earth | N. stromatolites | O. ultraviolet |
| P. unicellular organisms | Q. volcanic activities | |

2. From the list given below, choose one animal fossil that belongs to the groups mentioned on the underlined sentences number 1) and 2) in the passage above, and write down the corresponding letters (A–G) in the designated spaces (III-2 (1) and (2)) on the answer sheet.

- | | | | |
|------------------------|------------------------|-------------------------|-----------------------|
| A. Ammonite | B. <i>Anomalocaris</i> | C. Coelacanth | D. <i>Dickinsonia</i> |
| E. <i>Ichthyostega</i> | F. Trilobite | G. <i>Tyrannosaurus</i> | |

3. From the list given below, choose four terrestrial phyla of animals mentioned on the underlined sentence number 3) in the passage above, and write down the corresponding letters (A–H) in the designated space (III-2 (3)) on the answer sheet.

- | | | | |
|------------------|-----------------|-------------|-------------|
| A. Annelida | B. Arthropoda | C. Chordata | D. Cnidaria |
| E. Echinodermata | F. Hemichordata | G. Mollusca | H. Porifera |

4. From the list given below, choose an index fossil of Paleozoic era, which is mentioned on the underlined sentence number 4) in the passage above, and write down the corresponding letters (A–G) in the designated space (III-2 (4)) on the answer sheet.

- | | | | |
|------------------------|------------------------|-------------------------|-----------------------|
| A. Ammonite | B. <i>Anomalocaris</i> | C. Coelacanth | D. <i>Dickinsonia</i> |
| E. <i>Ichthyostega</i> | F. Trilobite | G. <i>Tyrannosaurus</i> | |

IV. Read the following passage and answer the subsequent questions (1–4).

Ecological disturbance is a temporary change in environmental conditions that sometimes causes a pronounced change in an ecosystem. 1)Major disturbances destroy [1] and affect the [2] of an ecosystem. Damaged ecosystems recover gradually for a long time by ecological [3].

Major disturbances reduce [2]. In contrast, 2)minor disturbances increase the variety of [1], and [2] becomes higher. For example, paddy fields grown by traditional agriculture provide an environment for freshwater animals to live, leading to a higher [2].

[4] are those that humans move intentionally or accidentally from the species' native locations to new areas. Without the predators, parasites, and pathogens that limit its population, a species may spread rapidly in a new area. 3)Invasive species disrupt their new community, often by preying on native organisms or outcompeting them for resources.

1. Fill in the blank ([1]–[4]) in the above passage using the most suitable term from the list given below and write down the corresponding letters (A–I).

- | | | |
|-----------------------|---------------------|-------------------|
| A. biodiversity | B. climax community | C. habitats |
| D. introduced species | E. keystone species | F. native species |
| G. population | H. refugia | I. succession |

2. From the list given below, choose each four causes of major and minor disturbances, which are mentioned in the underlined parts number 1) and 2) of the passage above, and write down the corresponding letters (A–H) in the designated spaces (IV-2 (1) and (2)) on the answer sheet.

- | | | |
|------------------------|----------------------|--------------|
| A. drought | B. epidemic | C. flood |
| D. intense forest fire | E. landslide | F. pollution |
| G. small wildland fire | H. volcanic eruption | |

3. From the list given below, choose three invasive species mentioned in the underlined sentence number 3), and write down the corresponding letters (A–F) in the designated space (III-2 (3)) on the answer sheet.

- A. alligator snapping turtle (*Macrochelys temminckii*) in Japan
- B. Brahminy blind snake (*Indotyphlops braminus*) in tropical regions
- C. brown tree snake (*Boiga irregularis*) in Guam
- D. domestic rabbit (*Oryctolagus cuniculus*) in Australia
- E. European honey bee (*Apis mellifera*) in Japan
- F. kudzu or Japanese arrowroot (*Pueraria montana*) in the U.S.A.