

2019 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 2019

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.

BIOLOGY

(2019)

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

I. Read the following passage and answer the subsequent questions using the answer sheet.

The DNA in eukaryotes is associated with proteins such as histones, resulting in formation of [1]. The chain of [1] is folded, leading to [2] structure. RNA polymerase is not able to bind the DNA at this state, so that genes present in the corresponding DNA region are not transcribed. It is necessary to loose the structure in that region for gene transcription. RNA polymerase and RNA are insufficient for the initiation of transcription, and [3] are also necessary for it. RNA polymerase and [3] bind the [4] region of target genes, initiating the transcription of them. Also, there are genes that are selectively expressed in particular cell types or in response to specific environmental conditions where organisms are present. This phenomenon is called selective gene expression, which is known to be regulated by binding of [5] to [6].

Transcribed RNA is called as [7]. Intron sequences are cut out from [7] and then each exon sequence is connected, resulting in the generation of mRNA. This step is called [8]. Subsequently, the genetic information carried by mRNA is translated and protein is produced.

Table 1 shows the genetic code (codon table) of mRNA in eukaryotes.

Table 1

		Second base of codon									
		U		C		A		G			
First base of codon	U	UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine	U	Third base of codon
		UUC		UCC		UAC		UGC		C	
		UUA	Leucine	UCA		UAA	STOP	UGA	STOP	A	
		UUG		UCG		UAG		UGG	Tryptophan	G	
	C	CUU	Leucine	CCU	Proline	CAU	Histidine	CGU	Arginine	U	Third base of codon
		CUC		CCC		CAC		CGC		C	
		CUA		CCA		CAA	Glutamine	CGA		A	
		CUG		CCG		CAG		CGG		G	
		AUU	Isoleucine	ACU	Threonine	AAU	Asparagine	AGU	Serine	U	Third base of codon
		AUC		ACC		AAC		AGC		C	
		AUA		ACA		AAA	Lysine	AGA	Arginine	A	
	A	AUG	Methionine	ACG		AAG		AGG		G	
		GUU	Valine	GCU	Alanine	GAU	Aspartic acid	GGU	Glycine	U	Third base of codon
		GUC		GCC		GAC		GGC		C	
		GUU		GCA		GAA	Glutamic acid	GGA		A	
		GUG		GCG		GAG		GGG		G	

1. Fill in the blanks ([1]-[8]) in the above passage using the most suitable term from the list given below and record the appropriate letters (A-X) in the designated spaces (I-1 (1)~(8)) on the answer sheet.

- | | | | |
|---|-------------------------------|---|------------------------------------|
| A | α -helix | B | amino acids |
| C | anticodon | D | chromatin |
| E | DNA polymerase | F | general transcriptional factors |
| G | general translational factors | H | gene regulatory proteins |
| I | ligase | J | lysosome |
| K | nucleolus | L | nucleosome |
| M | nucleus | N | operon |
| O | pre-mRNA | P | primer |
| Q | promoter | R | reverse transcriptase |
| S | ribose | T | ribosomal RNA |
| U | ribosome | V | silencing |
| W | splicing | X | transcription regulatory sequences |

2. Which of the following sentences is correct as an explanation of translation of genetic information in eukaryotes shown in the underlined part 1 above? Record the letter (A–E) indicating the correct sentence in the designated space (I–2) on the answer sheet.

- A On a ribosome, tRNA recognizes anticodon in mRNA and binds it.
- B A ribosome consists of a large subunit and a small subunit, and the mRNA binding site is present in the small subunit.
- C Stop codon is bound by tRNA that does not carry any amino acid, which terminates translation.
- D On a ribosome, amino acids are connected by disulfide bonds.
- E Ribosomes are always attached to the endoplasmic reticulum.

3. Related to Table 1, a part of the amino acid sequence of a particular protein is shown in Figure 1. How many combinations of codons are possible to specify this amino acid sequence (from arginine to glutamine)? Record the letter (A–E) for the correct answer in the designated space (I–3) on the answer sheet.

A 17 B 34 C 96 D 192 E 288 F 384

--[Arginine]--[Glycine]--[Isoleucine]--[Tyrosine]--[Glutamine]--

Figure 1

4. Figure 2 below represents the 5'-end sequence of mRNA derived from gene X. Which of amino acids comes to 5th position of the protein synthesized via translation of this mRNA? Record the letter (A–F) for the correct answer in the designated space (I–4) on the answer sheet.

A alanine B glutamic acid C glycine
D histidine E serine F valine

5'- G A C C U G A G A A A U C A U G G U C C U G C C U G G U C · · · ·

Figure 2

II. Read the following passages [1] and [2], and answer the subsequent questions using the answer sheet.

Passage [1]

The harvesting of energy from glucose, a 6 -carbon sugar molecule, by cellular respiration is a cumulative function of three metabolic stages, [1], the citric acid cycle, and the [2]. [1], which occurs in the [3], breaks a glucose into two molecules of [4], a [α]-carbon molecule. [1] does not require the [5] gas and does not generate the [6] gas.

In eukaryotes, [4] enters the mitochondrion and is first converted to [7], with the release of one molecule of [6]. The acetyl group from [7] joins the citric acid cycle and reacts with a 4 -carbon compound [8] to form a 6 -carbon compound [9]. In eukaryotic cells, the citric acid cycle occurs in the [10] of the mitochondrion.

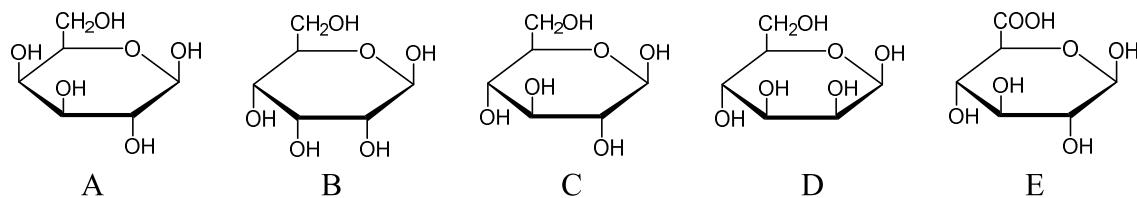
The electrons extracted from food are carried by NADH and [11] into the [2], in which the energy is released. This energy is used to pump hydrogen ions from the [10] of the mitochondrion into the [12] space. This creates a difference in the concentration of hydrogen ions between the [10] and the [12] space of the mitochondrion. This difference in the concentration is used to drive [13] synthase to produce [13]. The electrons passed from NADH and [11] are finally given to oxygen, resulting in the production of [14] by reacting with hydrogen ions.

1. Fill in the blanks ([1]-[14]) in the above passage using the most suitable term from the list given below and record the appropriate letters (A-X) in the designated spaces (II-1 (1)~(14)) on the answer sheet.

- | | | |
|---------------------|--------------------------|----------------------------|
| A acetyl-CoA | B alcoholic fermentation | C AMP |
| D ATP | E Calvin-Benson cycle | F carbon dioxide |
| G citrate | H cytosol | I electron transport chain |
| J FADH ₂ | K fumarate | L glycolysis |
| M hydroxide ion | N inner membrane | O intermembrane |
| P maleate | Q malonyl-CoA | R matrix |
| S NADPH | T nitrogen | U oxaloacetate |
| V oxygen | W pyruvate | X water |

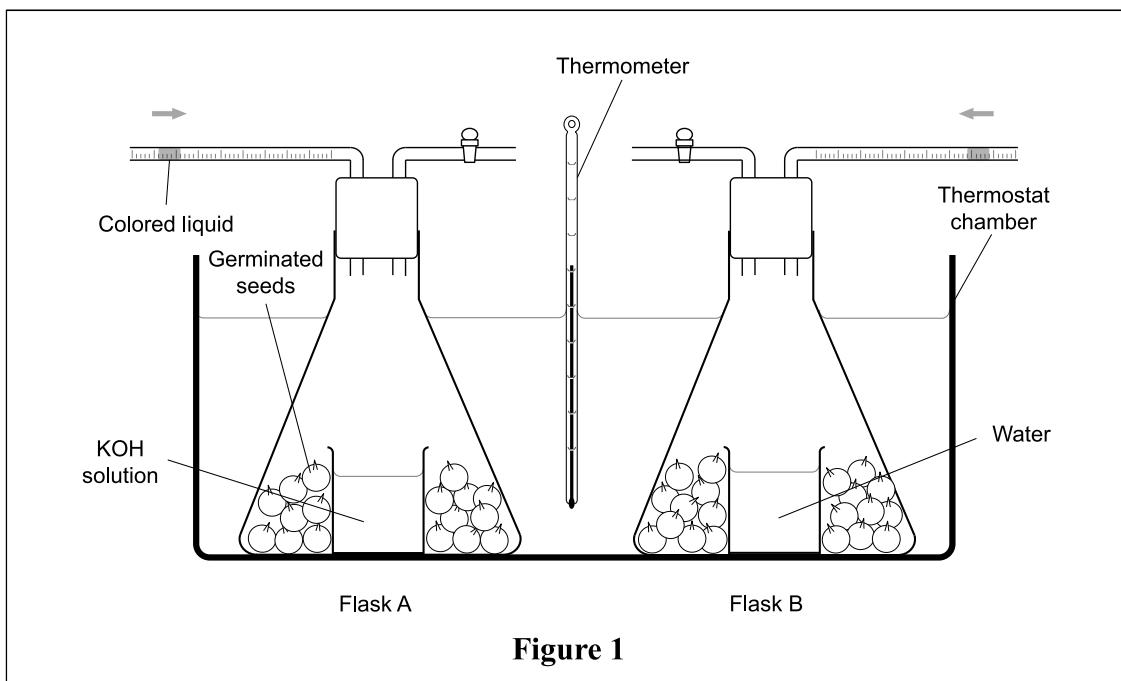
2. Fill in the blank [α] in the above passage with a correct number and record the number in the designated space (II-2) on the answer sheet.

3. Which of the following structure is correct as glucose, as shown in the underlined part 1 above? Record the letter (A–E) indicating the correct structure of glucose in the designated space (II –3) on the answer sheet.



Passage [2]

By using a pair of respirometers as shown in Figure 1, the respiratory quotient in germinating seeds of wheat was measured. After testae on the seeds were removed, the sample of seeds was weighed before being placed in the flasks A and B. Then the seeds were allowed to respire for a known time. In consequence, the reduced volumes of gases in the flasks A and B were 969 mL and 19 mL, respectively.



4. Which of the following numerical values is correct as the respiratory quotient for wheat seeds in this experiment? Record the letter (A–E) for the correct answer in the designated space (II –4) on the answer sheet.

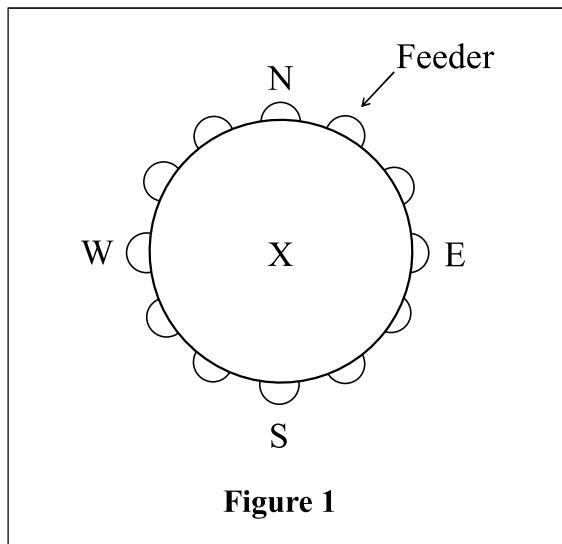
- A 0.66 B 0.71 C 0.85 D 0.98 E 1.12

5. Which of the following sentences is incorrect as an explanation in this experiment? Record the letter (A–E) for the incorrect sentence in the designated space (II–5) on the answer sheet.

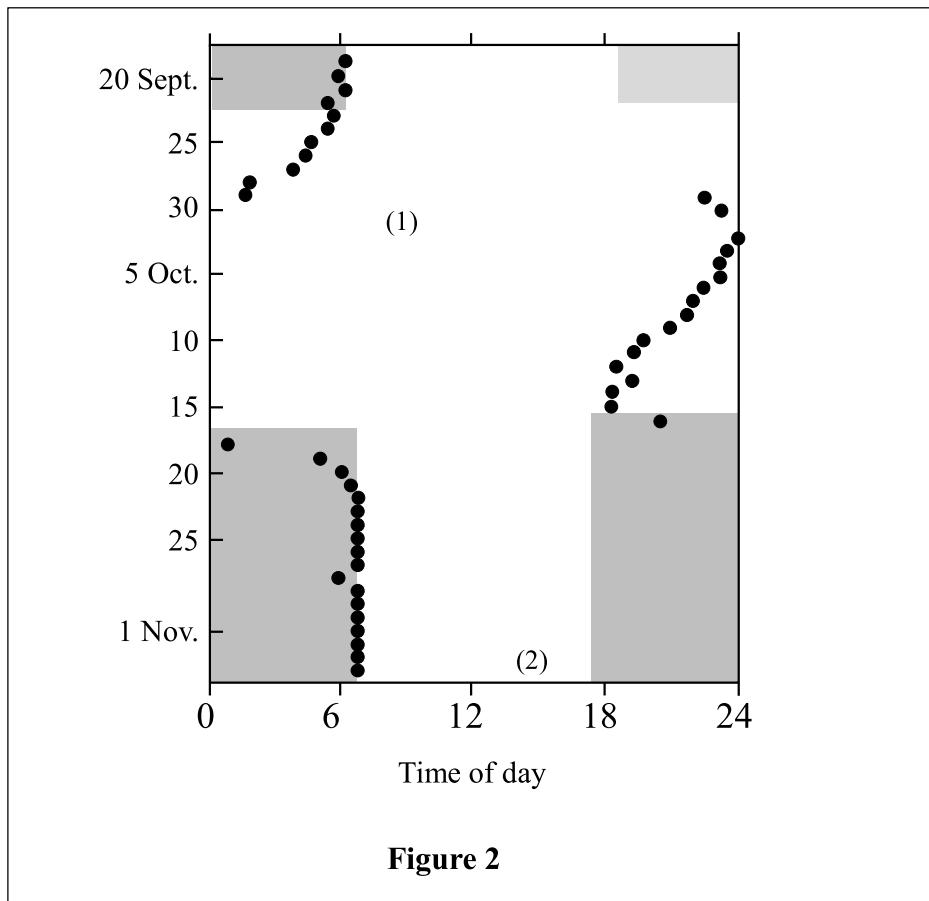
- A Before the experiment, the seeds were soaked in water for 24 hours to enhance respiration by activating metabolism.
- B In the flask A, KOH absorbs CO₂ released by the seeds.
- C In this experiment, carbohydrates were used as the respiratory substrates.
- D In this experiment, proteins were used as the respiratory substrates.
- E The respiratory quotient is a dimensionless number and indicates which macronutrients are being metabolized.

III. Read the following passage on the orientation of birds and answer the subsequent questions 1–3 using the answer sheet.

The common starling is a bird originally distributed in Europe and West Asia, and is closely related to the white-cheeked starling in East Asia. The common starling orients with reference to the direction of the sun. This orientation mechanism is called sun compass. The following experiment in this species was performed in Germany. Twelve feeders (semicircles in Figure 1) were placed on the circumference of a circle outdoors, and a bird was released at the center (X in Figure 1). After the bird was trained with food only in the north feeder, the bird became oriented to the north when placed at X even without food. This bird oriented to the north at any time of the day. The reason why the bird always oriented to the correct direction even though the direction of the sun changes from hour to hour is that the internal circadian clock corrected the time.



The common starling is diurnal and starts its locomotor activity around the sunrise. A bird trained to orient to the north at the place shown in Figure 1 was subjected to the experiment shown in Figure 2. After being kept under natural light-dark cycles in the laboratory for some days, the bird was transferred to constant light conditions. Then, the locomotor activity of the bird was recorded (filled circles represent the onset of locomotor activity on a day, and gray areas indicate darkness in Figure 2). This experiment showed that the onset of its locomotor activity gradually advanced day by day and that a few days after returned to conditions with light-dark cycles, the bird started its locomotor activity around the sun rise again.



1. Which of the following sentences are incorrect to explain the description in the underlined part 1 above and the results in Figure 2? Record the letters (A–E) for the two incorrect sentences in the designated spaces (III–1 (1)~(2)) on the answer sheet.

- A The locomotor activity of the bird is regulated by a circadian clock.
- B The locomotor activity of the bird is initiated directly by the sunrise.
- C The circadian clock of the bird has a period shorter than 24 h.
- D The circadian clock of the bird has a period longer than 24 h.
- E The circadian clock of the bird synchronizes its periodicity to the light-dark cycles.

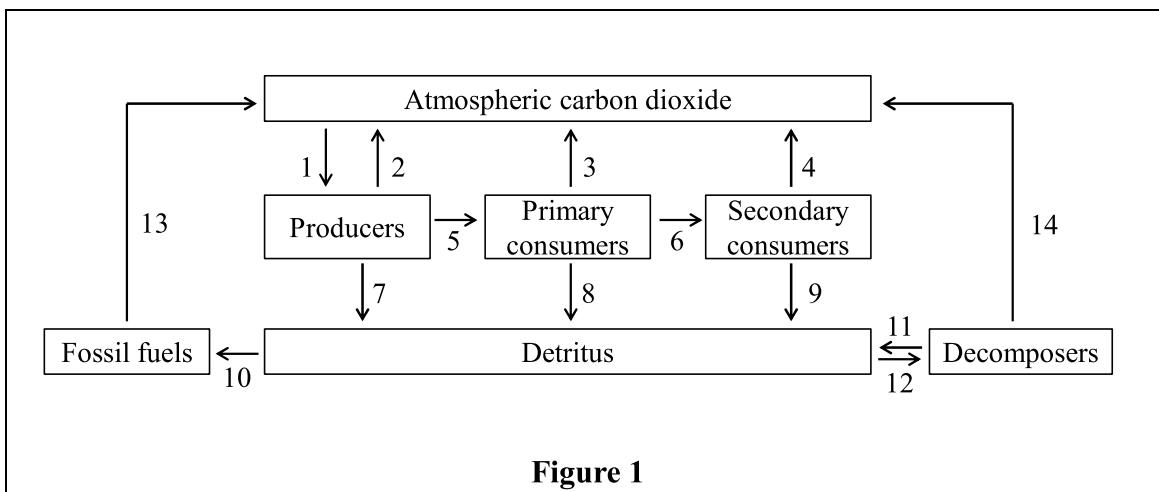
2. On the times of (1) and (2) in Figure 2, the bird was placed at X in Figure 1. Which directions did the bird orient to? Record the letters (A–E) for the most proper sentences for the cases of (1) and (2) in the designated spaces (III–2 (1)) and (III–2 (2)), respectively, on the answer sheet.

- A The bird oriented to the north.
- B The bird oriented to the east.
- C The bird oriented to the south.
- D The bird oriented to the west.
- E The bird dithered and did not orient to a specific direction.

3. A common starling was trained to orient to the north and subjected to another experiment. In this experiment, a strong artificial light was fixed at the east direction under the condition that the bird could not see the sun. Which direction did the bird orient to at different times of a day? Record the letters (A–E) for the most proper sentence in the designated space (III–3) on the answer sheet. Note that the starling had been shown to regard this artificial light as the sun.

- A The bird oriented to the south in the morning, to the west at noon, and to the north in the evening
- B The bird oriented to the south in the morning, to the east at noon, and to the north in the evening
- C The bird oriented to the north in the morning, to the east at noon, and to the south in the evening
- D The bird oriented to the north in the morning, to the west at noon, and to the south in the evening
- E The bird oriented to the north constantly at any time of a day.

IV. Figure 1 shows the carbon cycle in the terrestrial ecosystem schematically. Answer the subsequent questions 1–6.



1. As the biological activity corresponding to the arrows 1 in Figure 1, choose the most suitable term from the list given below, and record the appropriate letter (A–F) in the designated space (IV–1) on the answer sheet.

- | | | |
|--------------------|---------------------|----------------|
| A carbonization | B evaporation | C excretion |
| D ingestion | E photosynthesis | F storage |

2. Choose the arrows showing the same biological activity as the arrow 2 in Figure 1, and record all the numbers (1~14) in the designated space (IV–2) on the answer sheet.

3. Choose three primary consumers from the list given below, and record the letters (A–I) in the designated spaces (IV–3 (1)~(3)) on the answer sheet.

- | | | |
|----------------|----------------|-------------|
| A butterfly | B dandelion | C frog |
| D hawk | E honeybee | F mantis |
| G rabbit | H rice | I wolf |

4. When the measured values in Table 1 below are obtained for a forest, how much ($\text{g/m}^2/\text{year}$) is the gross production of this forest? Record the letter (A–E) for the most appropriate one in the designated space (IV–4) on the answer sheet.

- | | | | | |
|-----------|-----------|-----------|-----------|-----------|
| A 1500 | B 1700 | C 2100 | D 2200 | E 2700 |
|-----------|-----------|-----------|-----------|-----------|

Table 1

Respiration of plants	Dead tissues	Grazing	Growth
1500	600	100	500

(g/m²/year)

5. Choose an arrow representing the process that has been remarkably increased by recent human activities from arrows 1-14 in Figure 1, and record the number in the designated space (IV-5 (1)) on the answer sheet. In addition, choose the two most appropriate sentences that are related to this phenomenon from A-E, and record the letters in the designated spaces (IV-5 (2)~(3)) on the answer sheet.
- A Large carnivorous animals decreased.
B Tropical rainforest areas decreased.
C Atmospheric concentration of carbon dioxide increased.
D Earth's surface temperature increased by the effect of greenhouse gases.
E Inorganic materials originating from detritus increased.
6. There are some differences between the terrestrial ecosystem shown in Figure 1 and the marine ecosystem. Choose the two incorrect sentences for the marine ecosystem from A-E, and record the letters in the designated spaces (IV-6 (1)~(2)) on the answer sheet.
- A The sea water contains much more carbon dioxide than the atmosphere.
B The carbon dioxide concentration is maintained approximately constant in the sea water, independent of that in the atmosphere.
C Some animals transform carbon dioxide in the sea water into calcium carbonate, and consequently carbon is accumulated in limestone.
D A majority of producers is made up of seaweeds.
E Corals are primary consumers, but many of them have symbiotic zooxanthellae in their tissues, which are producers.

V. Choose the most suitable answer from A–E that matches the following phrases 1–6, and record the corresponding letters in the designated spaces (V–1~6) of the answer sheet.

1. Time when the modern humans (*Homo sapiens*) first appeared in Africa

- A 2,000 years ago B 20,000 years ago C 200,000 years ago
D 2,000,000 years ago E 20,000,000 years ago

2. A cell for innate immunity

- A B cell B cytotoxic T cell C erythrocyte
D helper T cell E macrophage

3. An organelle involved in secretion of proteins

- A chloroplast B Golgi apparatus C mitochondrion
D peroxisome E vacuole

4. The phenomenon in which actin filaments are not involved

- A changes in cell shapes B chromosome movements in cell divisions
C cytoplasmic streaming D maintenance of cell shapes
E muscle contraction

5. Which cell(s) is(are) fertilized with a sperm cell to form an endosperm during the double fertilization event

- A antipodal cells B central cell C egg cell
D embryo sac cell E synergid cells

6. Gaseous plant hormone under normal temperature and pressure

- A abscisic acid B auxin C cytokinin
D ethylene E gibberellin