

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

In very small quantities, plant hormones, such as [1], [2], [3], [4] and [5], regulate the growth and development of plants. [1], [2] and [3] promote plant growth, whereas [4] and [5] inhibit it. A major function of [1] is the acceleration of cell enlargement, for [2] the promotion of stem elongation and for [3] the acceleration of cell division, whereas [4] promotes the falling of leaves and the acceleration of [5] fruit [6] in addition to the inhibition of plant growth. Plant hormones are synthesized in an organ of the plant body, and in many cases are transported to other organs to show their activities. For example, [2] and [3] are mainly synthesized in roots, and transported to the apical meristem or leaves through [7] by transpiration flows. [5] is a gas and how this hormone is transported in the plant body had long been unknown. Now, however, we know that 1-aminocyclopropane-1-carboxylic acid (ACC), the [8] of [5], is the form of the transportation of [5]. Other than these 5 hormones, such substances as brassinolide and jasmonic acid are recognized as plant hormones.

Flowering is a very important physiological event for plants and affected by environmental factors, especially 1temperature and 2daylength. 3Chailakhyan clarified that a substance synthesized in a leaf is transported to the apical meristem and promotes flower bud initiation there, using a [9] plant, cocklebur (*Xanthium*). This substance to promote flower bud initiation, synthesized in a leaf, is called [10]. The true character of [10] had not been known for a long period, but recently it was revealed that [10] was a protein called [11].

1. Fill in the blanks ([1]–[11]) in the above passage from the list given below and record the appropriate letters (A–Z) in the designated spaces (I–1 (1)~(11)) on the answer sheet.

A abscisic acid	B adrenalin	C ATP
D auxin	E cytokine	F cytokinin
G day-neutral	H ethylene	I florigen
J FT	K gibberellin	L globulin
M juvenilization	N long-day	O malic acid
P maturation	Q metabolite	R oxaloacetic acid
S phloem	T polyphenol	U precursor
V product	W propylene	X RuBP
Y short-day	Z xylem	

2. Which of the following sentences is incorrect as an explanation of the relationship between flowering and temperature, as shown in the underlined part 1 above? Record the letter (A–D) of the incorrect sentence in the designated space (I–2) on the answer sheet.

- A Many of plants that germinate in autumn and flower in the next spring require a certain period of low temperatures for flower bud initiation.
- B Many of plants that germinate in spring and flower in summer require a certain period of low temperatures for flower bud initiation.
- C Flowering of short-day plants is affected only by temperature when the daylength is shorter than the critical daylength.
- D Day-neutral plants, where flowering is independent of the influence of daylength, generally initiate flower buds earlier when temperature is higher.

3. In the relationship between flowering and daylength, as shown in the underlined part 2 above, it is not the length of a day but the length of a night that is significant physiologically. In a greenhouse growing chrysanthemums that is located near a road with frequent traffic even at night, the plants receive light due to car headlights. Which statement is correct concerning the effect of headlights on flowering of chrysanthemums in this greenhouse? Record the letter (A–E) for the appropriate sentence in the designated space (I–3) on the answer sheet.

- A Because chrysanthemum is a short-day plant, flowering is delayed.
- B Because chrysanthemum is a short-day plant, flowering is hastened.
- C Although chrysanthemums are responsive to daylength, feeble lights from car headlights do not affect flowering.
- D Because chrysanthemum is a long-day plant, flowering is delayed.
- E Because chrysanthemum is a long-day plant, flowering is hastened.

4. In the experiment conducted by Chailakhyan, described in the underlined part 3 above, which experimental operation is indispensable to prove that [10] synthesized in a leaf is transported to the apical meristem and promotes the initiation of flower bud? Record the letter (A–E) of the explanation that describes the appropriate experimental operation in the designated space (I–4) on the answer sheet.

- A A short-day treatment was given to a plant with only one leaf, and where other leaves were pruned.
- B A short-day treatment was given to a plant where the apical portion including a growing point, had been excised.
- C A short-day treatment was given to a whole plant.
- D A short-day treatment was given to only one leaf on a plant.
- E A short-day treatment was given to a plant with all its leaves pruned.

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

Natural ecosystems have diversified functions, including fixation of energy, circulation of matter, natural regulation of population, conservation and resilience of the system and conservation of bio-diversity. Fixation of energy is mainly conducted through [1] by plants. [1] is a process to fix [2] in the atmosphere and synthesize [3] using [4] energy. Large quantities of [2] are fixed annually and accumulated in ecosystems as [3] for energy source. In an ecosystem, various matters circulate. For example, [5] in the atmosphere is fixed by [6], which can fix gaseous [5] directly, and after that it is absorbed by plants, symbiotic with that [6]. Then, [5] is provided to soils by the death of plants and/or abscission of leaves and branches, decomposed by soil [6], and partly returns to the atmosphere by denitrification. Natural regulation of population is an important function of an ecosystem and a population density of each species is maintained as a result of mutual interactions of diversified species, providing resilience to the ecosystem to some extent. In order for natural regulation of population, and maintenance and resilience of the system, biological interactions are significant and the conservation of 1) bio-diversity is prerequisite. When bio-diversity of a system is well conserved, natural regulation of population, and maintenance and resilience of the system can work well. On the other hand, although agricultural lands, an artificial ecosystem, have various functions like natural ecosystems, they differ from natural ecosystems in many ways. Generally, 2) ecosystems on agricultural lands are unstable and fragile, in comparison to natural ecosystems.

Ecologically, weeds are plant species adapted to disturbed environments. Agricultural lands fundamentally form an ecosystem frequently disturbed by human beings and provide weeds with appropriate habitats. Therefore, weeds grow very well on agricultural lands. Because both crops and weeds are adapted to the same environment, it is difficult to control and eradicate weeds in agricultural lands. As grown in the same habitat, 3) hybridization between crops and weeds frequently occurs, sometimes resulting in the generation of new crops or weeds. 4) Crops have been selected by human beings and differ in many ways from wild plants and weeds.

1. Fill in the blanks ([1]-[6]) in the above passage from the list given below and record the appropriate letters (A–O) in the designated spaces (II–1 (1)~(6)) on the answer sheet.

- | | | |
|------------|----------------|------------------|
| A Annelida | B carbohydrate | C carbon dioxide |
| D dormancy | E heat | F insects |
| G light | H lipid | I microorganisms |
| J nitrogen | K oxygen | L photosynthesis |
| M protein | N respiration | O water |

2. To quantitatively evaluate the bio-diversity of the system shown in the underlined part 1, various diversity indices are used. The following equation shows the calculation method of one of the popular indices, Simpson's diversity index (D). Now, there are 4 plant populations i) – iv), with the same area and the same number of composed species, shown in tables below. Regarding Simpson's diversity index and these 4 populations, which statement is incorrect? Record the letter (A–E) of the incorrect sentence in the designated space (II–2) on the answer sheet.

Equation:
$$D = 1 - \sum_{i=1}^S p_i^2$$
 (S : number of species, p_i : n/N , n : number of individual of i th species, N : Total number of individual)

Tables

i) Paddy field in a temperate area

Species	Number
rice	24
<i>Echinochloa oryzicola</i> *	1
<i>Sagittaria</i> *	1
water chestnut *	1
common duckweed *	1
water clover *	1
common sedge *	1

ii) Maize field in the tropics

Species	Number
maize	18
common crab grass *	3
goose grass *	1
green foxtail *	3
weedy sorghum *	3
common purslane *	1
Bermuda grass *	1

iii) Home garden in the tropics

Species	Number
maize	6
cassava	3
chilli pepper	9
groundnut	3
eggplant	3
common crab grass *	3
green foxtail *	3

iv) Wild bush forest in the tropics

Species	Number
paper mulberry **	6
bamboo A **	3
bamboo B **	6
cogon grass *	3
wild sorghum **	6
wild bitter gourd **	3
boneset *	3

* weed, ** wild plant

- A The larger the Simpson's diversity index D , the larger the bio-diversity of the system.
- B As the paddy field in a temperate area (i) is well managed, the bio-diversity is small.
- C The bio-diversity of the maize field in the tropics (ii) is smaller than that in the paddy field in the temperate area (i).
- D The bio-diversity of the tropical home garden (iii), with diversified crop species, is higher than those of the paddy field in the temperate area (i) and the maize field in the tropics (ii).
- E The bio-diversity of the wild bush forest in the tropics (iv) is higher than those of the paddy field in the temperate area (i) and the maize field in the tropics (ii).

3. Regarding the ecosystems of agricultural lands shown in the underlined part 2, which statement is incorrect? Record the letter (A–E) of the incorrect sentence in the designated space (II–3) on the answer sheet.

- A As a few crop species occupy most of the system, bio-diversity is low.
- B As human beings manage the system, the ability to restore the system is almost lost.
- C As the species composition is simple, natural regulation of population works well.
- D Depletion of specific elements is conspicuous.
- E As the harvest is brought out of the system, material circulation is not completed.

4. Regarding hybridization between crops and related weed species, as indicated in the underlined part 3, which statement is incorrect? Record the letter (A–E) of the incorrect sentence in the designated space (II–4) on the answer sheet.

- A In the case where both a crop and weed belong to the same species, hybridization occurs frequently and fertile seeds are produced.
- B In the case where a crop belongs to the same genus as a weed but different species, hybridization is not rare, but fertile seeds are produced in rare cases.
- C In the case where a crop and a weed belong to the different genera, hybridization rarely occurs.
- D In the case where a diploid crop hybridizes with a tetraploid weed with the same genome composition, F1 hybrid plants produce fertile seeds.
- E In the case where an F1 hybrid plant between a crop and a weed hybridizes repeatedly with the crop in the following generations, genes of weeds disappear soon in many cases.

5. Concerning the different traits of crops compared to those of weeds and wild plants, as indicated in the underline part 4, which statement is inappropriate in the case of cereal crops? Record the letter (A–E) of the inappropriate sentence in the designated space (II–5) on the answer sheet.

- A Utilized parts are gigantic.
- B Seeds shatter and fall before ripening.
- C Seeds does not show dormancy.
- D Seeds do not have a light-germinating trait.
- E There are very few spines or prickles in leaves, stems and testa.

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

The salt concentration of the body fluid in marine bony fishes, such as the cod, is approximately [1] % of the sea water. Therefore, such fishes constantly lose water, and balance the water loss by drinking large amounts of seawater. By drinking sea water, however, these fishes also incorporate salts. They make use of both their [2] and [3] to rid themselves of salts. In the [2], [4] actively transport Cl^- out, and Na^+ follows passively. In the [3], excess Ca^{2+} and SO_4^{2-} are excreted with the loss of only small amounts of water

Like bony fishes, marine cartilaginous fishes, such as sharks, have an internal salt concentration much less than sea water, so salts tend to diffuse into their bodies from the water, especially across their [2]. Unlike bony fishes, however, marine cartilaginous fishes are not hypoosmotic to sea water. The body fluid of these fishes contains high concentration of urea, a nitrogen waste product of protein metabolism, and these fishes keep an osmolarity slightly higher than that of sea water. Water slowly enters the body of these fishes by osmosis. This small influx of water is disposed of in urine.

The body fluids of freshwater animals must have salt concentrations higher than those of freshwater because animal cells cannot tolerate the low salt concentrations of freshwater. Having internal fluids with an osmolarity higher than that of their surroundings, freshwater bony fishes, such as the gold fish, face the problem of gaining water by osmosis and losing salts by diffusion. These fishes solve the problem of water balance by excreting large amounts of very dilute urine. At the same time, salts lost by diffusion and in the urine are replenished by eating, and [4] in the [2] actively transport Cl^- into the body, and Na^+ follows.

1. Fill in the blanks ([1]-[4]) in the above passage from the list given below and record the appropriate letters (A-P) in the designated spaces (III–1 (1)~(4)) on the answer sheet.

A	10	B	33	C	66
D	100	E	150	F	200
G	300	H	chloride cells	I	contractile vacuoles
J	gills	K	guts	L	kidneys
M	lungs	N	salt glands	O	skin
P	sweat glands				

2. As shown in the underlined statement 1, marine bony fishes drink large amounts of seawater. Do marine cartilaginous fishes and freshwater bony fishes drink their surrounding water or not? Choose the most appropriate answer from A–D and record the letter in the designated space (III–2) on the answer sheet.

- A Both marine cartilaginous fishes and freshwater bony fishes drink large amounts of their surrounding water.
- B Marine cartilaginous fishes drink large amounts of sea water, but freshwater bony fishes drink almost no water.
- C Freshwater bony fishes drink large amounts of fresh water, but marine cartilaginous fishes drink almost no water.
- D Both marine cartilaginous fishes and freshwater bony fishes drink almost no water.
3. As shown in the underlined statement 2, urea is a major nitrogen waste product of protein metabolism in cartilaginous fishes. Choose two other animal groups that excrete urea as a major nitrogen waste product of protein metabolism from the list given below, and record the appropriate letters (A-F) in the designated spaces (III-3 (1)~(2)) on the answer sheet.
- | | |
|-----------------------|-----------------------|
| A amphibians (adults) | B amphibians (larvae) |
| C birds | D bony fishes |
| E mammals | F reptiles |
4. Although urea is synthesized in the whole body of cartilaginous fishes, urea synthesis is restricted to an organ in the two animal groups that you answered in the previous question. Choose the name of this organ from A-F and record the letter in the designated space (III-4) on the answer sheet.

- | | | |
|-----------|---------|--------|
| A bladder | B gill | C gut |
| D kidney | E liver | F lung |

IV. Read the following passage and answer the subsequent questions 1-3.

A worker ant forages out of the nest, and when it finds food, it brings the food back to its nest. When foraging, the ant hovers around, but when it finds food, it returns straight to its nest. Therefore, the ant knows the direction of the nesting location. Ants know the direction from a landmark such as a big tree, or by referring to the direction of the sun. Although a landmark does not usually change its place with time, 1the direction of the sun changes with time yet the ant precisely knows the direction of the nest. In addition, 2ants know the direction of the nesting location if any part of the blue sky is visible, even though the sun is covered with clouds.

When a worker ant returns to its nest, it deposits a substance called “trail pheromone” on the ground. Then other workers in the nest can also reach the food source by following the trail pheromone.

1. Among the sentences A-F about ants, choose two that are incorrect, and record the appropriate letters in the designated spaces (IV-1 (1)~(2)) on the answer sheet.

- A Worker ants are female, but they usually do not lay eggs.
- B Worker ants remove their wings by themselves.
- C In ants, females develop from fertilized eggs whereas males develop from unfertilized eggs.
- D The number of ant species that have been described is more than twice that of the number of mammal species.
- E Insects that live in colonies and manifest group integration, division of labor, and overlap of generations, such as ants, termites, bees and wasps are called “social insects”.
- F Ants, termites, bees and wasps are closely related systematically, and all of them are holometabolous insects.

2. Choose the physiological mechanisms that are closely related to the abilities shown in the underlined statements 1 and 2 from A-F, and record the appropriate letter for the underlined statement 1 in the designated space (IV-2(1)) and the appropriate letter for the underlined statement 2 in the designated space (IV-2(2)) on the answer sheet.

- | | |
|------------------|------------------------------|
| A chemical sense | B circadian clock |
| C color vision | D learning |
| E photoperiodism | F polarized light perception |

3. There are various pheromones other than the trail pheromone. Among the sentences A-F on chemical substances, choose two that do not meet the definition of the pheromone, and record the appropriate letters in the designated spaces (IV-3 (1)~(2)) on the answer sheet.

- A A female moth secretes a substance from the abdomen that evokes mating behavior in a male moth.
- B When a nymph of a stink bug is attacked by a lady beetle, the nymph secretes a stinky substance from the scent gland, and other nymphs walk away from the place.
- C A cockroach secretes a substance from the rectum to the feces, and the substance attracts other cockroaches.
- D A caterpillar secretes a substance into the saliva, and the substance attracts a parasitic wasp that lays eggs into the caterpillar.
- E A queen honey bee secretes a substance from the skin, and any workers that eat this substance are prevented from becoming queens.
- F A cricket brain secretes a substance into the body fluid, and the substance increases the aggressiveness of this cricket.

V. Choose the most suitable biological item 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 A phenomenon that two homologous chromosomes attach together during meiosis

- | | | |
|-----------------|------------|-----------------|
| A crossing-over | B deletion | C retrogression |
| D synapsis | E xenia | |

2 A steady state for a long period that appears at the end of vegetation succession

- | | | |
|------------------|---------------|---------------|
| A climax | B equilibrium | C homeostasis |
| D resting period | E stagnation | |

3 A biological process in which unnecessary portions are eliminated and portions with genetic information are connected together in RNA

- | | | |
|-----------------|---------------|------------|
| A exon | B intron | C splicing |
| D transcription | E translation | |

4 Organelle that does not exist in an animal sperm

- | | | |
|----------------|-------------------------|-------------|
| A central body | B endoplasmic reticulum | C flagellum |
| D nucleus | E mitochondrion | |

5 Animal group that does not undergo ecdysis

- | | | |
|------------|-------------|-------------|
| A Annelida | B Arachnida | C Crustacea |
| D Insecta | E Nematoda | |

6 Substance or cell that is not involved in natural immunity of vertebrates

- | | | |
|--------------|--------------|--------------|
| A antibody | B complement | C interferon |
| D lymphocyte | E macrophage | |