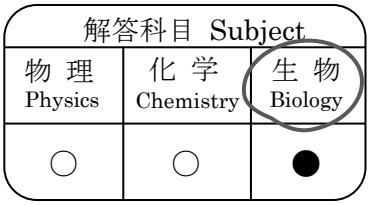
Biology

Marking Your Choice of Subject on the Answer Sheet

Choose two subjects from Physics, Chemistry, and Biology, and answer the questions for each. Use the front of the answer sheet for one subject and the back for the other.

As shown in the example on the right, if you answer the Biology questions, circle "Biology" and completely fill in the oval under the subject name.

＜解答用紙記入例＞



If you do not fill in the correct oval, your answers will not be graded.

Q1 The Earth was formed approximately [a] billion years ago, and it is believed that there was almost no [b] in the atmosphere of the primitive Earth. Organic compounds that make up life were created through chemical evolution, and primitive life forms emerged. It is thought that these organisms were either [c] or performed chemosynthesis, but eventually, organisms that performed photosynthesis emerged. As a result, organisms that utilized [b] for respiration appeared, and it is believed that eukaryotic organisms emerged through endosymbiosis. Choose the correct combination of terms to fill in [a] through [c] from the options ① to ⑥ below. [1]

	[a]	[b]	[c]
①	2.2	oxygen	autotrophic
②	2.2	oxygen	heterotrophic
③	2.2	carbon dioxide	autotrophic
④	4.6	carbon dioxide	heterotrophic
⑤	4.6	oxygen	autotrophic
⑥	4.6	oxygen	heterotrophic

Q2 In a population of a certain species where Hardy-Weinberg equilibrium holds, the number of alleles *A* and *a* in the gene pool are 8000 and 2000, respectively. Choose the correct ratio of the number of individuals with genotype *AA* to the number of individuals with genotype *Aa* in the next generation from options ① to ⑧. The ratio is expressed in the order of *AA* : *Aa*. [2]

① 1 : 1	② 1 : 2	③ 2 : 1	④ 1 : 4
⑤ 4 : 1	⑥ 2 : 5	⑦ 5 : 2	⑧ 8 : 1

Q3 Choose the correct classification combination for coral, sea urchin, and amphioxus (lancelet) from the options ① to ⑧. [3]

	Coral	Sea Urchin	Amphioxus
①	Cnidaria	Echinodermata	Chordata
②	Cnidaria	Echinodermata	Porifera
③	Echinodermata	Cnidaria	Chordata
④	Echinodermata	Cnidaria	Porifera
⑤	Porifera	Arthropoda	Echinodermata
⑥	Porifera	Annelida	Echinodermata
⑦	Arthropoda	Porifera	Cnidaria
⑧	Annelida	Porifera	Cnidaria

Q4 How many of the elements in the following group are part of the composition of eukaryotic chromosomes? Choose the correct answer from options ① to ⑦. 4

［Element Group］

Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Sulfur (S), Phosphorus (P)

① 1	② 2	③ 3	④ 4
⑤ 5	⑥ 6	⑦ None of the above	

Q5 Choose the correct combination of cytoskeletal structure and the protein that constitutes it, related to flagellar movement, from the options ① to ⑨. 5

	Cytoskeleton	Protein
①	Actin filaments	Collagen
②	Actin filaments	Myosin
③	Actin filaments	Tubulin
④	Intermediate filaments	Collagen
⑤	Intermediate filaments	Myosin
⑥	Intermediate filaments	Tubulin
⑦	Microtubules	Collagen
⑧	Microtubules	Myosin
⑨	Microtubules	Tubulin

Q6 Read the following statements (A) to (C) about transport proteins, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above." 6

[Statements]

(A) The glucose transporter transports glucose following the concentration gradient.

(B) Sodium-potassium ATPase transports sodium and potassium ions against the concentration gradient.

(C) Aquaporins transport water following the concentration gradient.

① (A), (B), (C)	② (A), (B)	③ (B), (C)	④ (A), (C)
⑤ (A)	⑥ (B)	⑦ (C)	⑧ None of the above

Q7 The chemical equation for respiration using glucose as the substrate is represented as follows:

$$C_6H_{12}O_6 + 6H_2O + 6O_2 \longrightarrow 6CO_2 + 12H_2O + \text{Energy}$$

If 22 g of carbon dioxide (CO_2) is produced by respiration, choose the correct mass of glucose consumed [g] from options ① to ⑧. Assume the atomic weights are H＝1.0, C＝12.0, O＝16.0. 7

① 10	② 15	③ 20	④ 25
⑤ 30	⑥ 35	⑦ 40	⑧ 50

Q8 Read the following statements (A) to (C) about respiration, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above." 8

[Statements]

(A) ATP is not synthesized in glycolysis or the citric acid cycle.

(B) When amino acids are used as substrates, they undergo deamination to form variousorganic acids, which are then incorporated into the citric acid cycle.

(C) When fats are used as substrates, they are broken down into glycerol and fatty acids, both of which are incorporated into glycolysis.

① (A), (B), (C)	② (A), (B)	③ (B), (C)	④ (A), (C)
⑤ (A)	⑥ (B)	⑦ (C)	⑧ None of the above

Q9 Read the following statements (A) to (C) about photosynthesis, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above." 9

[Statements]

(A) Chlorophyll primarily absorbs green light.

(B) In the Calvin cycle, CO_2 is fixed, and the resulting compounds are gradually oxidized to synthesize sugars.

(C) ATP is synthesized in the Calvin cycle.

① (A), (B), (C)	② (A), (B)	③ (B), (C)	④ (A), (C)
⑤ (A)	⑥ (B)	⑦ (C)	⑧ None of the above

Q10 When DNA is replicated, the bonds between complementary bases are broken, and the double helix structure is unwound by the action of [d]. A [e] is synthesized at the starting point of replication on the template strand, and from this point, DNA polymerase synthesizes the new strand in the [f] direction. Choose the correct combination of terms for [d] to [f] from options ① to ⑧. [10]

	[d]	[e]	[f]
①	DNA helicase	DNA primer	5´ to 3´
②	RNA helicase	DNA primer	5´ to 3´
③	DNA helicase	DNA primer	3´ to 5´
④	RNA helicase	DNA primer	3´ to 5´
⑤	DNA helicase	RNA primer	5´ to 3´
⑥	RNA helicase	RNA primer	5´ to 3´
⑦	DNA helicase	RNA primer	3´ to 5´
⑧	RNA helicase	RNA primer	3´ to 5´

Q11 How many of the following terms represent proteins? Choose the correct number from options ① to ⑧ [11]

［Term Group］ Basic transcription factor, Repressor, Operator, Promoter, Transcriptional regulator, Histone, Intron

① 1 ② 2 ③ 3 ④ 4
⑤ 5 ⑥ 6 ⑦ 7 ⑧ None of the above

Q12 Read the following statements (A) to (C) about frog development, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above." 12

[Statements]

(A) When the egg is fertilized, cortical rotation occurs, moving Dishevelled protein to the opposite side of the sperm entry point, which inhibits the degradation of β-catenin, leading to its accumulation.

(B) The side where β-catenin accumulates will form the future dorsal structures.

(C) At the end of the blastula stage, invagination occurs, and after the neurula stage, the embryo becomes a gastrula.

① (A), (B), (C)	② (A), (B)	③ (B), (C)	④ (A), (C)
⑤ (A)	⑥ (B)	⑦ (C)	⑧ None of the above

Q13 Read the following statements (A) to (C) about the human eye, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above." 13

[Statements]

(A) The ciliary body is a muscle that functions in near and far vision adjustment.

(B) The blind spot has no distribution of optic nerves.

(C) The macula has a high density of rod cells and cone cells.

① (A), (B), (C)	② (A), (B)	③ (B), (C)	④ (A), (C)
⑤ (A)	⑥ (B)	⑦ (C)	⑧ None of the above

Q14 Choose the correct order in which air vibrations are transmitted in the human ear from the options ① to ⑥. 14

① Eardrum → Lymphatic fluid → Ossicles → Basilar membrane

② Eardrum → Ossicles → Lymphatic fluid → Basilar membrane

③ Eardrum → Basilar membrane → Lymphatic fluid → Ossicles

④ Ossicles → Lymphatic fluid → Basilar membrane → Ossicles

⑤ Ossicles → Lymphatic fluid → Ossicles → Basilar membrane

⑥ Ossicles → Eardrum → Basilar membrane → Lymphatic fluid

Q15 When a neuron receives an excitatory neurotransmitter, various transport proteins (with one protein unrelated to the process) become active, leading to the generation of an action potential.

Protein A: A voltage-gated sodium channel that opens in response to a change in membrane potential.

Protein B: A voltage-gated potassium channel that opens in response to a change in membrane potential.

Protein C: A sodium channel that opens upon binding to a neurotransmitter.

Protein D: A potassium channel that opens upon binding to a neurotransmitter.

Choose the correct order in which these proteins function from the options ① to ⑧. 15

① C→A→B
② C→B→A
③ C→A→D
④ C→D→A
⑤ C→B→D
⑥ C→D→B
⑦ D→A→B
⑧ D→B→A

Q16 Read the following statements (A) to (C) about skeletal muscle contraction, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above." 16

[Statements]

(A) The length of the dark band does not change during contraction.

(B) The length of the light band shortens during contraction.

(C) The amount of creatine inside muscle cells increases with repeated contractions.

① (A), (B), (C)
② (A), (B)
③ (B), (C)
④ (A), (C)
⑤ (A)
⑥ (B)
⑦ (C)
⑧ None of the above

Q17 Read the following statements (A) to (C) about plant hormones, and choose the option from ① to ⑦ that contains all the letters corresponding to the correct statements. If none of the statements are correct, choose ⑧ "None of the above.". 17

[Statements]

(A) Auxin is involved in phototropism and seed germination.

(B) Ethylene is involved in fruit ripening and leaf abscission.

(C) Gibberellin is involved in stomatal opening and closing as well as stem elongation.

① (A), (B), (C)	② (A), (B)	③ (B), (C)	④ (A), (C)
⑤ (A)	⑥ (B)	⑦ (C)	⑧ None of the above

Q18 In an ecosystem, the position occupied by a species in terms of resources such as food or space, and how it uses them, is called [g]. The greater the overlap between different species in these aspects, the more intense the competition. However, even species with a large overlap may change their traits over a long period of time to coexist, and this trait change is called [h]. Additionally, species that occupy the same [g] in different ecosystems are called [i] species, and although they are evolutionarily different, they may have similar forms or diets. Choose the correct combination of terms for [g] to [i] from options ① to ⑧. 18

	[g]	[h]	[i]
①	ecological equivalent	trait transformation	ecological niche
②	ecological equivalent	character displacement	ecological niche
③	ecological equivalent	nonsense mutation	ecological niche
④	ecological equivalent	missense mutation	ecological niche
⑤	ecological niche	trait transformation	ecological equivalent
⑥	ecological niche	character displacement	ecological equivalent
⑦	ecological niche	nonsense mutation	ecological equivalent
⑧	ecological niche	missense mutation	ecological equivalent

Q19 Regarding the material balance of an ecosystem over one year, assuming the initial biomass of the producers is 100, the gross production is 550, the respiration amount is 200, and the amount of dead material is 50. Additionally, the assimilation amount of the primary consumers is 100, and the undigested excretion amount is 20. Choose the appropriate growth amount for the producers from options ① to ⑧. 19

① 50	② 100	③ 120	④ 180
⑤ 200	⑥ 300	⑦ 350	⑧ 500

Q20 A life table summarizes the survival of individuals over time as they age. The following table is a life table for a certain animal. Choose the correct combination of the species and its characteristics from options ① to ⑨. 20

Age	Number of survivors	Number of deaths
0	5000	4800
1	200	80
2	120	60
3	60	20
4	40	10

	Animal Species	Characteristics
①	Chimpanzee	produces many offspring (eggs) and has a high mortality rate in early life.
②	Chimpanzee	produces many offspring (eggs) and parents protect their young.
③	Chimpanzee	has a roughly constant mortality rate during growth.
④	Sardine	produces many offspring (eggs) and has a high mortality rate in early life.
⑤	Sardine	produces many offspring (eggs) and parents protect their young.
⑥	Sardine	has a roughly constant mortality rate during growth.
⑦	Crow	produces many offspring (eggs) and has a high mortality rate in early life.
⑧	Crow	produces many offspring (eggs) and parepznts protect their young.
⑨	Crow	has a roughly constant mortality rate during growth.

Q21 You want to introduce a gene into *E. coli* by recombining it with a plasmid. To do so, the DNA containing the target gene was cut using a restriction enzyme. Part of the base sequence of this fragment is shown in Figure 1. You want to insert this fragment into the site indicated by the arrow in the plasmid shown in Figure 2. The base sequence at the insertion site is shown in Figure 3. Choose the appropriate restriction enzyme to cut the plasmid from options ① to ⑨. The recognition sequences for each restriction enzyme are shown in Figure 4, with dashed lines indicating where the DNA strands are cut. 21

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AATTGTA·····GAC
    CAT·····CTGTTAA
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Figure 1: Fragment of the target gene

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·····GATAGTGGATCCAGAATTCCCGGGTGGC·····
·····CTATCACCTAGGTCTTAAGGGCCCACCG·····
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Figure 3: Base sequence of the insertion site

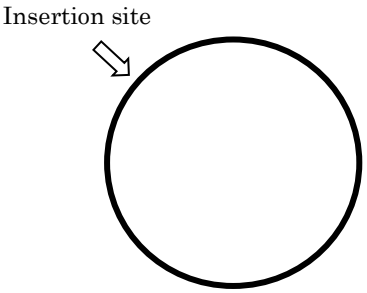


Figure 2: Plasmid

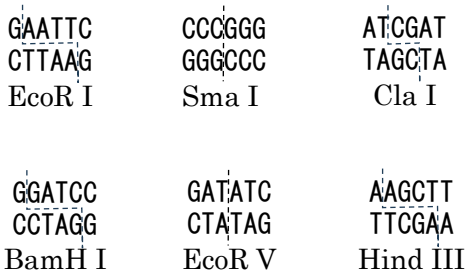


Figure 4: Restriction enzymes and their recognition sequences

① EcoR I ② Sma I ③ Cla I
④ BamH I ⑤ EcoR V ⑥ Hind III
⑦ Two appropriate enzymes exist.
⑧ Three appropriate enzymes exist.
⑨ Four appropriate enzymes exist.

Q22 In angiosperms, during the process of sperm cell formation, repeated occurrences of cytokinesis and nuclear division take place. When changes in the amount of DNA per nucleus were measured over time, the results appeared as shown in Figure 5.

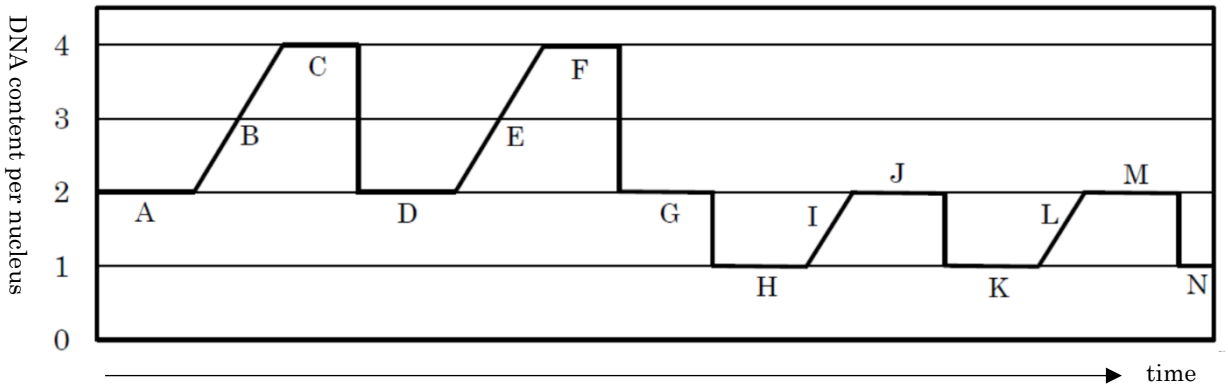


Figure 5: DNA content per nucleus during the process of sperm cell formation.

Among the following statements (a) to (e) regarding this process, choose the correct combination of statements from options ① to ⑩. 22

(a) D to H are included in the period of meiosis.
(b) During J to K, cells of equal size are produced through division.
(c) From one cell in the A stage, four sperm cells are produced.
(d) C to D and J to K include periods of mitosis.
(e) The DNA replicated in I and the DNA replicated in L contain the same genetic information.

① a, b	② a, c	③ a, d	④ a, e	⑤ b, c
⑥ b, d	⑦ b, e	⑧ c, d	⑨ c, e	⑩ d, e

End of Biology questions. Leave the answer spaces 23 ~ 75 blank.
Please check once more that you have properly marked the name of your subject as "Biology" on your answer sheet.

Do not take this question booklet out of the room.