Entrance Examination

For October 2016 and April 2017 students

Master's Course

(Specialized subjects)

Notes

- Name, examinee's number and course name should be written on the top of each answer sheet.
- Select and answer three QUESTIONS from the total twelve major QUESTIONS. The three QUESTIONS can be selected from any subjects.
- The QUESTION number you select should be written in the right box on each answer sheet. "Question number" maybe written appropriately.
- One sheet should be used for each selected QUESTION. The reverse side could be used, if necessary.

Division of Biosphere Science

Graduate School of Environmental Science

Hokkaido University

QUESTION 1 (Subject on Field Science)

Question 1-1. Figure shows light-response curve of photosynthetic rate of leaves (Lower right is enlarged view of weak light intensity). Point out which curve (a or b) is sun leaf or shade leaf. Explain the property of each leaf type.

Question 1-2. Explain light compensation point. If necessary, the figure may be used.

Question 1-3. Within a canopy (treetop region) of a tall tree (e.g. 20m in height), light intensity decrease quickly from upper layer to lower layer of the canopy. Describe what kind of spatial variation of herbivory (leaf damage by insects) occurs within a canopy. Explain the reason.

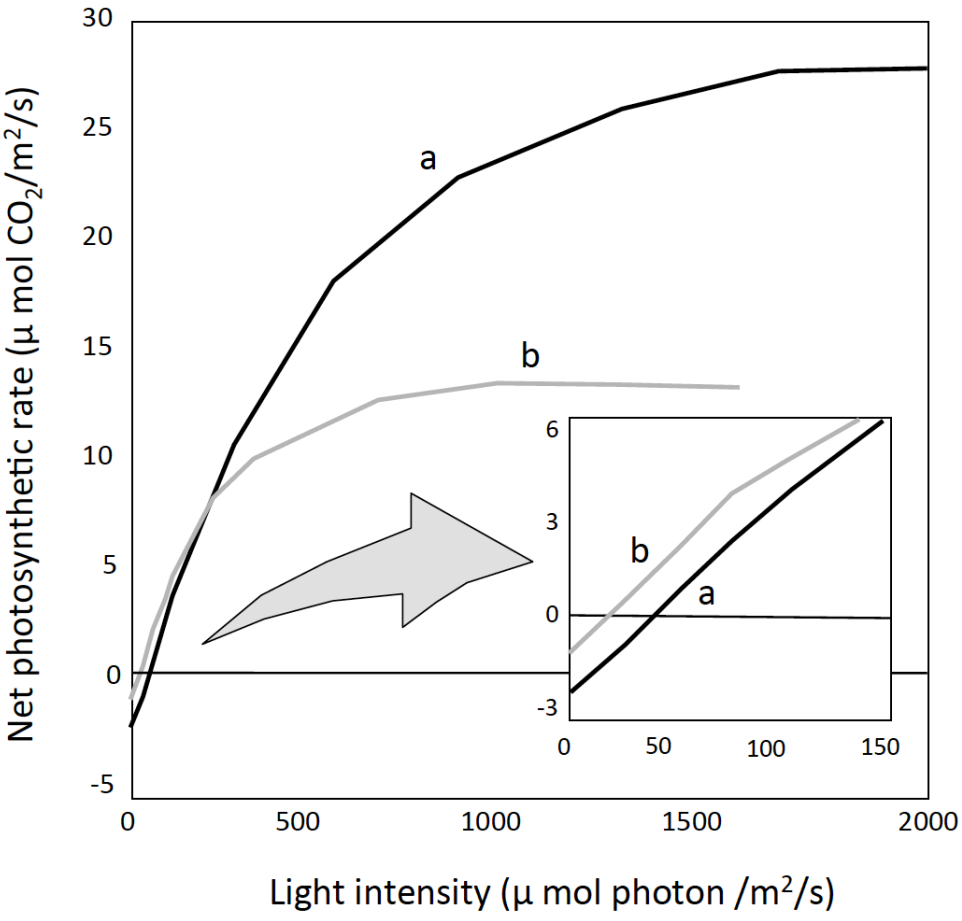


Fig 1

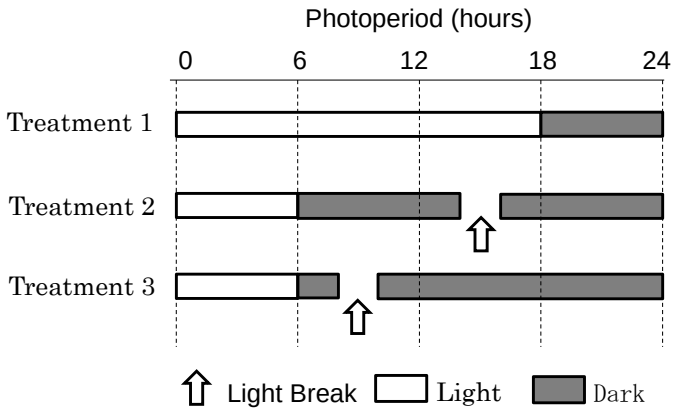
QUESTION 2 (Subject on Field Science)

Answer the following questions on plant photoperiodism

Question 2-1. Plants are divided into 3 types, short-day plant, long-day plant and day-neutral plant from the view point of photoperiodism. Explain the characteristics of short-day plant, long-day plant and day-neutral plant. Choose two applicable plants in each type from the plants described below.

petunia, soybean, cucumber, spinach, chrysanthemum, tomato

Question 2-2. For checking the flowering of short-day plant (A) and long-day plant (B), three treatments shown below were conducted in the experiment. Critical dark period is 12 hours in both used plants. Select the plants (A or B) that will reach the flowering in the treatment. If both plants will not reach the flowering, write 'no flowering in both plants'.



Question 2-3. Point out the plants that are commercially cultivated with the control of light condition and explain such cultivation.

QUESTION 3　(Subject on Field Science)

Read the following text and answer questions from 1 to 4.

Altruistic behavior in biological organisms can be defined as an individual action which is at a cost to themselves but benefits another individual. In birds, more than two individuals besides parents, which are called (①), often contribute to the care of the young. Also, a (②) is another example of altruistic behavior, which can reduce the likelihood of predation of group members with attracting a predator to the caller. In eusocial colonies of ants and bees, (③) forgo reproduction during their entire lives, but forage for food, care for the young, and maintain the nest.

How can altruistic behavior evolve? Consider a gene, which promotes altruistic behavior. The gene increases the fitness of other individuals (i.e., benefit) at the expense of the one that performs the action (i.e., cost). Individuals, which possess the gene, have a (④) in a population by its behavior. Thus, the frequency of the gene will (⑤) in a gene pool through generations without other specific conditions. Accordingly, it can be expected that natural selection would eliminate altruism. However, this conclusion is not so compelling when the beneficiaries of altruistic behavior are close relatives. Close relatives have a (⑥) probability to carry the same genes than randomly selected individuals. Even if altruistic individuals lose their direct fitness, the same genes can pass through close relatives (i.e., the recipient of the altruism). If the average benefit of close relatives is greater than behavior's cost, a gene promoting altruistic behavior would increase in the frequency in a gene pool through generations.

Based on this idea, the following inequality specifies the conditions under which altruism evolves: $\underline{rB > C}$

where B is the benefit gained by the recipient of the altruism, C is the cost suffered by the donor of the altruistic behavior, and r is the genetic relatedness of the altruist to the beneficiary. Relatedness is the probability that a gene in the potential altruist is shared by the potential recipient of the altruistic behavior.

Question 3-1. Fill the blanks from (①) to (⑥) with the most appropriate term in the following box. Do not use the same term repeatedly.

workers; queen; helpers; parasites; disadvantage; advantage higher; lower; increase; decrease; food call; alarm call

Question 3-2.

(1) The underlined sentences explain one type of evolutionary selection. What is the name of the selection?

(2) The underlined sentences raise the importance of inclusive fitness for the evolution of altruistic behavior. Explain “inclusive fitness” in comparison with the usual definition of “fitness”.

Question 3-3. Imagine an animal society in which member individuals share one-fourth of their genes with one another in average. If the benefits of an altruistic act to a recipient individual is 3 but the costs of an individual of performing the behavior are 1, can the altruism evolve in this society or not? Based on the double-lined inequality, explain your prediction and reasoning.

Question 3-4. It is known that diverse social behaviors widespread in animals. On the other hand, researchers have recently begun to discuss social properties in plants. For example, plants receiving damage by herbivorous insects often emit specific volatiles as an airborne signal, and neighboring plants seem to respond to the volatile cues to increase levels of defense against herbivory. This communication may be more effective among plants that are closer relatives. Describe an appropriate design to experimentally test the phenomenon of the wavy-lined sentences. Illustrate an experimental design if you need.

QUESTION 4 (Subject on Field Science)

The following sentences mention the measurement of species diversity in biological communities. Read the text and answer to each question.

Research on species diversity in biological community uses multiple different indices depending on the research purpose and types of obtained data. The simplest measure of species diversity is “species richness” which is the number of species appearing each site or sample. Species richness varies with sampling area and effort, and it may underestimate true value if many rare species occur. In such case, adjustment considering differences in sampling area or effort is necessary to compare species richness among different sites.

Other measures of species diversity are also available. Even in the case when species richness of the samples is the same, we can evaluate that any communities with more even composition of the number of individuals are richer in diversity than those in which most of the individuals are belonging to small number of dominant species. The evaluation can be made by quantitatively obtaining “evenness” measure of the community. Some diversity indices have been developed to take into account both the species richness and the evenness, such as Shannon-Wiener Index and Simpson’s Index.

Question 4-1. In which situation should we use species richness or other diversity indices considering evenness (such as Shannon-Wiener Index and Simpson’s Index) ? Explain by listing advantages and disadvantages of different indices.

Question 4-2. We surveyed invertebrate community in three lakes by a sampling net and obtained the data in Table 1. Species richness, the number of individuals of each species, and the sampling effort (the number of net casts) varied among the lakes. We want to compare species richness by adjusting the difference in the sampling effort. Consider and explain available methods.

Question 4-3. We are planning to conserve these three lakes as nature reserves. However, due to budget limitation, we can only register them one by one. Which order do you register the lakes for the most effective conservation of invertebrate communities? Rank the three lakes and explain about the reason.

Table 1. The number of individuals for each invertebrate species collected from the three lakes

	Lake 1	Lake 2	Lake 3
Species 1	20	15	0
Species 2	5	1	0
Species 3	1	0	3
Species 4	15	5	0
Species 5	0	0	15
Species 6	12	3	0
Species 7	2	0	2
Species 8	8	2	0
Species 9	0	0	5
Species 10	3	1	1
The number of net sample	10	8	10

QUESTION 5 (Subject on Life Science)

The following sentences refer to the proteinogenic amino acids. Read the text, and answer to each question.

Amino acid is an organic compound having both of the amino and carboxyl groups in the molecule. In particular, the molecules in which two functional groups bind to the same carbon atom are referred to as the α-amino acids. About (①) types of natural amino acids are known to constitute the protein. Because all amino acids except glycine has an (②) carbon to which every different atoms or atomic groups bind to the center carbon atom, an optical isomer is present. However, all proteinogenic amino acids are (③)-amino acids. Amino acids are differently charging by the pH in the aqueous solution. In a neutral condition, positive and negative charges are thought to coexist in the same molecule as the (④)ion. Especially a pH at which the charge of the whole molecule is zero is referred to as (⑤). By chemical characteristics indicated by the side chains, amino acids are often classified into neutral, acidic, basic, and hydrophobic groups.

Question 5-1. Answer the most appropriate terms that are applied to the (①)~(⑤).

Question 5-2. For the underlined part, the following is a rational formula that represents the ionization equilibrium state of alanine at the different pH conditions. Answer the chemical formula that are applied to the [①]~[④], including the accurate state of charging.

Acidic aqueous solution	Neutral aqueous solution	Basic aqueous solution
N[①]-CH(CH_3)-COOH	N[②]-CH(CH_3)-CO[③]	NH_2-CH(CH_3)-CO[④]

Question 5-3. The following sentences are those described certain amino acid(s). Answer all the name of the amino acid corresponding to the description.

a) It has a side chain that binds to the amino group, and become imino acid. Its cyclic structure limits the formation of three-dimensional structures of a protein.
b) According to a highly reactive aliphatic hydroxyl group, it may be subject to phosphorylation, or glycosylation.
c) It has a highly reactive thiol group. A disulfide bond between the two molecules is known to stabilize the structure of a protein.
d) It has an aromatic side chain, and is required for the formation of hydrophobic regions of a protein. There is an absorption in the near ultraviolet region at 280 nm.

Question 5-4. Phenylketonuria is a human disease impaired in normal phenylalanine hydroxylase activities during the synthesis of tyrosine from phenylalanine. As the symptomatic treatment of this disease, proper maintenances of phenylalanine concentrations in the blood have been recommended by dietary restrictions. Briefly explain the reasons for this therapy from the point of view of amino acid metabolism.

QUESTION 6 (Subject on Life Science)

Read the following sentences, and answer the below questions.

Recently, infectious diseases such as Ebola hemorrhagic fever, Zika fever, dengue fever, AIDS and etc. have been threatening humans. Viruses, causing these infectious diseases, consist of two major substances, i.e. (i) and (ii), and lack (iii) that are minimum units of organisms, so that viruses are excluded from the definition of organisms. Most organisms possess (iv) as genetic substances, while many viruses have (v) as their genetic substances.

In general, for organisms to accomplish the functions of genes, (a)the "flow of genetic information" as shown by "(iv) => (v) => (i)" is important. This is thought to be the principle of biology. However, in case that viruses possessing (v) infect their hosts, (b)the flow of genetic information shows different patterns from that shown above. For the special patterns of genetic information flow at the time of infection, (c)a special enzyme is encoded in the genetic information of such viruses. In areas of biotechnologies, (d)analyses on expressed genes can be easily performed by using the enzyme.

Question 6-1-1.
Fill the blanks (i) ~ (v) with the appropriate words.

Question 6-1-2.
About the sentences underlined (a), what is called the "flow of genetic information"? In addition, explain the principle of biology.

Question 6-1-3.
Explain how the genetic information flow is, in case viruses having (v) infect hosts.

Question 6-1-4.
Describe the common name of the enzyme underlined (c).

Question 6-1-5.
About eh sentences underlined (d), explain the analytical method on expressed genes by using this enzyme, focusing on the enzyme function.

Question 6-1-6.
Most organisms possess "phenotypic plasticity", that are features changes phenotypes depending on environmental conditions. Briefly explain how gene expression mechanisms are involved in phenotypic plasticity.

QUESTION 7 (Subject on Life Science)

Bacterial cells were grown for several generations in a medium containing a heavy isotope of nitrogen (^{15}N) and then transferred to a new medium containing the normal lighter isotope (^{14}N). After the transfer, at one and two generations, samples of the bacteria were collected, and their DNA was dissolved in a solution of cesium chloride, which was spun rapidly in a centrifuge.

Question 7-1. Explain the experimental results (DNA band pattern) for the following the samples. (a) Unlabeled DNA of control cells, (b) DNA of cultured cells in the ^{15}N medium, (c) DNA of F_1 generation cells in the ^{14}N medium, (d) DNA of F_2 generation cells in the ^{14}N medium

Question 7-2. Answer a conclusion of this experimental result to continue in the following underlined part.

Replication of the DNA duplex _____.

We conducted an experiment to isolate the arginine synthesis-deficient mutants of *Neurospora crassa*. This fungus was cultured on an artificial medium in the test tube. The spores were irradiated to increase the frequency of mutation. The spores after irradiation were planted on a complete medium containing all the nutrients. Each spore colonies formed in the complete medium was transferred to a minimal medium. The deficient mutant of each gene was identified by growing on minimal medium supplemented with intermediates in biosynthesis pathway for arginine. This experiment revealed the relationship between the arginine synthetic pathway and the genes (Figure). This conclusion is leaded from the results of the presence or absence of growth on each culture medium.

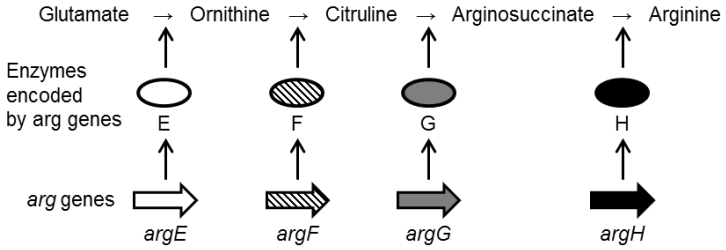


Figure. Conclusion

Question 7-3. Answer (1) – (16) in Table. When grown is "+", when no grown is "–".

Table. Growth of arginine synthesis-deficient mutants

Mutation in enzyme	Plus Ornithine	Plus Citruline	Plus Arginosuccinate	Plus Arginine
E	(1)	(2)	(3)	(4)
F	(5)	(6)	(7)	(8)
G	(9)	(10)	(11)	(12)
H	(13)	(14)	(15)	(16)

Question 7-4.

The number and type of proteins found in a cell can be influenced by genetic mutation and regulation of gene expression. Explain how these two processed differ.

Question 7-5.

If you are given a sample of DNA from an unknown organism, how could you determine the origin of the DNA sample?

Question 8 (Life Science)

Question 8-1. Read the following sentences and answer the questions.

Most animals and plants reproduce through sexual reproduction. Sexual reproduction is accomplished by meiosis and (①), and the life cycle is maintained by repeats of meiosis and (①). (①) means the fusion of each gamete having opposite sex to form a new cell, and (①) is also called syngamy.

The specific features of chromosome behavior during meiosis are found in prophase of meiosis I. At this time, homologous chromosomes are closely associated with the partner chromosomes. This process is called (②). The homologous chromosomes align along the metaphase plate. Then, each homologous chromosome is separated at each pole of the cell in telophase of meiosis I. As a result, meiosis I reduces the number of chromosomes by half. Therefore, first division of meiosis is called “reduction division”.

Another unique event takes place in prophase I of meiosis I. This is “genetic recombinant” or “crossing over”, which cause exchange of chromosomal materials partially between homologous chromosomes. The sites of crossing over on the chromosomes are called (③). Random combination of chromosomes and crossing over through sexual reproduction are key factors to increase genetic diversity.

Question 8-1-1. Fill the blanket (①) with appropriate word.
Question 8-1-2. Fill the blanket (②) with appropriate word.
Question 8-1-3. Fill the blanket (③) with appropriate word.
Question 8-1-4. Meiosis consists of two successive cell division, meiosis I and meiosis II. Meiosis II is similar to mitosis. But, meiosis II is different from mitosis regarding DNA replication. Describe the differences.

Question 8-2. Explain the meaning the following terms briefly.

(1) Karyotype
(2) Centromere
(3) Nucleolus
(4) Chromatid
(5) Spindle fiber (Spindle apparatus)

QUESTION 9 (Subject on Aquatic and Marine Science)

Read the following descriptions on the salinity adaptation in teleosts and answer the questions.

Salinity of seawater is approximately (A)‰, which can be expressed as (B)%. (C) and (D) are the two major ions composing approximately 86% of the total solute weight in seawater. Teleosts ("fish") have body ion concentrations lower than those of seawater, being around (E)% of seawater. The difference in ion concentration causes a difference in (F). In such situation, fish in seawater gain (G) and loss (H) from the environment. On the other hand, fish in freshwater gain (I) and loss (J). Both marine and freshwater fish have physiological mechanisms to overcome the difference in (F). Marine fish drink (K) and their (L) pumps (M) out by using energy (i.e. ATP). Divalent (M) is/are also extruded with a small volume of (N) in marine fish. Freshwater fish take (O) up at the (L), produce a large volume of (N) at the (P) to exclude excess (Q). These facts led some fish biologists to hypothesize that rearing marine fish in (R)% seawater saves energy for the regulation of (S) and should improve (T) of cultured fish.

Some groups of teleosts are capable of migrating between freshwater and seawater. ① Anadromous fish are species that migrate from seawater to freshwater for spawning, whereas ②catadromous fish migrate from freshwater to seawater for spawning. These species change their physiological system through the (U) before migration. A signal molecule from the (U) important for adapting to seawater is (V), whereas (W) is essential for freshwater adaptation.

Question 9-1. Fill each gap (A-W) by choosing the most appropriate word or the closest number from the box below. Note that the same word or number may be used more than once to fill different gaps (alphabets).

0.035, 0.35, 3.5, 35, H^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, OH^- H_2O, CO_2, HCO_3^-, ammonium, ethanol, ions, chlorides, acid, base, somatolactin, prolactin, growth hormone, thyroxine, globulin, albumin, osmotic pressure, hydrostatic pressure, oxygen partial pressure, protein concentration, freshwater, brackish water, seawater, liver, kidney, gill, muscle, intestine, urine, mucus, feces, motor nervous system, endocrine system, immune system, growth, maturation

(continued on the next page)

Question 9-2. Provide a species name for each of the underlined ①anadromous and ②catadromous fish.

QUESTION 10 (Subject on Aquatic and Marine Science)

Question 10-1. There are distinct differences between marine primary producers (phytoplankton) and terrestrial primary producers (plants). Describe these differences at the following viewpoints and explain the reasons for these in relevant to environmental characteristics in their habitat.

Viewpoints:

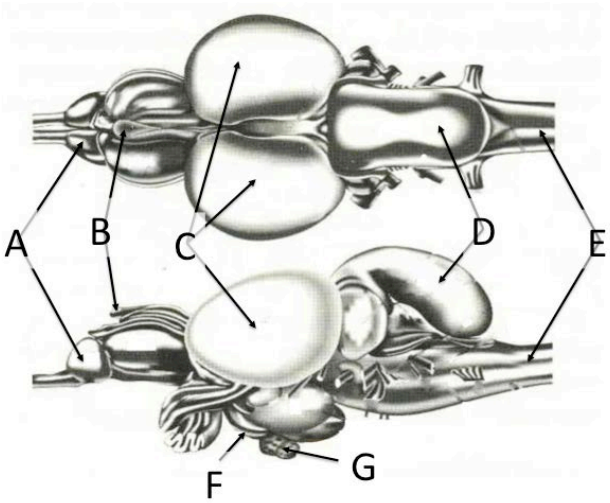
(1) Size
(2) Basic structure
(3) Acquisition
(4) Constituents
(5) Predation
(6) P/B ratio (production/biomass ratio)

Question 10-2. Select three of the following five terms and explain the meaning respectively.

(1) Nutrient
(2) Microbial loop
(3) CTD
(4) Global deep water flow (thermohaline circulation)
(5) Ocean acidification

QUESTION 11 (Subject on Aquatic and Marine Science)

These figures are shematic dorsal and lateral views of the brain of rainbow trout. Answer the questions from 11-1 to 11-2.



Question 11-1. Select the name and function of the parts at A to G in this figure from following wards and explanations.

【Part name】

1. hypophysis	2. cerevellum	3. spinal cord
4. olfactory bulb	5. optic lobe	6. hypothelamus
7. epiphysis	8. medulla oblongata	9. telencephalon

【Function】

i. Modulation of seasonal and circadian rhythm
ii. Secresion of several hormones, namely growth hormone, thyroid stimulating hormone and so on.
iii. Main target of optic nerve
iv. Main target of olfactory nerve
v. Integration of environmental information and neural reguration of growth and osmolality
vi. Connection between brain and all part of body through sensory and morter neuron
vii. Integrations of sensory perception and motor control

(continued on the next page)

Question 11-2. In the propagation of bony fish, we can get mature eggs from female fish by three methods of artificial stimulations or endocrinological treatments that mimic the three function of the three parts of brain in the figure. Indicate the three brain parts and explain the procedures for artificial induction of ovulation.

QUESTION 12 (Subject on Aquatic and Marine Science)

Question 12-1. The table below summarizes environment and characteristics of r- and K-selected organisms**.** Select the (A) to (V) with the most appreciate words or phase from the following choice ① to ㉒. The choices at "Population size" and "Selection favors" are in no particular order.

	r- selection	K- selection
Climate	(A)	(B)
Mortality	(C)	(D)
Population size	(E),(F) *Random order	(G),(H) *Random order
Intra- and inter specific competition	(I)	(J)
Selection favors	(K),(L),(M),(N),(O) *Random order	(P),(Q),(R),(S), (T) *Random order
Length of life	(U)	(V)

①	Fairly constant and/or predictable	②	Variable and/or unpredictable
③	Usually well below carrying capacity of environment	④	Often catastrophic, nondirected, density independent.
⑤	More directed, density dependent	⑥	Variable, often lax
⑦	At or near carrying capacity of the environment	⑧	Rapid development
⑨	Greater competitive ability	⑩	Variable in time, nonequilibrium
⑪	High maximal rate of increase	⑫	Fairly constant in time, equilibrium
⑬	Small body size	⑭	Early reproduction
⑮	Slower development	⑯	Delayed reproduction
⑰	Usually keen	⑱	Many small offspring
⑲	Larger body size	⑳	Short
㉑	Longer	㉒	Fewer, larger progeny

Question 12-2. If two different seawater masses (A and B) with different temperatures, salinities and a same density are mixed in the equal proportion, the mixed water mass (C) will have an averaged temperature and salinity. Explain the density of the mixed water mass (C) becomes denser than that of the original water masses (A and B) graphically using T-S diagram.