Student Code: _____

22nd INTERNATIONAL BIOLOGY OLYMPIAD

July 10-17, 2011

Taipei, Taiwan

THEORETICAL TEST: PART A

Duration: 120 minutes

Dear participants,

- Check your **Student Code** on the **Answer Sheet** before starting the test.
- The questions in Part A have **only one** correct answer. Fill your answer in the Answer Sheet.

  Mark the correct answer with "X" on the Answer Sheet clearly, as shown below.

No.	A	B	C	D	E	F
A0	X					

- You can use a ruler and a calculator provided.
- Write down your results and answers in the **Answer Sheet**. **Answers written in the Question Paper will not be evaluated.**
- Some of the questions may be marked "DELETED". DO NOT answer these questions.
- The maximal point of Part A is 116 (2 points each for each question).
- Stop answering and put down your pen IMMEDIATELY after the end bell rings.

:

Good Luck!!

I. Cell Biology

A1. Endorphin is a natural analgesic secreted by the pituitary gland. Upon binding to its receptor in brain cells, endorphin can relieve pain and create a sense of euphoria. Morphine can achieve similar pain relief effects by binding to the endorphin receptor. Why do both endorphin and morphine bind to the endorphin receptors in brain cells?

(A) Sizes of both molecules are similar.

(B) Molecular weights of both molecules are similar.

(C) Both are isomers.

(D) Shapes of both molecules are similar.

(E) Net charges of both molecules are identical.

A2. Most biological macromolecules are made by the polymerization of small principal components. The major structural polysaccharide of the insect exoskeleton is a polymer. Which of the following statements regarding this kind of polysaccharide is **NOT correct**?

(A) It is made by polymerization of glucose.

(B) It contains C, H, O and N atoms.

(C) Its structure is similar to that of cellulose.

(D) It can be used to produce chitosan and glucosamine in industry.

(E) This polymer can also been found in the cell wall of fungi.

A3. In some cells, synthesis of isoleucine from threonine is catalyzed by the sequential action of five enzymes a, b, c, d and e which produce 4 intermediates A, B, C, D, and the end product isoleucine, respectively. What is most likely to happen when isoleucine is overproduced and there is an ample supply of threonine in cells?

(A) Isoleucine associates with threonine to inhibit the activity of enzyme a.

(B) Isoleucine associates with intermediate D to inhibit the activity of enzyme e.

(C) Isoleucine binds to enzyme a and inhibits its activity.

(D) Isoleucine binds to enzyme e and inhibits its activity.

(E) Threonine is converted into isoleucine continuously through the 5 enzymes.

A4. In some prokaryotic organisms, SO_4^{2-} is used as the final electron receptor at the end of electron transport chain during cellular respiration. Which of the following statements regarding cellular respiration in these prokaryotic organisms is **NOT correct**?

(A) It is anaerobic respiration.

(B) The reception of electron by SO_4^{2-} is accompanied by the production of H_2O.

(C) Operation of the electron transport chain builds up a proton motive force.

(D) ATP can be produced.

(E) Production of ATP is correlated with the mobility of H^+.

A5. Three stages in bacteria growth are:

I. Lag phase

II. Log phase

III. Stationary phase

In which phase or phases can penicillin inhibit the synthesis of the bacterial cell wall?

(A) Only I

(B) Only II

(C) Only III

(D) Only I and II

(E) Only I and III

(F) I, II and III

A6. Which structural or physiological feature of bacteria can be used as a target for developing drugs to kill bacteria effectively but with no harm to human cells?

(A) Glycolysis

(B) Components of plasma membrane

(C) Components of ribosome

(D) Components of the electron transport chain in aerobic respiration

(E) Requirement of oxygen

A7. Histones are small basic proteins that assemble with DNA molecules to form chromosomes. There are five histones, including H1, H2A, H2B, H3 and H4, in eukaryotic cells. Which of the following structural features of chromosomes is associated with Histone H1?

(A) Telomere

(B) Nucleosome fiber (10-nm fiber)

(C) 30-nm fiber

(D) Looped domains

(E) Centromere

A8. DNA is a double helix molecule containing four different types of nitrogen bases. Which of the following statements regarding both the replication and chemical composition of DNA is correct?

(A) Base sequences of both strands are the same.

(B) The amount of purine is equal to that of pyrimidine in a double-stranded DNA.

(C) Both strands are synthesized continuously in 5'→3' direction.

(D) The first base of the newly synthesized DNA is catalyzed by DNA polymerase.

(E) The proof-reading activity of DNA polymerase proceeds in the 5'→3' direction.

A9. Mister Spiderman has compared the DNA, the corresponding RNA and protein sequences of many human genes. What conclusion can be drawn from the sequence comparison?

(A) The number of exons is always more than that of introns.

(B) The translation start codon is located within the first exon.

(C) The translation stop codon is located within the last exon.

(D) The G nucleotide of RNA capping is the first nucleotide transcribed from DNA.

(E) The polyA tail is transcribed from the polydT of DNA.

A10. Miss Ling-Ling conducts DNA synthesis and transcription reactions in two separate test tubes. Which of the following substances needs to be added to both reactions?

(A) ATP

(B) DNA template

(C) RNA primer

(D) DNA polymerase

(E) DNA ligase

A11. The Nobel Prize in Physiology or Medicine 2009 was awarded jointly to Blackburn, Greider and Szostak for the discovery that chromosomes are protected by telomeres and the enzyme telomerase is highly correlated with aging and cancer in animals. Which of the following statements regarding telomere and telomerase is correct?

(A) Telomerase is a DNA exonuclease.

(B) Telomerase is an RNA polymerase.

(C) Embryonic cells possess long telomeres and high telomerase activity.

(D) Telomeres are longer and telomerase is inactive in cancer cells.

(E) Telomeres are longer and telomerase is highly active in somatic cells.

A12. *Eco*RI restriction enzyme is a DNA endonuclease that can recognize the sequence GAATTC. It was first discovered in *E. coli*, therefore it was named *Eco*RI. To produce a large quantity of the endonuclease, the DNA fragment encoding the gene was subcloned into an expression plasmid and the resultant recombinant plasmid was transformed into *E. coli* cells to produce recombinant enzyme for a study. Why is the host DNA not cleaved by the recombinant *Eco*RI?

(A) The host DNA does not contain *Eco*RI cleavage sites.

(B) *Eco*RI is secreted out of the host cells.

(C) Environmental factors such as temperature and pH value inhibit *Eco*RI activity.

(D) The *E. coli* host produces inhibitors to block *Eco*RI activity.

(E) The *Eco*RI cleavage sites within the host DNA are modified.

II. Plant anatomy and physiology

A13. Hypersensitive response is one of the plant defense responses to pathogens. Each of four pathogen strains, **a** to **d,** produce a distinct range of effectors. One of the effectors, Avr, recognized by a specific receptor protein encoded by the resistance (R) gene in the host plant is present in strains **b** and **c**. Host plants **B** and **D** produce the R protein. Which plant(s) are likely to develop a hypersensitive response after the host plants **A** to **D** are infected by pathogens **a** to **d** (**a→A**, **b→B**, **c→C**, **d→D**), respectively?

(A) **A** only

(B) **B** only

(C) **C** only

(D) **D** only

(E) **B** and **C**

(F) **B** and **D**

A14. Plant movement occurs when plant organs change their spatial distribution after being exposed to stimuli, and may be caused either by differential growth or by differential turgor change among cells within the organs. Which of the following plant movements uses a mechanism distinct from the others?

(A) The gravitropic movement of corn roots

(B) The closure of soybean leaflets during night time

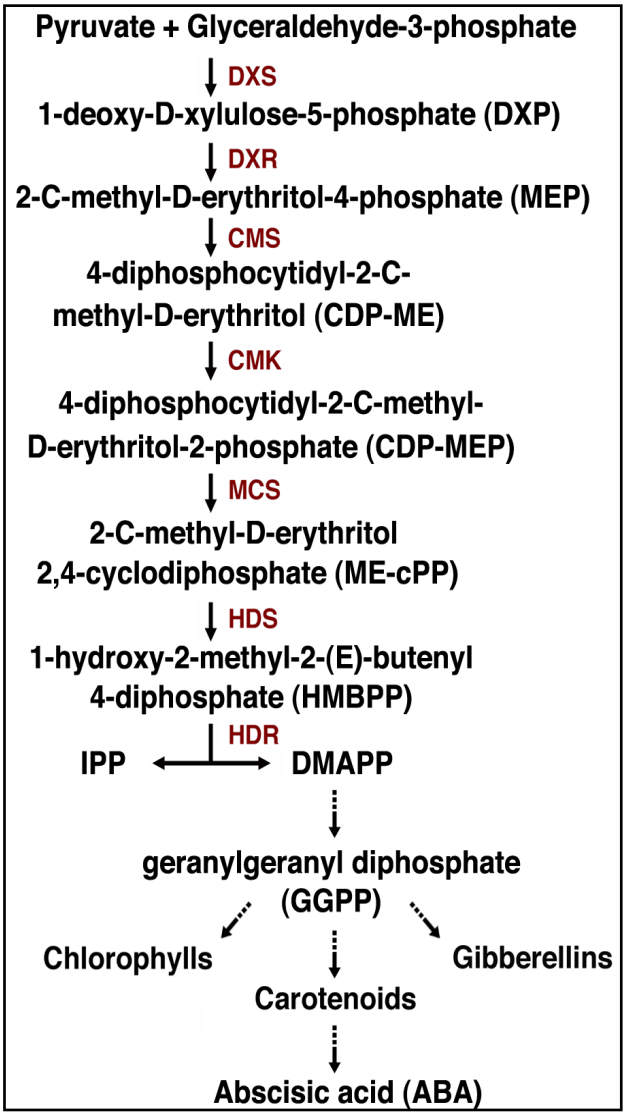
(C) The tentrils of cucumber moving along the trellis

(D) The phototropic movement of mungbean seedlings

(E) The downward bending of the tomato leaves after flooding treatment

Questions 15 and 16 are a **problem set**

A15. In the model plant Arabidopsis, the DXS, DXR, CMS, CMK, MCS, HDS and HDR enzymes are involved in the methyl erythritol phosphate (MEP) pathway of isopentenyl diphosphate (IPP) and dimethylallyl diphosphate (DMAPP) biosynthesis. The Arabidopsis *white devil* albino mutant is impaired in the enzyme HDS. Assuming Arabidopsis can efficiently take up the intermediate metabolites of the MEP pathway, the *white devil* albino mutant will grow and turn green if given which of the following compound?



(A) MEP

(B) CDP-ME

(C) CDP-MEP

(D) ME-cPP

(E) HMBPP

A16. The plant MEP pathway is located in which of the following organelle?

(A) nucleus

(B) vacuole

(C) chloroplast

(D) mitochondrion

(E) endoplasmic reticulum

A17. Dennis dissected a plant leaf and found bundle sheath cells full of starch granules. Which of the following characteristics can be observed in this plant?

I. Stomata open at night

II. Presence of PEP carboxylase in mesophylls

III. Presence of Rubisco in bundle sheath cells

IV. High photorespiration rate on hot summer days

V. Light reaction and carbon fixation occur in different cell types

VI. Carbon assimilation rate is saturated in the early morning on summer days

(A) Only I, III

(B) Only II, IV

(C) Only II, IV, V

(D) Only II, III, V

(E) Only II, III, V, VI

(F) Only II, IV, V, VI

A18. It has been estimated that around 124 million children are vitamin A deficient, causing about 500,000 children to go blind each year. To help children who suffer from vitamin A deficiency, scientists have developed a variety of rice (*Oryza sativa* L.), Golden Rice, through genetic engineering. The original Golden Rice was produced using the japonica variety Taipei 309, which is genetically enriched in

(A) auxin

(B) starch

(C) β-carotene

(D) iron

(E) anthocyanins

A19. Abscisic acid (ABA) is one of the important growth regulators of plants. It often antagonizes the functions of hormones that promote growth. Plant biologists have been interested in elucidating the signaling pathway of ABA by genetic approaches. They screened mutants of the model plant *Arabidopsis thaliana* that respond abnormally to ABA treatment to identify the involving components of the pathway. One type of mutant phenotype is ABA-insensitive (*abi*). Which of the following phenotypes are likely to be

observed in the *abi* mutants?

(1) Seeds germinate at the presence of exogenous ABA.

(2) Seeds become dormant at the presence of exogenous ABA.

(3) Stomata do not close in response to drought.

(4) More tolerant to drought than the wild-type plants.

(5) Leaf does not abscise when it becomes senescent.

(6) Leaf is prematurely abscised even when greenish.

(A) Only (1), (3)

(B) Only (2), (3)

(C) Only (2), (5)

(D) Only (2), (4), (5)

(E) Only (1), (3), (6)

(F) Only (2), (4), (6)

A20. Ethylene is a hormone that influences plant's growth and development. It is known that treatment with 10 ppm of 1-methylcyclopropene (MCP) can block the signal transduction of ethylene. If certain plant tissues were treated with 10 ppm MCP, which of the following phenotypes could be observed in MCP-treated tissues?

(A) Shorter hypocotyl in etiolated mung bean seedling

(B) Increased degradation of chlorophyll in detached leaves

(C) Increased synthesis of ethylene in banana fruits

(D) Inhibition of the ripening of tomato fruits

(E) Induction of the senescence of carnation cut flowers

A21. During leaf development in water lily, the sclereid-initials grow and elongate along the palisade mesophyll cells or the intercellular space between them. After elongation they gradually form calcium oxalate crystals in the cell wall along the cell membrane. Thereafter, they form the secondary cell wall. Four cell wall structures are: (I) primary cell wall; (II) secondary cell wall; (III) middle lamella; (IV) calcium oxalate crystals. What is the final sequence of structures in the mature sclereids of water lily, starting from the plasma membrane as the innermost layer to the outermost layer?

(A) I → IV → II → III

(B) III → IV → I → II

(C) I → IV → II → III

(D) III → I → IV → II

(E) II → IV → I → III

A22. *Agrobacterium tumefaciens*-mediated transformation, a widely used method to transfer foreign genes into the plant genome, has contributed to the considerable successes that plant biotechnology has already achieved. For instance, a gene encoding the coat protein (CP) of papaya ringspot virus (PRSV) was used to generate the virus-resistant transgenic

SunUp papaya in Hawaii. The construct used for transformation includes the *CP* gene and a selectable marker gene (*nptII*) conferring kanamycin resistance. Both *CP* and *nptII* genes are driven by a constitutive cauliflower mosaic virus (CaMV) 35S promoter. According to the above information, which of the following statements is **NOT correct**?

(A) The SunUp papaya is resistant to kanamycin.

(B) The SunUp papaya contains some DNA sequences from CaMV.

(C) The SunUp papaya contains some genomic DNA of *Agrobacterium tumefaciens.*

(D) The SunUp papaya contains a portion of the Ti plasmid termed T-DNA.

(E) The SunUp papaya contains the *nptII* gene.

III. Animal anatomy and physiology

A23. Which of the following is the only vertebrate in which blood flows directly from respiratory organs to body tissues without returning to the heart first?

(A) Fish

(B) Amphibians

(C) Mammals

(D) Reptiles

(E) Birds

A24. How does the hemocyanin of arthropods differ from the hemoglobin of mammals?

(A) The oxygen dissociation curve of hemocyanin is not a S-shape

(B) Hemocyanin carries considerably more carbon dioxide

(C) Hemocyanin is a single-chain respiratory pigment

(D) Hemocyanin is a protein coupled with magnesium

(E) Hemocyanin is a protein coupled with copper

A25. A shark is more likely to survive for an extended period of food deprivation than is a dolphin with equivalent size because

(A) The shark maintains a higher basal metabolic rate

(B) The shark expends more energy/kg body weight than the dolphin

(C) The shark invests much less energy in temperature regulation

(D) The shark metabolizes its stored energy more readily than the dolphin does

(E) The shark has a better insulation on its body surface

A26. Increased arteriolar resistance contributes to hypertension. Which one of the following factors contribute to the increased vascular resistance most significantly?

(A) Vessel length

(B) Blood viscosity

(C) Vascular diameter

(D) Total leukocyte counts

(E) Heart rate

A27. A method to estimate an mammal's blood volume uses a specific radioactive isotope of iodine(123I). This isotope, usually produced synthetically, has a half-life time of 13 hours. It decays to 123Te, which is almost perfectly stable. To estimate the blood volume, 10 mL of iodine solution are injected into the animal's vein. The activity of the solution at the injection is 2mSv. A sample of 10 mL of the animal's blood, taken 13 hours after the injection, is 0.0025mSv. The estimate volume of the animal's blood volume is?

(A) 10.0 L

(B) 8.0 L

(C) 4.0 L

(D) 2.5 L

(E) 1.25 L

A28. Which of the following events will result in an excitatory postsynaptic potential?

a. Increasing sodium influx.

b. Blocking potassium out-flux.

c. Increasing calcium influx.

d. Closing a chloride channel.

(A) Only a & b

(B) Only b & c

(C) Only a, c & d

(D) Only b, c & d

(E) a, b, c & d.

A29. Which of the following is the correct effect of hyperthyroidism (hypersecretion of thyroid hormone) on Thyrotropin-releasing hormone (TRH), thyroid-stimulating hormone (TSH), and Thyroid hormones T3 and T4?

↑: increase ↓: decrease —: remains unchanged

	TRH	TSH	T3	T4
A	↑	↑	—	↑
B	↑	↑	↑	—
C	↓	↓	↑	↑
D	↓	↓	↓	↓
E	↓	↑	↑	↑

A30. Which of following receptors/molecules are required for the activation of Helper T cells trigged by antigen-presenting cells.

1. CD8

2. CD4

3. Class I MHC molecule

4. Class II MHC molecule

5. T cell receptor

(A) Only 1, 3 & 5

(B) Only 2, 4 & 5

(C) Only 3, 4 & 5

(D) Only 2 & 4

(E) Only 1 & 3

A31. Inspect the following table which is revealed to the function of kidneys in vertebrate.

What	1. Urine concentration by NaCl reabsorption 2. Urine concentration by urea reabsorption 3. Aquaporin mediated water reabsorption
How	4. Countercurrent multiplier system 5. Countercurrent exchange
Where	6. Loop of Henle 7. Collecting duct 8. Proximal tubule

Figure out which of the following alternatives show a correct combination.

(A) 1-4-6

(B) 1-4-8

(C) 2-4-6

(D) 2-5-8

(E) 3-5-7

A32. When people lose blood quickly as happens in a car accident, which of the following situations will **NOT** occur

(A) Stroke volume increases; cardiac output increases

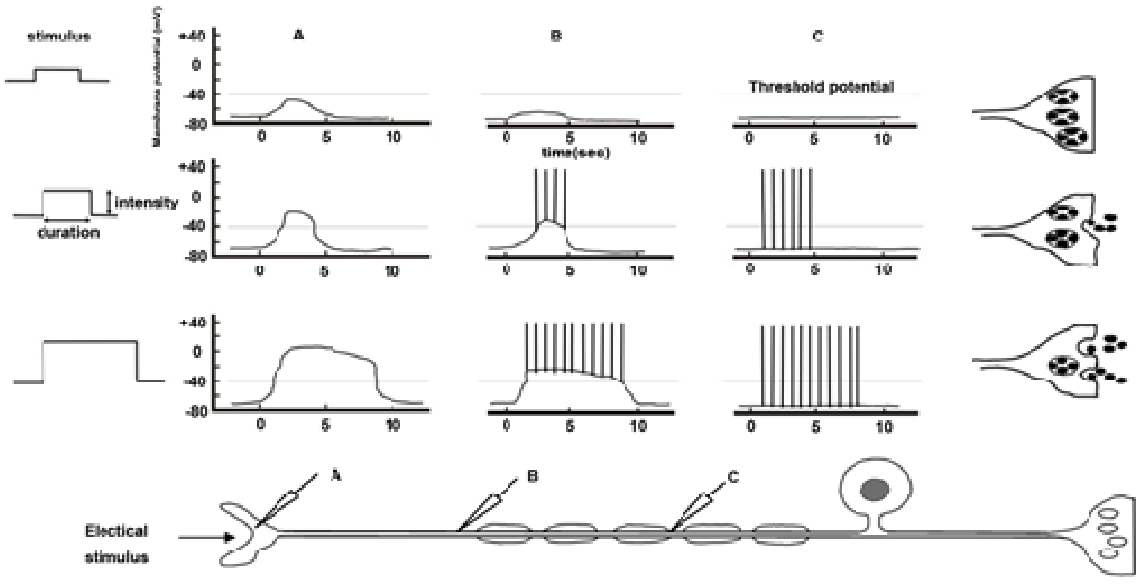
(B) Blood volume decreases but interstitial fluid increases

(C) Increase in the resistance of blood vessel

(D) Decrease of sodium concentration in urine

(E) Decrease in the proportion of red blood cells in blood.

A33. The following figure illustrates the membrane potential changes measured at three different sites (A, B, C) along a sensory neuron and the release of neurotransmitters from the axon termini when depolarizing electrical stimuli with varied intensities were applied to the dendrite. Based on the information provided in the figure below, choose the correct statements in the following box.



1. The membrane potential changes evoked at A site would be proportional to the intensity of the electrical stimuli applied to the dendrite.
2. An action potential would be recorded at B site only when the intensity of the applied current stimulus causes the membrane potential to be higher than the threshold potential in the axon hillock.
3. The frequency of the action potentials at B site is independent of the intensity of the applied current stimulus at A.
4. The quantity of the neurotransmitters released from the axon termini is unlikely to depend on the frequency of the action potential at C site.

(A) Only 1 and 2

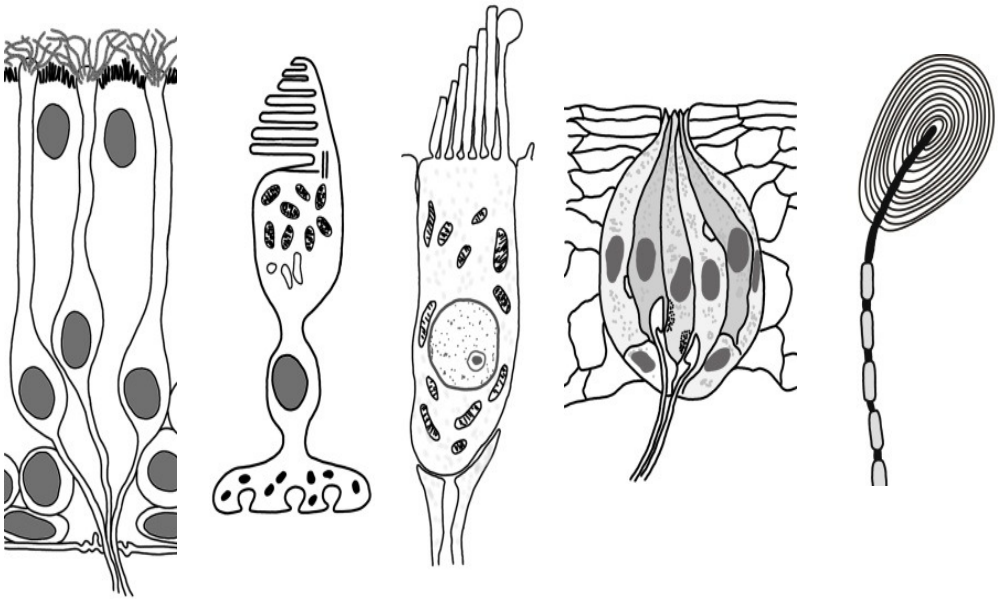
(B) Only 1 and 3

(C) Only 2 and 3

(D) Only 3 and 4

(E) Only 1, 2, and 3

A34. The perception of the messages from the environmental changes is carried out by specialized sensory cells. Their structural composition is in a strict accordance to their functions. Please analyze the following pictures and answer the question below:



1 **2** **3** **4** **5**

Which one of the above receptors in human receptors will be activated by a stimulation and trigger the opening of a potassium channel?

(A) 1

(B) 2

(C) 3

(D) 4

(E) 5

IV. Ethology

A35. There are three types of chemical substances that organisms emit to mediate interspecific interactions: kairomone, allomone, and synomone. Kairomone benefits individuals of another species which receives it but is disadvantageous to the emitter. Allomone benefits the emitter, and does not benefit or harm the receiver. Synomone benefits both the emitter and receiver. A plant species emits a volatile essential oil that attracts a phytophagous beetle to feed and lay eggs on its leaves. At the same time, it also attracts a parasitoid wasp, and helps this parasitic natural enemy of the beetles to locate the beetle larvae within which they can lay their own eggs. Which of the following descriptions of the role that this essential oil plays is correct?

(A) It acts as a synomone between the plant and the beetle, and an allomone between the plant and the parasitoid wasp.

(B) It acts as a kairomone between the plant and the parasitoid wasp, and a synomone between the beetle and the parasitoid wasp.

(C) It acts as a kairomone between the plant and the beetle, and a synomone between the plant and the parasitoid wasp.

(D) It acts as a kairomone between the plant and the beetle, and an allomone between the beetle and the parasitoid wasp.

(E) It acts as a kairomone between the plant and the parasitoid wasp, as well as between the

beetle and the parasitoid wasp.

A36. In terms of the benefits and harms received by each of the two parties interacting, which of the following pairs of biological interactions are most similar to each other?

(A) Clownfish and sea anemones; mistletoes and apple trees.

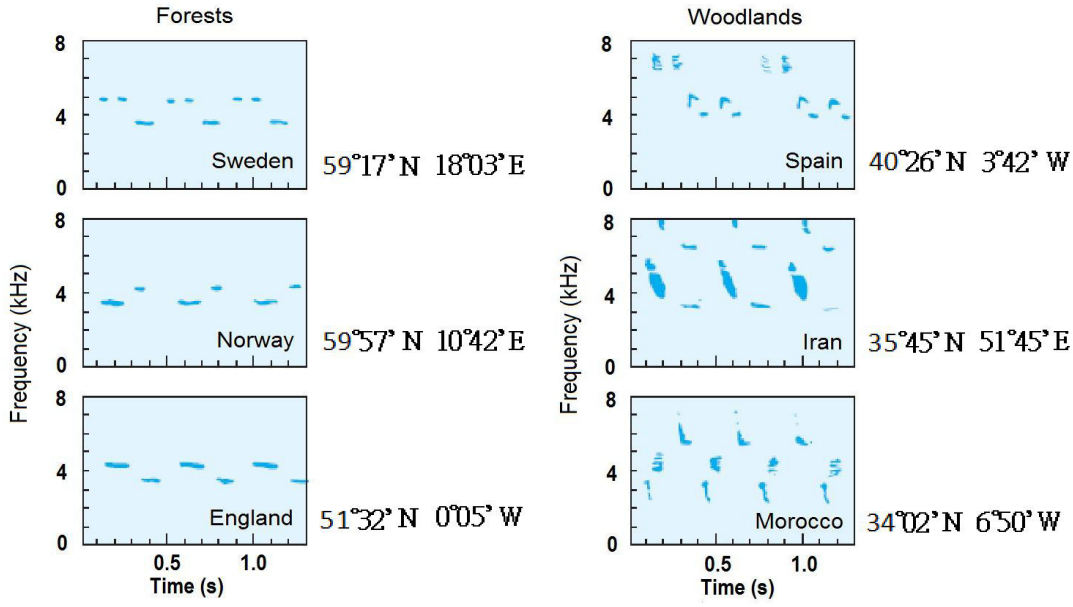
(B) Sea stars and bivalves; locusts and grasshoppers.

(C) Lichens and maples; mistletoes and oaks.

(D) Caterpillars and parasitic wasps; food plants and caterpillars.

(E) HIV virus and human; mushrooms and rotten woods.

A37. Great tits (*Parus major*) inhabiting forests and woodlands (patchy forest) have different song patterns. It is documented that high frequency sounds become less degraded in open habitat than in places with dense vegetation. Consider the following graphs showing song characteristics of great tits from 6 locations. Which of the following statements is correct?



(A) There is less variability in song frequency in low-latitude regions.

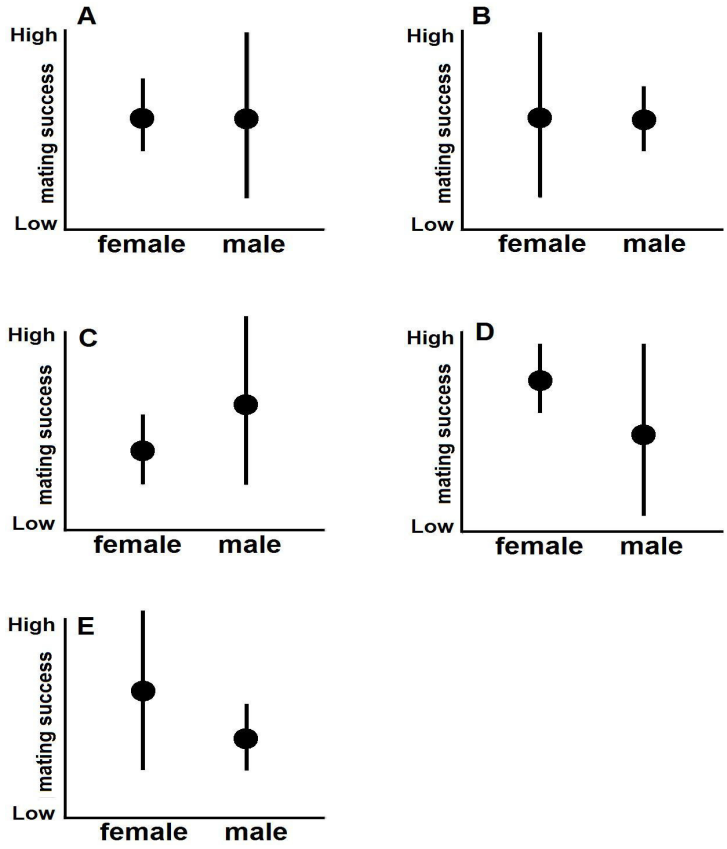
(B) Forest inhabitants are more varied in song frequency than woodland inhabitants.

(C) Songs of forest inhabitants have more notes per phrase than those of woodland inhabitants.

(D) The variation of song type has nothing to do with habitat type

(E) If an individual moves from forests to open grassland, the mean frequency of the song is likely to increase**.**

A38. A hypothetical insect species employs the polygynous mating system, in which the males are capable of multiple mating, but the females mate only once. The adults of this species occur in the fall when matings take place. All adults of this species die off soon after the mating season. The sex ratio of this species is 1:1. The below shows the comparison of the mating success, defined as the number of mating in a given season, for both male and female in this species. Which one of the graphs below (A to E) best describes the mean and variance of both male and female in this species? Solid dots represent means, and lines denote the ranges of variance.


A
High
mating success
Low
female
male
B
High
mating success
Low
female
male
C
High
mating success
Low
female
male
D
High
mating success
Low
female
male
E
High
mating success
Low
female
male

V. Genetics and evolution

A39. Frank has subcloned a cDNA fragment from an animal into an expression plasmid. The recombinant plasmid was transformed into bacteria to produce recombinant protein., What is the major reason that the expressed protein is non-functional ?

(A) Differences in codon usage between animals and bacteria

(B) Differences in protein modification between animals and bacteria

(C) Components of bacterial culture media

(D) Modulators of gene transcription

(E) Secretion signal of proteins

A40. Gregor Mendel discovered that segregation of genes on non-homologous chromosomes is independent of each other in his garden pea hybridization experiments. Four alleles A, B, C and D are located on four non-homologous chromosomes. Which of the following genotypes will have the highest chance to produce the dominant trait in all four loci when it mates with an organism with the genotype AaBbCcDd?

(A) aabbccdd

(B) AaBbCcDd

(C) AaBBccDd

(D) AaBBCCdd

(E) aaBBCCdd

A41. An X-linked allele determines the coat color of cats with orange being dominant and black being recessive. Which of the following statements regarding the inheritance pattern of orange/black mosaic cats is correct?

(A) Half of all male cats are mosaic.

(B) The mosaic phenotype is a consequence of gene interaction.

(C) The mosaic phenotype is correlated with genomic imprinting.

(D) The mosaic phenotype results from random X-chromosomal inactivation.

(E) The offspring from matings of orange males and black females are mosaic.

Questions 42 and 43 are a **problem set**

A42. On a remote island, Dr. Yeh discovered a new plant species, which can produce either white or blue flowers. This species is self fertilized or cross pollinated by insects. Genetic experiments showed that the white-flower phenotype is recessive to the blue-flower phenotype. Statistical analysis revealed that 91% of these plants on the island produce blue flowers. If one is to randomly select two blue-flower plants and cross them, then what is the approximate probability that their F1 offspring will produce white flowers?

(A) 0.09 (B) 0.21 (C) 0.42 (D) 0.49 (E) 0.91

A43. Dr. Yeh treated the seeds of the above-mentioned homozygous blue-flower plants with chemical mutagen to produce a mutant population. Three recessive mutants, *wf1, wf2,* and *wf3*, produced white flowers were selected. He crossed the mutants and obtained the

following results: *wf1* x *wf3* produced F2 offspring with only white flowers, and *wf2* x *wf3* produced F2 offspring with blue and white flowers in a ratio of 9:7. According to these data, which of the statements below is **NOT correct**?

(A) *wf1* and *wf3* are unable to complement each other.

(B) *wf2* and *wf3* are able to complement each other.

(C) *wf1* and *wf3* are in the same locus.

(D) *wf2* and *wf3* are not in the same locus

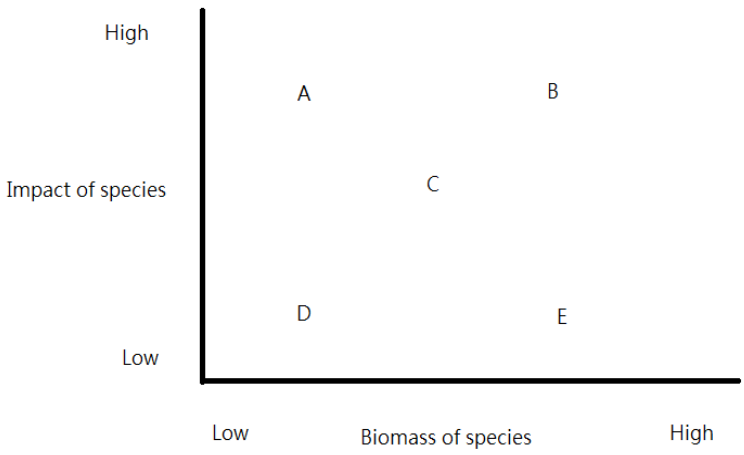
(E) The F1 offspring from crossing *wf1* and *wf2* will all produce white flowers

VI. Ecology

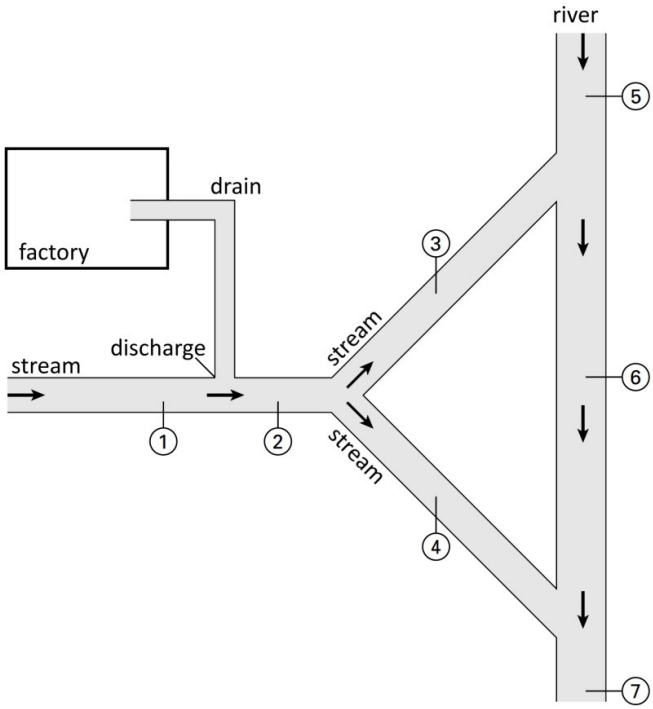
A44. Biogeography researchers found that continental islands tend to have a species composition similar to the mainland, but a lower degree of species differentiation comparing to oceanic islands. If one compares the biome of an oceanic island (X) to a continental island (Y), assuming the two have approximately the same area, and are located in the same latitudinal range, which of the following descriptions is correct?

	Proportion of endemic species	Total number of species
A	X<Y	X>Y
B	X>Y	X>Y
C	X>Y	X<Y
D	X<Y	X<Y
E	X=Y	X<Y

A45. In the figure below, A to E denote five different species in an ecosystem. Which of the species is most likely to be a keystone species?



A46. A group of students would like to know how the discharge of waste water from a factory might influence water quality of a river. The picture shows 7 potential sampling locations (① to ⑦) in relation to the locations of the factory and the river. Which locations are essential to be included in the sampling in order to draw valid conclusions about the pollution of the river by the factory?



(A) Locations 1, 2, 4, 7

(B) Locations 1, 3, 4, 7

(C) Locations 1, 2, 5, 7

(D) Locations 2, 3, 4, 6

(E) Locations 2, 5, 6, 7

A47. Biogeography researchers have long recognized that terrestrial biomes on islands are often associated with dispersal and colonizing ability of different organisms. Based on dispersal and colonizing ability of the following groups of organisms, which one <u>is least likely</u> to occur on an oceanic, tropical island with a large area, numerous mountains, a dense vegetation cover, and a high level of biodiversity?

(A) Insects

(B) Birds

(C) Ferns

(D) Amphibians

(E) Reptiles

A48. A male guppy (*Poecilia reticulata*) with large, bright spots on the body is more likely to attract females, which increases his opportunity to reproduce. In the meantime, he is also more easily detected by the natural enemy, which increases his predation risk. Consider male guppies from three different rivers: X, Y and Z, males from X have the largest spots, males from Y have the intermediate-sized spots, and males from Z have the smallest spots. Which of the following descriptions about the guppies in the three rivers is correct?

The density of

(A) male guppies in X is higher than in the other rivers.

(B) male guppies in Z is higher than in the other rivers.

(C) natural enemy of guppies in X is higher than in the other rivers.

(D) natural enemy of guppies in Z is higher than the other rivers.

(E) female guppies in X is higher than the other rivers.

A49. Species M had been introduced multiple times to an ecosystem outside its native distribution, but could not establish itself. Although no parameter in ecosystem changed between the different attempts, the final one introduction was eventually successful, and led to a rapid and wide-spread expansion of species M in the ecosystem. Which of the

followings is the most plausible explanation for why species M was not natively distributed in this ecosystem?

(A) There are too many competitors of species M in the ecosystem.

(B) There are too many predators of species M in the ecosystem.

(C) Species M is not able to disperse to the ecosystem on it own.

(D) The abiotic environment in the ecosystem is not suitable for the growth of species M.

(E) The ecosystem is frequently under disturbance, which creates an unfavorable condition for species M to sustain.

A50. A large forest is cleared. The land is rapidly colonized by species with which of the following characteristics?

(1) long lifespan, (2) rapid reproduction, (3) fast growth, (4) strong dispersal ability, (5) strong defense against natural enemies or predators.

(A) Only 1, 2, 3

(B) Only 1, 2, 5

(C) Only 1, 4, 5

(D) Only 2, 3, 4

(E) Only 3, 4, 5

A51. A large proportion of angiosperms are pollinated by animals. Assign the following flower descriptions (I to V) to the most likely pollinator (a to e).

I. Flower white, open during night, intensive fragrant, nectar hidden in long, tight tubes.

II. Flower often with ultraviolet coloring pattern, open during daytime, pleasant fragrant.

III. Flower large and coarse, bright red, open during daytime, no fragrance but large

amounts of nectar

IV. Flower large and coarse, far opened, open during night, intensive fragrant, large amounts of nectar

V. Flower reddish brown, no nectar, smell of rotten flesh

a. bats

b. birds

c. bees

d. flies

e. moths

Which of the following statement is correct?

(A) Ia, IIb, IIIc, IVe, Vd

(B) Ib, IIc, IIId, IVa, Ve

(C) Id, IIe, IIIa, IVb, Vc

(D) Ie, IIc, IIIb, IVa, Vd

(E) Ie, IId, IIIc, IVb, Va

A52. It has been demonstrated that house roaches show less threat to human health than mosquitos in terms of serving as disease vectors. Which feature possessed by roaches given below may explain this observation?

(A) piercing mouthpart, injecting saliva into the tissue which it feeds upon

(B) chewing mouthpart, swallowing food without saliva

(C) mouthpart sponge-like, secreting saliva upon the food they feed on

(D) microhabitats they prefer much more cleaner than those by mosquitos

(E) by natural they are anthropophobia

VII. Biosystematics

[Questions 53-55] The following table shows the main characteristics of 8 different animals (taxa 1 to 8). A "+" sign indicates that the animal possesses such characteristic, and a "blank" indicates that the animal does not possess such characteristic:

Characteristic	Taxon							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Amnion			+	+	+			
Limbs with fingers	+		+		+			
Mammary glands					+			
Lateral line system	+	+				+		
Cycloid scales		+						
Sternum	+		+		+			
Semicircle canals	+	+	+	+	+	+	+	
Ventral nerve cords								+

Please answer questions A53 to 55using the information in the table above.

A53. Which of the following taxa most likely belongs to the same Class as "Taxon 4"?

(A) Taxon 1

(B) Taxon 2

(C) Taxon 3

(D) Taxon 5

(E) Taxon 6

A54. "Taxon 8" is least likely to be which of the following organisms?

(A) Earthworm

(B) Grasshopper

(C) Lobster

(D) Sea star

(E) Spider

A55. "Taxon 1" is most likely to be which of the following organisms?

(A) Shark

(B) Eel

(C) Sea lion

(D) Turtle

(E) Frog

A56. Table A is a data matrix for characters of four kinds of animals. The number entries denote shared characters if the same values (0 or 1) are given, not shared if different values (0 and 1) are given.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Animal A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Animal B	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Animal C	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
Animal D	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0

If relationship among organisms can be inferred from the degree of similarity, and the degree of similarity is defined as a coefficient S:

S = quantity of shared characters/(quantity of shared characters + different charcters)

According to the data matrix given by Table A, which animal is the most closely related to animal A, and which one is to C? Please give your animal in the format of (the animal most closely related to A, the animal most closely related to C).

(A) (B，A)

(B) (B，B)

(C) (C，B)

(D) (C，A)

(E) (D，A)

A57. Mary bought rice, potatoes, tomatoes, kelp, pine nuts, mushrooms, dates, bird nest fern, bananas, and corn cobs from the supermarket. Based on hierarchical classification, how many different phyla do these items belong to?

(A) 4

(B) 5

(C) 6

(D) 7

(E) 8

A58. A scientist unearthed four plant fossils (I to IV) with some prominent structures intact.

These are listed in the following table:

Structure / Fossil #	Spore	Ovary	Embryo	Pollen	Xylem	Ovule
I			✓		✓	
II			✓	✓	✓	✓
III		✓		✓	✓	✓
IV	✓		✓			

According to this table, which sequence below correctly represents the order of evolution of these plants?

(A) I→II→III→IV

(B) II→III→IV→I

(C) III→IV→I→II

(D) IV→I→II→III

(E) II→I→IV→III

(F) III→I→IV→II