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# **AP<sup>®</sup> Biology**

## **2016 Free-Response Questions**

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**2016 AP<sup>®</sup> BIOLOGY FREE-RESPONSE QUESTIONS**

**BIOLOGY**

**Section II**

**8 Questions**

**Total Time—90 minutes**

**Reading Period—10 minutes**

**Writing Period—80 minutes**

**Directions:** Questions 1 and 2 are long free-response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3–8 are short free-response questions that require about 6 minutes each to answer. Questions 3–5 are worth 4 points each and questions 6–8 are worth 3 points each.

Read each question carefully and completely. You are advised to spend the 10-minute reading period planning your answers. You may begin writing your responses before the reading period is over. Write your response in the space provided for each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

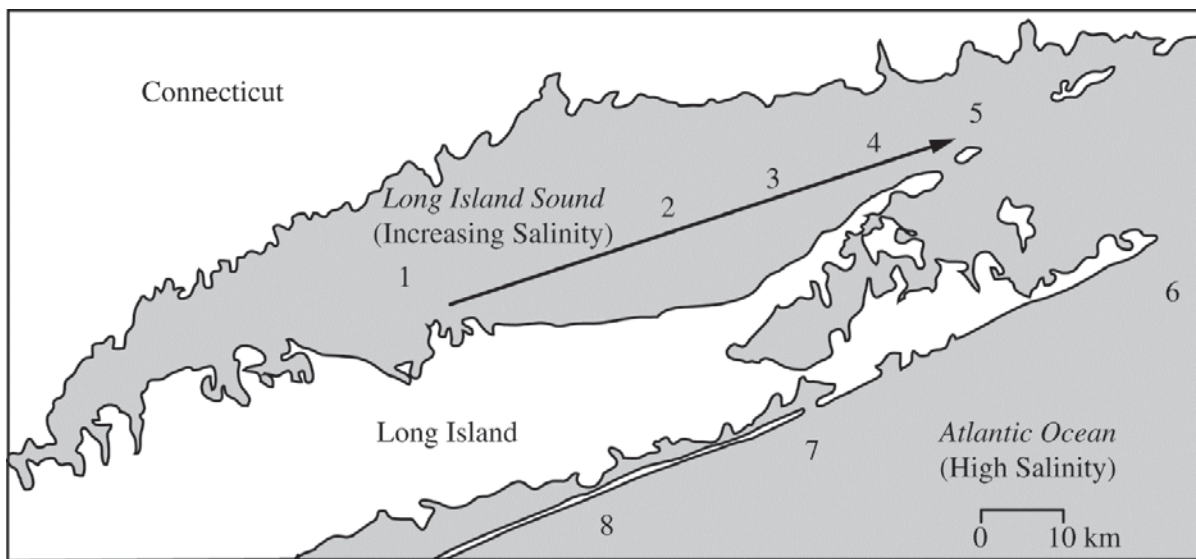


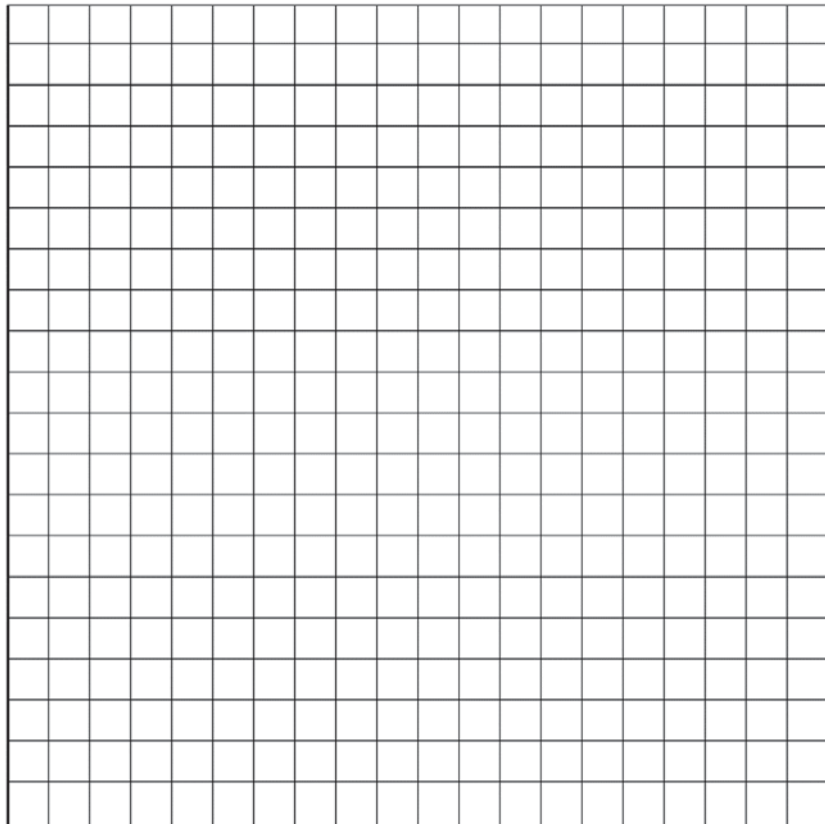
Figure 1. Sampling sites of marine mussels at various locations (1–8) in Long Island Sound and the Atlantic Ocean

TABLE 1. PERCENT OF INDIVIDUALS POSSESSING *lap*<sup>94</sup> ALLELE

	Long Island Sound					Atlantic Ocean		
Site	1	2	3	4	5	6	7	8
<i>lap</i> <sup>94</sup> frequency (%)	13	16	25	37	55	59	59	59
Salinity	Low $\longrightarrow$ High					High		

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1. Leucine aminopeptidases (LAPs) are found in all living organisms and have been associated with the response of the marine mussel, *Mytilus edulis*, to changes in salinity. LAPs are enzymes that remove N-terminal amino acids from proteins and release the free amino acids into the cytosol. To investigate the evolution of LAPs in wild populations of *M. edulis*, researchers sampled adult mussels from several different locations along a part of the northeast coast of the United States, as shown in Figure 1. The researchers then determined the percent of individuals possessing a particular *lap* allele, *lap*<sup>94</sup>, in mussels from each sample site (table 1).
- (a) On the axes provided, **construct** an appropriately labeled bar graph to illustrate the observed frequencies of the *lap*<sup>94</sup> allele in the study populations.
- (b) Based on the data, **describe** the most likely effect of salinity on the frequency of the *lap*<sup>94</sup> allele in the marine mussel populations in Long Island Sound. **Predict** the likely *lap*<sup>94</sup> allele frequency at a sampling site between site 1 and site 2 in Long Island Sound.
- (c) **Describe** the most likely effect of LAP<sup>94</sup> activity on the osmolarity of the cytosol. **Describe** the function of LAP<sup>94</sup> in maintaining water balance in the mussels living in the Atlantic Ocean.
- (d) Marine mussel larvae are evenly dispersed throughout the study area by water movement. As larvae mature, they attach to the rocks in the water. **Explain** the differences in *lap*<sup>94</sup> allele frequency among adult mussel populations at the sample sites despite the dispersal of larvae throughout the entire study area. **Predict** the likely effect on distribution of mussels in Long Island Sound if the *lap*<sup>94</sup> allele was found in all of the mussels in the population. **Justify** your prediction.



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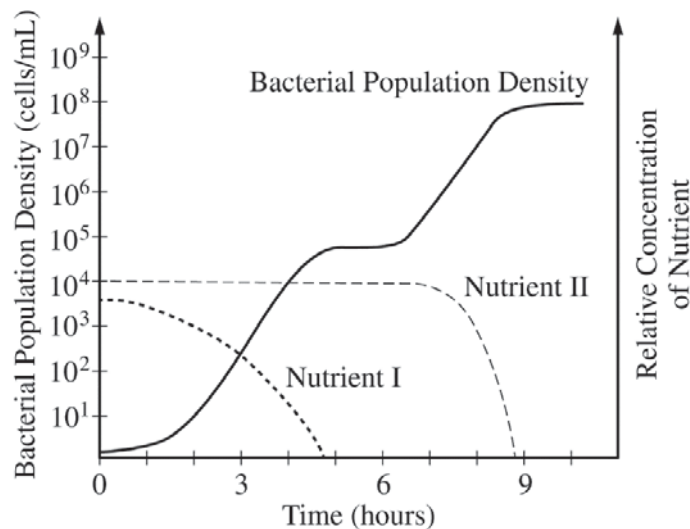


Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

2. Bacteria can be cultured in media with a carefully controlled nutrient composition. The graph above shows the growth of a bacterial population in a medium with limiting amounts of two nutrients, I and II.
- Estimate** the maximum population density in  $\frac{\text{cells}}{\text{mL}}$  for the culture. Using the data, **describe** what prevents further growth of the bacterial population in the culture.
  - Using the data, **calculate** the growth rate in  $\frac{\text{cells}}{\text{mL} \times \text{hour}}$  of the bacterial population between hours 2 and 4.
  - Identify** the preferred nutrient source of the bacteria in the culture over the course of the experiment. Use the graph to **justify** your response. **Propose** ONE advantage of the nutrient preference for an individual bacterium.
  - Describe** how nutrient I most likely regulates the genes for metabolism of nutrient I and the genes for metabolism of nutrient II. **Provide** TWO reasons that the population does not grow between hours 5 and 6.

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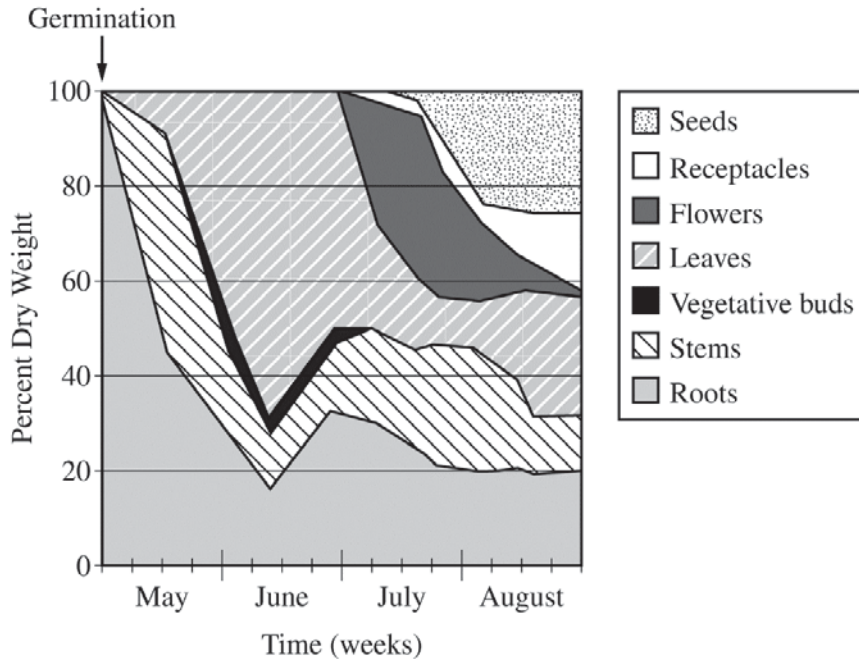
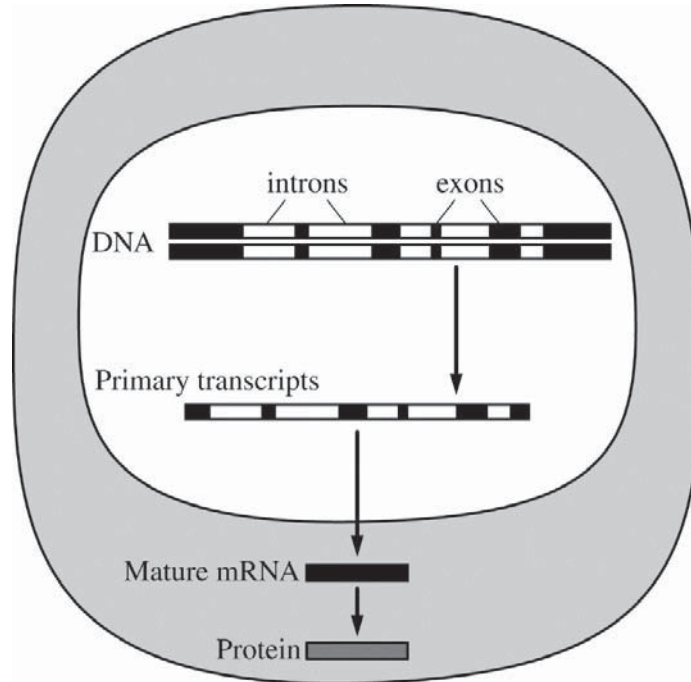


Figure 1. Percent dry weight of different plant structures during the growing season for an annual plant

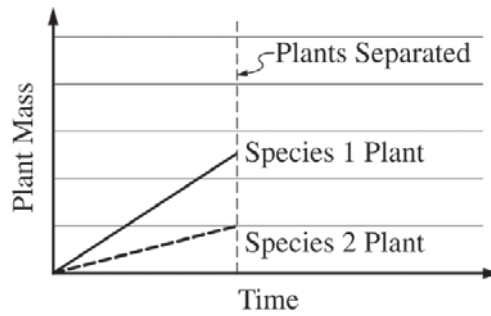
3. The graph above illustrates the percent dry weight of different parts of a particular annual plant (plants that live less than one year) from early May to late August. The percent dry weight can be used to estimate the amount of energy a plant uses to produce its leaves, vegetative buds, stems, roots, and reproductive parts (seeds, receptacles, and flowers).
- Identify** the direct source of the energy used for plant growth during the first week of May, and **identify** the part of the plant that grew the most during the same period.
  - Based on the data on the graph, **estimate** the percent of the total energy that the plant has allocated to the growth of leaves on the first day of July.
  - Compared with perennials (plants that live more than two years), annual plants often allocate a much greater percentage of their total energy to growth of their reproductive parts in any given year. **Propose** ONE evolutionary advantage of the energy allocation strategy in annual plants compared with that in perennial plants.

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4. The figure represents the process of expression of gene *X* in a eukaryotic cell.
- (a) The primary transcript in the figure is 15 kilobases (kb) long, but the mature mRNA is 7 kb in length. **Describe** the modification that most likely resulted in the 8 kb difference in length of the mature mRNA molecule. **Identify** in your response the location in the cell where the change occurs.
- (b) **Predict** the length of the mature gene *X* mRNA if the full-length gene is introduced and expressed in prokaryotic cells. **Justify** your prediction.

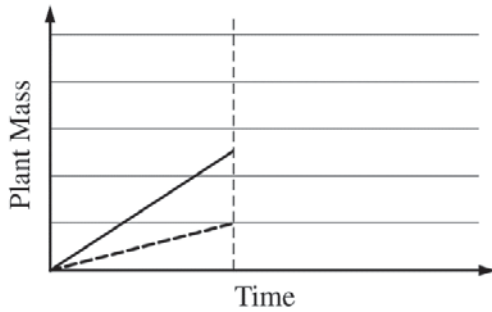
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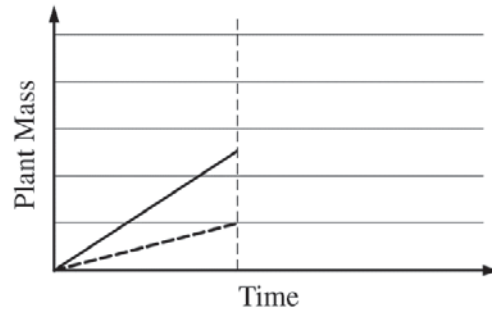
5. The graph above shows the mass of plants from two different species over time. The plants grew while attached to each other. The plants were separated at the time indicated by the vertical line in the graph.

Using template 1, **graph** the predicted shape of the plant-mass lines after separation of the two plants if the plants were in an obligate mutualistic relationship. On template 2, **graph** the predicted shape of the plant-mass lines if the species 2 plant was a parasite of the species 1 plant. **Justify** each of your predictions.

TEMPLATE 1: OBLIGATE MUTUALISM



TEMPLATE 2: PARASITISM



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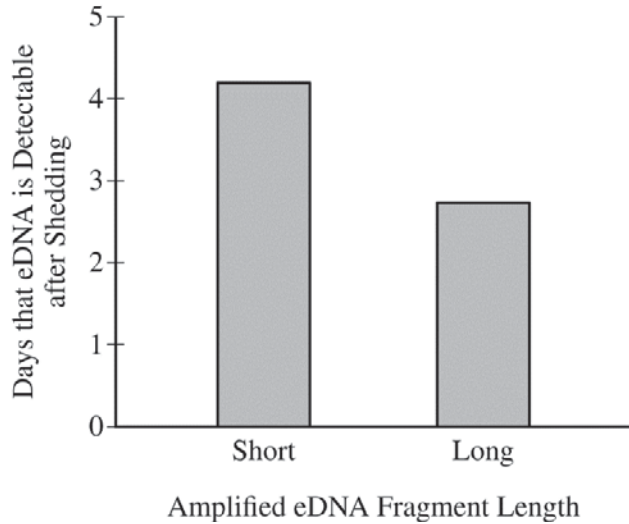


Figure 1. Detectability of eDNA fragments of varying lengths

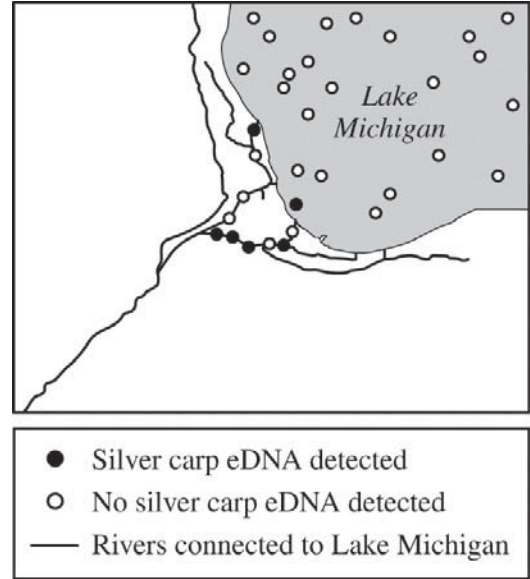


Figure 2. Map of the waterways that connect a nearby river system to Lake Michigan

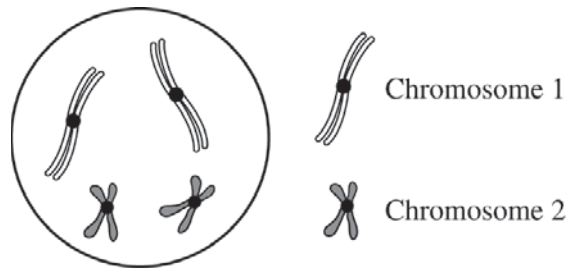
6. Living and dead organisms continuously shed DNA fragments, known as eDNA, into the environment. To detect eDNA fragments in the environment, the polymerase chain reaction (PCR) can be used to amplify specific eDNA fragments. eDNA fragments of different lengths persist in the environment for varying amounts of time before becoming undetectable (Figure 1).

To investigate whether silver carp, an invasive fish, have moved from a nearby river system into Lake Michigan, researchers tested water samples for the presence of eDNA specific to silver carp (Figure 2).

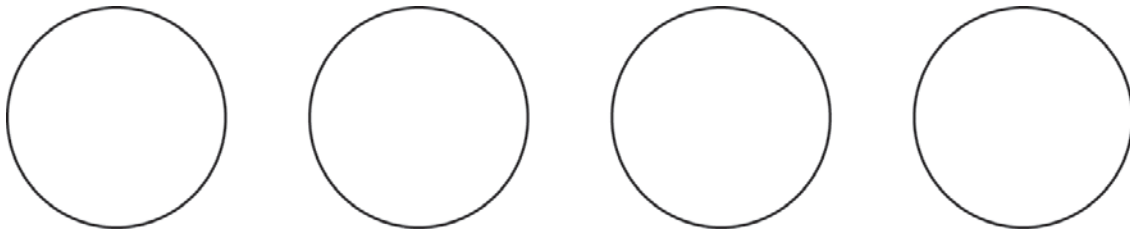
- (a) **Justify** the use of eDNA sampling as an appropriate technique for detecting the presence of silver carp in an environment where many different species of fish are found. **Propose** ONE advantage of identifying long eDNA fragments as opposed to short fragments for detecting silver carp.
- (b) The researchers tested a large number of water samples from Lake Michigan and found eDNA specific to silver carp in a single sample in the lake, as indicated in Figure 2. The researchers concluded that the single positive sample was a false positive and that no silver carp had entered Lake Michigan. **Provide reasoning** other than human error to support the researchers' claim.



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7. In a certain species of plant, the diploid number of chromosomes is 4 ( $2n = 4$ ). Flower color is controlled by a single gene in which the green allele ( $G$ ) is dominant to the purple allele ( $g$ ). Plant height is controlled by a different gene in which the dwarf allele ( $D$ ) is dominant to the tall allele ( $d$ ). Individuals of the parental (P) generation with the genotypes  $GGDD$  and  $ggdd$  were crossed to produce  $F_1$  progeny.
- Construct** a diagram below to depict the four possible normal products of meiosis that would be produced by the  $F_1$  progeny. Show the chromosomes and the allele(s) they carry. Assume the genes are located on different chromosomes and the gene for flower color is on chromosome 1.
  - Predict** the possible phenotypes and their ratios in the offspring of a testcross between an  $F_1$  individual and a  $ggdd$  individual.
  - If the two genes were genetically linked, **describe** how the proportions of phenotypes of the resulting offspring would most likely differ from those of the testcross between an  $F_1$  individual and a  $ggdd$  individual.



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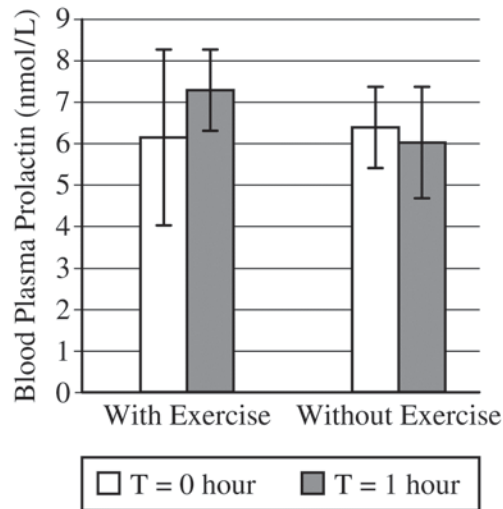


Figure 1. Effect of exercise on blood prolactin levels in adult males. The data represent the means  $\pm 2SE_{\bar{x}}$ .

8. Researchers conducted a study to investigate the effect of exercise on the release of prolactin into the blood. The researchers measured the concentration of prolactin in the blood of eight adult males before (T = 0 hour) and after one hour (T = 1 hour) of vigorous exercise. As a control, the researchers measured the concentration of blood prolactin in the same group of individuals at the same times of day one week later, but without having them exercise. The results are shown in Figure 1.
- (a) **Justify** the use of the without-exercise treatment as the control in the study design.
- (b) Using evidence from the specific treatments, **determine** whether prolactin release changes after exercise. **Justify** your answer.

**STOP**

**END OF EXAM**