AP® BIOLOGY
2016 SCORING GUIDELINES

Question 1

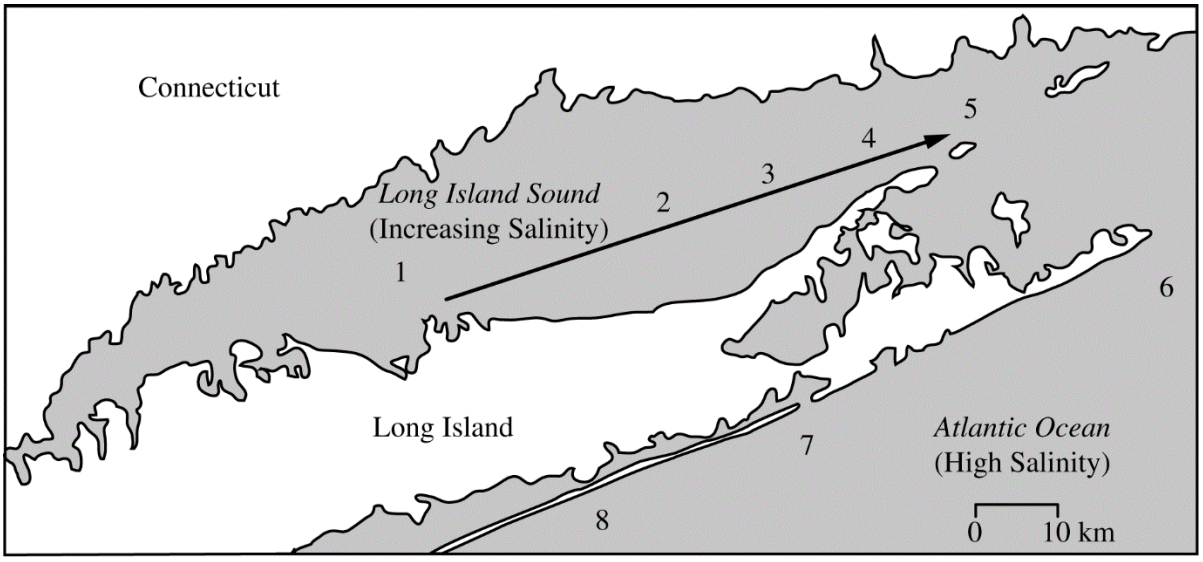

Figure 1. Sampling sites of marine mussels at various locations (1-8) in Long Island Sound and the Atlantic Ocean

TABLE 1. PERCENT OF INDIVIDUALS POSSESSING *lap*^{94} ALLELE

	Long Island Sound					Atlantic Ocean		
Site	1	2	3	4	5	6	7	8
lap^{94} frequency (%)	13	16	25	37	55	59	59	59
Salinity	Low →				High	High		

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*^{94}, in mussels from each sample site (table 1).

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Question 1 (continued)

(a) On the axes provided, **construct** an appropriately labeled bar graph to illustrate the observed frequencies of the *lap*^{94} allele in the study populations. **(3 points)**

Construct graph (3 points)

- Correctly plotted bar graph that accurately represents the trend
- Correct axis labeling
- Correct scale and units

(b) Based on the data, **describe** the most likely effect of salinity on the frequency of the *lap*^{94} allele in the marine mussel populations in Long Island Sound. **Predict** the likely *lap*^{94} allele frequency at a sampling site between site 1 and site 2 in Long Island Sound. **(2 points)**

Description (1 point)	**Prediction (1 point)**
• As salinity increases *lap*^{94} frequency increases • As salinity decreases *lap*^{94} frequency decreases	Between 13 and 16 percent (or a selected value between 13 and 16 percent)

(c) **Describe** the most likely effect of LAP^{94} activity on the osmolarity of the cytosol. **Describe** the function of LAP^{94} in maintaining water balance in the mussels living in the Atlantic Ocean. **(2 points)**

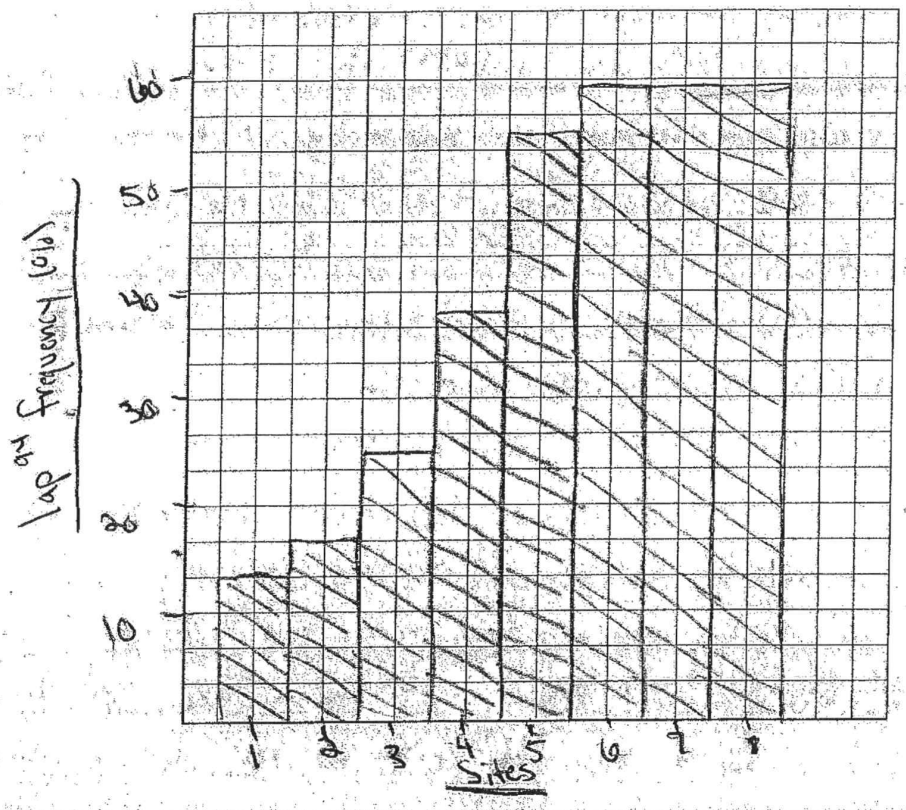
Describe effect of LAP^{94} activity (1 point)	**Describe function of LAP^{94} in maintaining water balance (1 point)**
• LAP^{94} increases osmolarity/solute concentration of the cytosol • LAP^{94} decreases water potential of the cytosol	Prevents water loss to the environment

(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*^{94} 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*^{94} allele was found in all of the mussels in the population. **Justify** your prediction. **(3 points)**

Explanation (1 point)	**Prediction (1 point)**	**Justification (1 point)**
• Mussels with *lap*^{94} allele are more likely to survive in high salinity/less likely to survive in low salinity. • Mussels without *lap*^{94} allele are less likely to survive in high salinity/more likely to survive in low salinity.	• Mussel population will increase in high salinity. • Mussel population will decline in low salinity.	• Mussels in high salinity with *lap*^{94} allele will osmoregulate. • Mussels in low salinity with *lap*^{94} allele will not osmoregulate.

PAGE FOR ANSWERING QUESTION 1

Percent of Individuals Possessing lap^{94} Allele 1A,



(b) The most likely effect on the frequency of the lap^{94} allele is that an increase in salinity is associated with an increase in the frequency of the lap^{94} allele. There is a direct relationship. The lap^{94} allele frequency between site 1 and site 2 is 15%. (c) LAP^{94} activity releases amino acids in the cytosol which lowers the Water Potential (Ψ) inside of the cell. This leads to a flow of water into the cell. The reason why LAP^{94} activity increases as salinity increases is because the hypertonic environment surrounding the cell would cause

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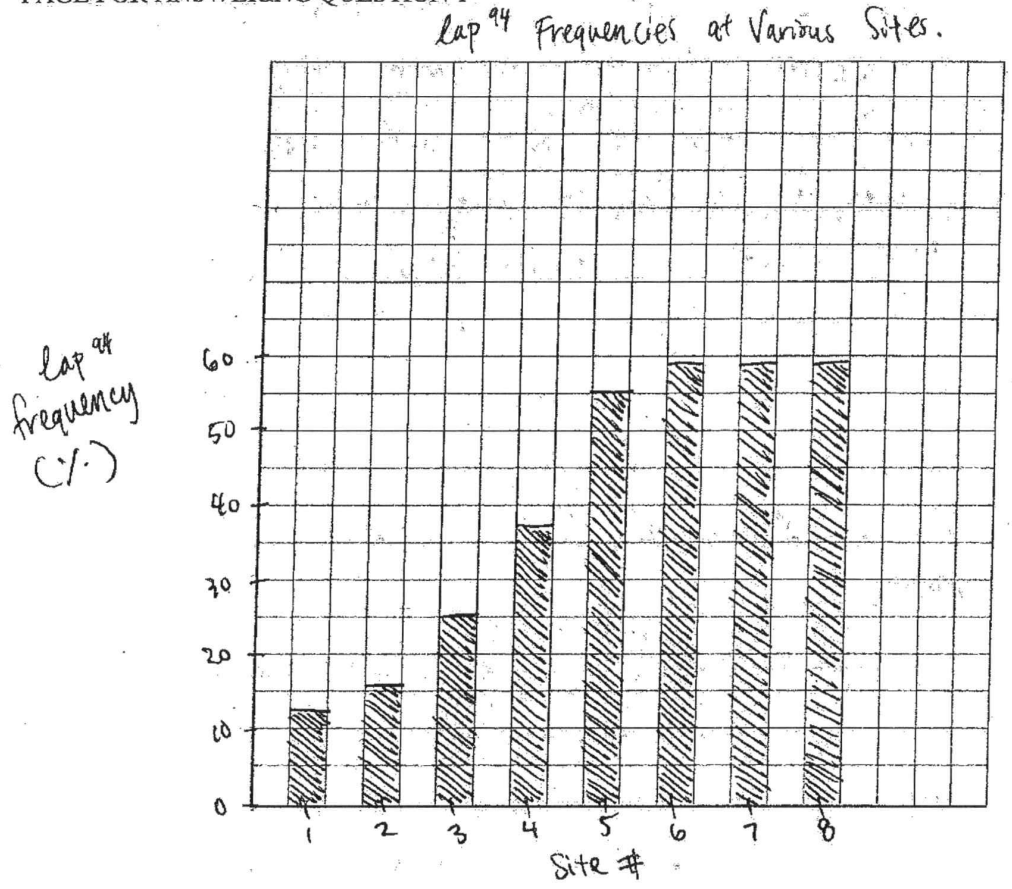
ADDITIONAL PAGE FOR ANSWERING QUESTION 1

the water inside the cell to leave, eventually the cell would plasmolysize and die. LAP^{94} attempts to counterbalance the effect ~~of~~ of an increase in salinity. Attempting to create an isotonic solution. (D) The differences in lap^{94} allele frequency are due to the differences of salinity at the sites where adult mussels attach themselves to rocks. A higher population of individuals with the lap^{94} allele will survive ~~with~~ in areas of high salinity. That is why the frequency of the allele is different across the data presented. There would be a greater number of mussels in areas of high salinity if all the mussels had the lap^{94} allele. This is because if mussels with the allele were in areas of low salinity, then water would flow into the cell causing it to burst.

PAGE FOR ANSWERING QUESTION 1



b) As the salinity of the water increases, the frequency of the lap^{94} allele in the marine mussel populations living in that water increases. The frequency of the lap^{94} allele in a marine mussel population living between sites 1 and 2 could ~~but~~ be 15%.

c) LAP^{94} activity most likely increases the osmolarity of the cytosol. This decreases the difference in solute ~~conse~~ concentrations between the cytosol and the surrounding environment, which is beneficial to mussels living in the Atlantic Ocean because they do not lose as much water from their cells to the surrounding water due to diffusion.

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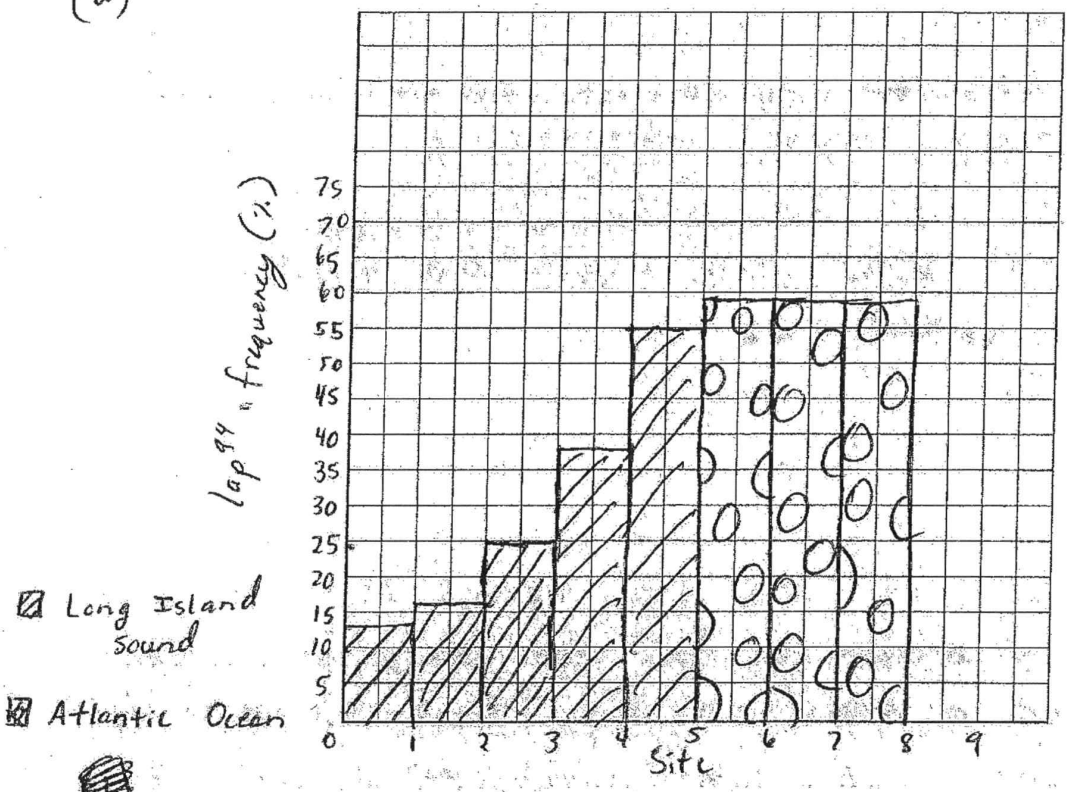
d) Though mussel larvae disperse evenly through the water, ~~only~~ those with the lap^{94} allele can survive better in water with higher salinity. Larvae that do not carry the lap^{94} allele that land in areas with high salinity may not be able to survive, dying off before they become adults, resulting in higher frequencies of the lap^{94} allele in adults at higher salinities. If the lap^{94} allele was found in all of the mussels, it is probable that mussels would be found distributed all throughout ~~th~~ Long Island Sound, since they would all be able to tolerate and thrive in ~~waters with~~ both low and high salinity.

PAGE FOR ANSWERING QUESTION 1

(a)



(b) Based on the data, one can see how salinity is directly correlated with the frequency of the lap^{94}. This is observed because as salinity increases so does the lap^{94} frequency meaning that the frequency is directly affected by salinity. The likely lap^{94} allele frequency between site 1 and 2 in Long Island Sound would be 15%.

(c) The most likely effect of LAP^{94} activity on the osmolarity of cytosol is an increase in

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

osmolarity due to the amino acids being released into the cytosol. The function of LAP^{94} in maintaining water balance in the mussels living in the Atlantic Ocean is that of removing the right amount of ~~amino~~ amino acids and therefore ~~#~~ balancing ~~proteins~~ ~~are~~ proteins as well.

(d) The lap^{94} allele frequency differences among adult mussels at the sample sites despite dispersal of larvae is a decrease since the more ~~mature~~ mature larvae become the more they attach to rocks meaning a decrease in lap^{94}. The likely effect on distribution of mussels in Long Island Sound if lap^{94} allele frequency are found in all mussels is a lack in distribution.

AP® BIOLOGY
2016 SCORING COMMENTARY

Question 1

Question 1 was written to the following Learning Objectives in the AP® Biology Curriculum Framework: 1.1, 2.24, 2.28, 4.19, 4.25, and 4.26.

Overview

This question was based on an investigation of the effects of salinity on the frequency of a specific allele of a leucine aminopeptidase gene (*lap*^{94}) in a population of mussels living in Long Island Sound. Students were presented with a figure depicting the Long Island Sound and the nearby Atlantic Ocean with eight sampling sites of increasing salinity. Students were also presented a table of data indicating the *lap*^{94} allele frequency at each sampling site. Students were asked to construct a graph to illustrate the observed allele frequencies and to describe the most likely effect of salinity on the *lap*^{94} allele frequency. Students were asked to use their analysis to predict the likely *lap*^{94} allele frequency at a different site in Long Island Sound. Students were then asked to describe the most likely effect of LAP^{94} on the osmolarity of the cytosol and the function of LAP^{94} in maintaining water balance in the organism. Finally, students were asked to explain the differences in allele frequency in adult mussels at the different sampling sites despite the dispersal of larval mussels throughout the study area. Students were asked to predict, with justification, the likely effect on the distribution of mussels in the study area if the *lap*^{94} allele was present in all mussels in the area.

Sample: 1A
Score: 10

The response earned 1 point in part (a) for correctly plotting the bar graph with correct trend. The response earned 1 point in part (a) for correctly labeling the axes. The response earned 1 point in part (a) for correct scaling and units. The response earned 1 point in part (b) for describing that an increase in salinity is associated with an increase in the *lap*^{94} allele frequency. The response earned 1 point in part (b) for predicting that the *lap*^{94} allele frequency between site 1 and site 2 is 15 percent. The response earned 1 point in part (c) for describing that LAP^{94} activity will lower the water potential inside the cells. The response earned 1 point in part (c) for describing that LAP^{94} function prevents plasmolysis by maintaining the cytosol isotonic to the environment. The response earned 1 point in part (d) for explaining that mussels with the *lap*^{94} allele will be more likely to survive in water with high salinity. The response earned 1 point in part (d) for predicting that there would be more mussels in higher salinity areas if all mussels had the *lap*^{94} allele. The response earned 1 point in part (d) for the justification that without the *lap*^{94} allele, mussel cells would burst in low salinity.

Sample: 1B
Score: 8

The response earned 1 point in part (a) for correctly plotting the bar graph with correct trend. The response earned 1 point in part (a) for correctly labeling the axes. The response earned 1 point in part (a) for correct scaling and units. The response earned 1 point in part (b) for describing that as salinity increases the *lap*^{94} allele frequency increases. The response earned 1 point in part (b) for predicting the *lap*^{94} allele frequency between site 1 and site 2 could be 15 percent. The response earned 1 point in part (c) for describing that LAP^{94} activity will increase the osmolarity of the cytosol. The response earned 1 point in part (c) for describing that LAP^{94} function prevents water loss from the cell. The response earned 1 point in part (d) for explaining that mussels with the *lap*^{94} allele will be more likely to survive in water with high salinity. The response could have earned 1 point for explaining that those without the allele would not survive as well in high salinity, but the point had already been earned.

Question 1 (continued)

Sample: 1C
Score: 6

The response earned 1 point in part (a) for correctly plotting the bar graph with correct trend. The response earned 1 point in part (a) for correctly labeling the axes. The response earned 1 point in part (a) for correct scaling and units. The response earned 1 point in part (b) for describing that as salinity increases so does the *lap*^{94} allele frequency. The response earned 1 point in part (b) for predicting that the *lap*^{94} allele frequency between site 1 and site 2 is 15 percent. The response earned 1 point in part (c) for describing that LAP^{94} activity will increase the osmolarity of the cytosol.