2017

AP CollegeBoard

AP Biology

Sample Student Responses and Scoring Commentary

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AP® BIOLOGY
2017 SCORING GUIDELINES

Question 1

TABLE 1. EFFECT OF 0.1 mM CAFFEINE ON MEMORY IN BEES

Treatment	Memory (average probability of revisiting a nectar source $\pm 2SE_{\bar{X}}$)	
	10 Minutes	24 Hours
Control	0.72 ± 0.09	0.41 ± 0.07
Caffeine	0.83 ± 0.07	0.78 ± 0.08

In flowering plants pollination is a process that leads to the fertilization of an egg and the production of seeds. Some flowers attract pollinators, such as bees, using visual and chemical cues. When a bee visits a flower, in addition to transferring pollen, the bee can take nectar from the flower and use it to make honey for the colony.

Nectar contains sugar, but certain plants also produce caffeine in the nectar. Caffeine is a bitter-tasting compound that can be toxic to insects at high concentrations. To investigate the role of caffeine in nectar, a group of researchers studied the effect of 0.1 mM caffeine on bee behavior. The results of an experiment to test the effect of caffeine on bees' memory of a nectar source are shown in Table 1.

(a) On the axes provided, **construct** an appropriately labeled graph to illustrate the effect of caffeine on the probability of bees revisiting a nectar source (memory). **(3 points)**

Construct graph (3 points)

- Correctly plotted means on a bar graph/modified bar graph
- Appropriate labels, units, and scaling
- Correctly plotted error bars

(b) Based on the results, **describe** the effect of caffeine on each of the following: **(2 points)**

- Short-term (10 minute) memory of a nectar source
- Long-term (24 hour) memory of a nectar source

Description (2 points)

Short-term	Caffeine does not affect short-term memory/memory at 10 minutes.
Long-term	Caffeine improves/increases the long-term memory/memory at 24 hours.

(c) **Design an experiment** using artificial flowers to investigate potential negative effects of increasing caffeine concentrations in nectar on the number of floral visits by bees. **Identify** the null hypothesis, an appropriate control treatment, and the predicted results that could be used to reject the null hypothesis. **(3 points)**

Question 1 (continued)

Identification (3 points; 1 point per row)

Null hypothesis	Increasing caffeine concentration has no effect (on the number of floral visits by bees).
Control	(Nectar/flowers with) no caffeine
Predicted results	• The number of floral visits by bees is different at increasing caffeine concentrations. • The number of floral visits by bees is different than the control.

(d) Researchers found that nectar with caffeine tends to have a lower sugar content than nectar without caffeine. Plants use less energy to produce the caffeine in nectar than they do to produce the sugar in nectar. **Propose ONE benefit** to plants that produce nectar with caffeine and a lower sugar content. **Propose ONE cost** to bees that visit the flowers of plants that produce nectar with caffeine and a lower sugar content. **(2 points)**

Proposed plant benefit (1 point)

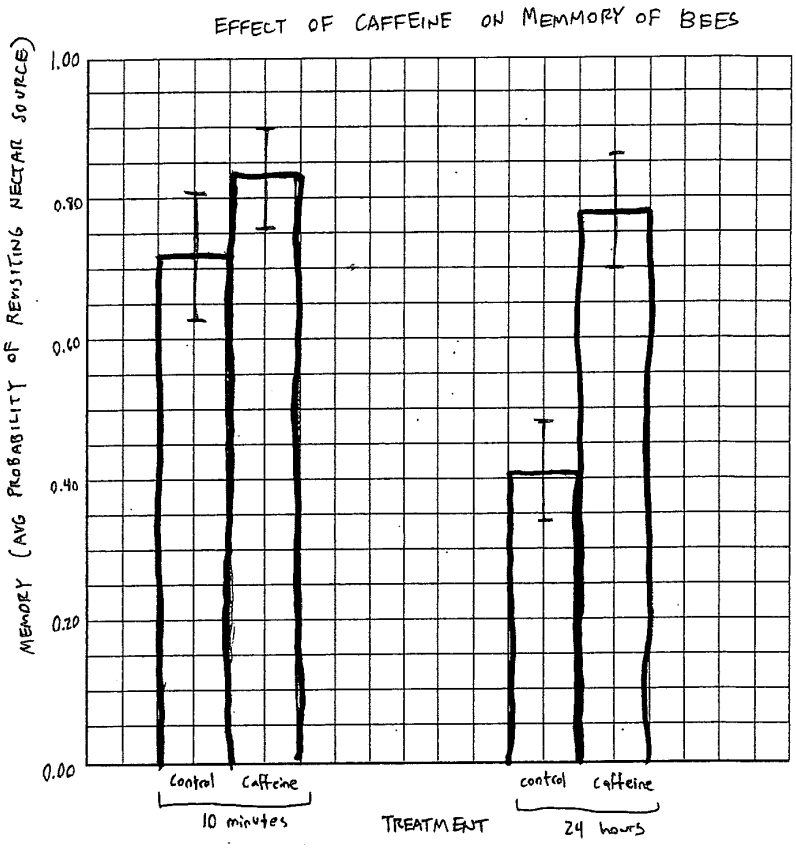
- More pollen is transferred/more visits by pollinators.
- Plants store energy/have more energy available for other uses.

Proposed bee cost (1 point)

- (Individual) bees visit more flowers.
- (Individual) bees use more energy.
- The colony/bees may produce less honey
- The colony/bees may produce lower quality honey/honey that provides less energy.

PAGE FOR ANSWERING QUESTION 1

A)



B) On a short term (10 minute) scale, caffeine has no significant effect on the bees' memory of nectar source. The standard deviation of the control and the experimental (caffeine) group overlapped.

On a long term (24 hours) scale, caffeine improves significantly bees' memory of the nectar source. According to the data, the bees who consumed nectar with caffeine were almost twice more likely to revisit that source than bees who consumed control nectar (no caffeine).

C) A null hypothesis would be that varying caffeine concentrations in nectar will have no effect on floral visits by bees. Observed data will not ~~should~~ differ significantly from this expected results.

In my ~~experimental group~~ experiment, the independent variable being controlled is the caffeine concentration in nectar. There will be nine experimental groups ranging from 0.1 M to 0.9 M

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

incrementally. This there will be one control group without any caffeine. (This will be prepared with artificial flowers and careful measuring out of nectar solutions in them.) The dependent variable will be the number of floral visits by bees over a 24-hour time period. This will be recorded by camera footage and analyzed by computer software. The number of bees and type of flower and amount of nectar solution will be kept constant for each group. The experiment will be repeated ten times. Predicted results would be that the greatest concentration solution (0.9 M caffeine) will yield a drastically lower number of floral visits by bees than the control solution (no caffeine). This would yield a X^2 value large enough to reject the null hypothesis.

D) Plants with higher caffeine content and lower sugar content in their nectar benefit since they use less energy in metabolic processes. (less sugar production requires lesser energy.) They are more efficient, and can use saved energy to support other aspects that will improve survival/reproductive rates. On the flip side, bees who consume the nectar of such plants are obtaining less sugar per visit. Since flying around visiting plants uses energy, these bees are less efficient in obtaining energy. They get the short end of the stick. Lower efficiency means lower rates of reproductive/survival success.

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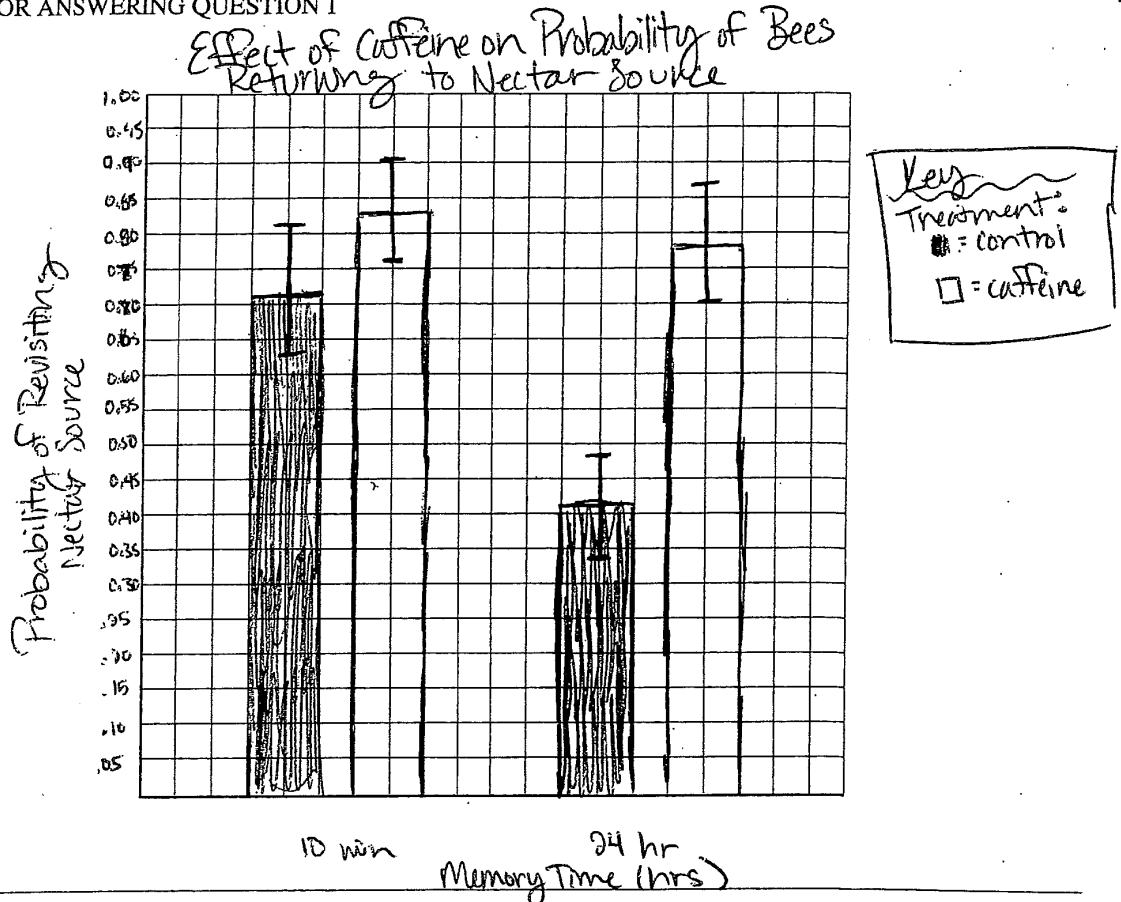
PAGE FOR ANSWERING QUESTION 1



b.) Caffeine has ~~&~~ no ~~[illegible]~~ statistically significant impact on bee short-term memory of a nectar source. This is b/c the error bars for the 10 min period overlap. Caffeine does, however, drastically increase long term memory of a nectar source because over the 24 hr period, the bar for caffeine-exposed bees was significantly larger.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

c.) An experiment could be done by placing different concentrations of caffeine on different artificial flowers to examine the effects of the high-concentrations on the bees. The control in the experiment would be the artificial flower with no caffeine on it. The independent variable would be the concentration of caffeine and the dependent variable would be the number of floral visits by bees. The null hypothesis is that changing the concentration of caffeine will have no affect on the number of floral visits by bees. If it were observed that bees revisited flowers with high concentrations significantly more than the flowers without, the null hypothesis would be rejected.

1B3

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

d.) One benefit to plants nectar w/ caffeine is that they would be consuming less energy and therefore wouldn't need to produce as much to carry out the process. One cost to the bees is that ~~the bees need energy as well and their energy comes from sugar, with less sugar available the bees are not getting as much out of the bees~~ high concentrations of caffeine can be toxic to the bees, so they are at risk when they come to these plants.

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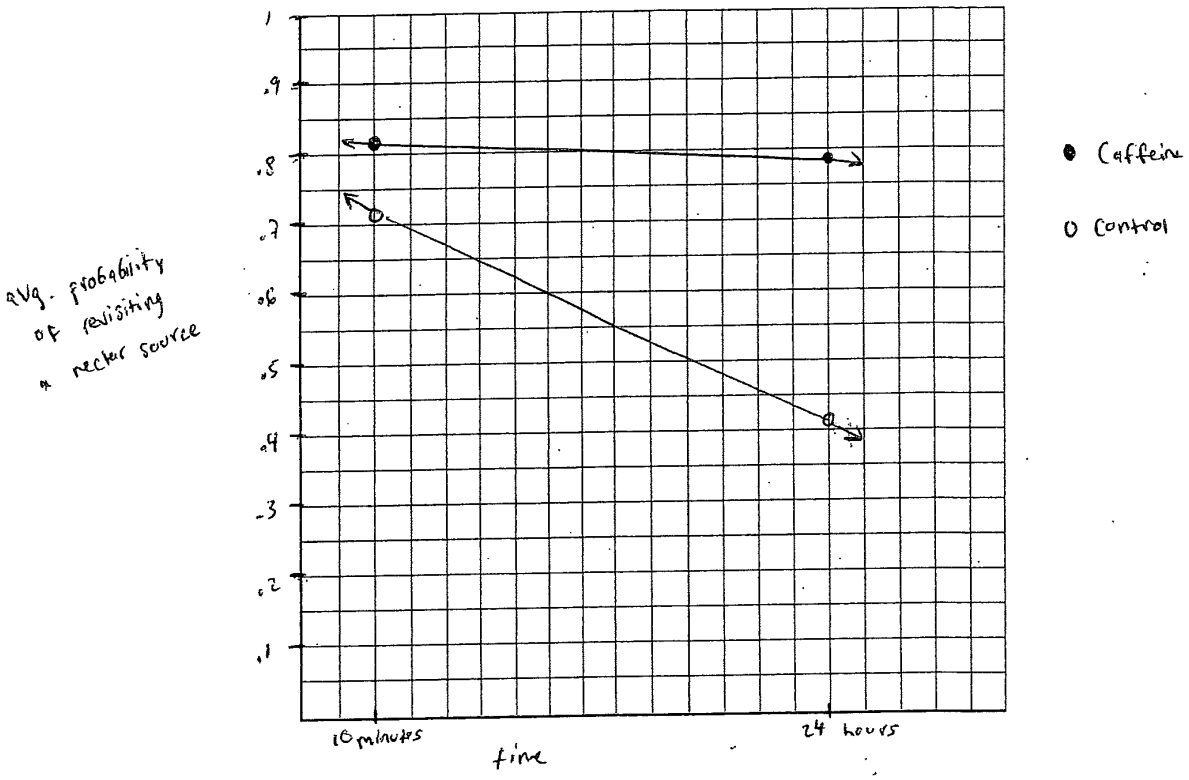
1C



b The short term effects of caffeine on memory of a nectar source is that there is a slight increase in memory. The long term effects of caffeine on memory of a nectar source is that there is a large increase in memory.

c H_0: Caffeine concentration has no effect on number of floral visits by bees.

H_1: Caffeine concentration has negative effects on number of floral visits by bees.

First, you would take 1000 artificial flowers and 500 bees. Take a random sample of 500 artificial flowers and put

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IC2

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

caffeine in them (use the same amount of caffeine for each flower). Put all the flowers in a controlled environment and assort them randomly. Let the bees loose in the controlled environment and over a period of a week track how many visits each artificial flower gets. The control treatment is the 500 flowers without caffeine. The predicted results are that on average the flowers without caffeine on them will get more visits by bees than flowers with caffeine, and these results could be used to reject the null hypothesis Ho.

One benefit would be that the average probability the bees revisiting that nector source is increased with more caffeine. One cost to the bees would be that caffeine is toxic to insects at high concentrations.

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2017 SCORING COMMENTARY

Question 1

Overview

This question was based on investigations of the effects of caffeine on memory in bees. Caffeine is often produced by plants in their nectar, and researchers studied the effect of caffeine on the probability of bees remembering and, therefore, revisiting a nectar source. Students were presented with a data table indicating the average probability of bees revisiting caffeinated and caffeine-free (control) nectar sources after 10 minutes and after 24 hours. The data included inferential error bars to compare groups. Students were asked to construct an appropriate graph based on the data provided. Students were then asked to describe the effect of caffeine on the short-term (10 minute) and long-term (24 hour) memory of a nectar source. Next, students were asked to design an experiment using artificial flowers to investigate potential negative effects of increasing caffeine concentrations in nectar on the number of floral visits by bees. As part of their experimental design, students were asked to identify the null hypothesis, an appropriate control treatment, and the predicted results that could be used to reject the null hypothesis. Finally, students were told that nectar with caffeine often has a lower sugar content than nectar without caffeine, and plants expend less energy to produce caffeine than to produce sugar. Based on this information, students were asked to propose one benefit to plants that produce nectar with caffeine and to propose one cost to bees that visit the flowers of the plants that produce nectar with caffeine.

Sample: 1A
Score: 10

The response earned 1 point in part (a) for correctly plotting the means on a bar graph. The response earned 1 point in part (a) for appropriate labels, units, and scaling. The response earned 1 point in part (a) for correctly plotting the error bars. The response earned 1 point in part (b) for describing the effect of caffeine on the short-term (10 minute) memory of a nectar source as having no significant effect. The response earned 1 point in part (b) for describing that long-term (24 hour) memory was significantly improved by caffeine. The response earned 1 point in part (c) for identifying the null hypothesis as varying caffeine concentrations in nectar will not affect floral visits by bees. The response earned 1 point in part (c) for identifying that the control group was without any caffeine. The response earned 1 point in part (c) for identifying that the greatest concentration of caffeine would yield a lower number of floral visits by bees than the control solution as the predicted results. The response earned 1 point in part (d) for proposing that one benefit to plants is using saved energy to support other aspects that will improve survival/reproductive rates. The response earned 1 point in part (d) for proposing that one cost to bees is decreased efficiency because flying around plants uses energy.

Sample: 1B
Score: 8

The response earned 1 point in part (a) for correctly plotting the means on a bar graph. The response earned 1 point in part (a) for appropriate labels, units, and scaling. The response earned 1 point in part (a) for correctly plotting error bars. The response earned 1 point in part (b) for describing the effect of caffeine on the short-term (10 minute) memory as not being statistically significant. The response earned 1 point in part (b) for describing that caffeine increases the long-term memory of a nectar source. The response earned 1 point in part (c) for identifying that the control would be artificial flowers with no caffeine. The response earned 1 point in part (c) for identifying that changing the concentration of caffeine will not affect the number of floral visits by bees as the null hypothesis. The response earned 1 point in (c) for identifying that if bees revisited flowers with high concentrations of caffeine significantly more than the flowers without caffeine the null hypothesis would be rejected.

Question 1 (continued)

Sample: 1C
Score: 6

The response earned 1 point in part (a) for appropriate labels, units, and scaling. The response earned 1 point in part (b) for describing that the effect of caffeine on the long-term (24 hour) memory is a large increase in memory. The response earned 1 point in part (c) for identifying that caffeine concentration will not affect the number of floral visits by bees as the null hypothesis (H_0). The response earned 1 point in part (c) for identifying an appropriate control treatment as flowers without caffeine. The response earned 1 point in part (c) for identifying that the number of floral visits by bees will be negatively affected by caffeine concentration. The response earned 1 point in part (d) for proposing that one benefit to plants is that the average probability of the bees revisiting the nectar source is increased with more caffeine.