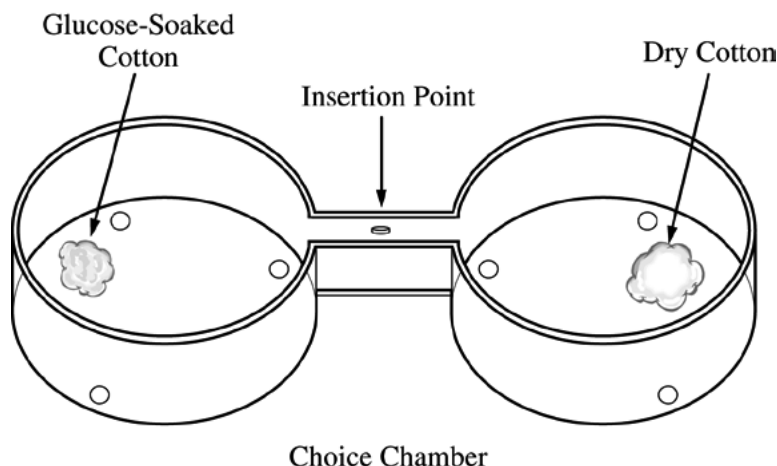# AP® BIOLOGY
2013 SCORING GUIDELINES

Question 1

Choice Chamber

In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10 percent glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

(a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction. (**2 points maximum**)
- 1 point for predicting the location of the flies in the choice chamber
- 1 point for justifying the prediction

(b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment. (**4 points maximum**)
- Experimental control
- Environmental factors

	Proposed Improvement (includes but not limited to) (**1 point maximum**)	Explanation (**1 point maximum**)
Experimental control	Replace the dry cotton ball with a water-soaked cotton ball.	Ensures that glucose is the attractant
	Constant light or temperature or duration of experiment or time of day, etc.	Other variables must be held constant

	Proposed Improvement (includes but not limited to) (**1 point maximum**)	Explanation (**1 point maximum**)
Environmental factors	• Use different concentrations of glucose • Use different temperature(s) • Use different light levels • Use a different choice chamber (size/shape) • Vary duration of the experiment • Vary time of day when experiment is performed	Attributes movement of flies only to glucose preference

(c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

Time (minutes)	Position in Chamber		
	End with Ripe Banana	Middle	End with Unripe Banana
1	21	18	21
10	45	3	12

Perform a chi-square test on the data for the 10-minute time point in the banana experiment. **Specify** the null hypothesis that you are testing and **enter** the values from your calculations in the table below. (**2 points maximum**)

PART (c): CHI-SQUARE CALCULATION

Null Hypothesis: (**1 point**) The flies will be evenly distributed across the three different parts of the choice chamber.			
	Observed (o)	Expected (e)* (**1 point**)	$(o - e)^2/e$
End with ripe banana	45	20	31.25
Middle	3	20	14.45
End with unripe banana	12	20	3.2
Total	60	60	48.9

*Expected values must be those predicted by the null hypothesis provided in the student response, add up to 60, and include no cells equal to 0.

(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation. (**1 point maximum**)
- Correct explanation with justification of why the stated null hypothesis is rejected or not rejected. Response must clarify each of the following:
  o degrees of freedom (df) = 2 and p = 0.05 (critical value = 5.99)
     OR
     degrees of freedom (df) = 2 and p = 0.01 (critical value = 9.21)
  o how the calculated test statistic compares to the selected critical value
  o whether the null hypothesis should be rejected

(e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber. (**1 point maximum**)
- Stimulus → Response
- Input →(possible integration) →Output

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PART (C): CHI-SQUARE CALCULATION

Null Hypothesis: The number of flies in the chamber with the ripe banana will be equal to the number of flies in the chamber with the unripe banana and equal to the number of flies in the middle.			
	Observed (o)	Expected (e)	$(o - e)^2/e$
End with ripe banana	12	20	$\frac{(12-20)^2}{20} = 3.2$
Middle	3	20	$\frac{(3-20)^2}{20} = 14.45$
End with unripe banana	45	20	$\frac{(45-20)^2}{20} = 31.25$
Total	60	60	$\Sigma = 48.9$

a) The flies will be distributed so that there are more flies in the chamber with the glucose soaked cotton ball because glucose is an energy source for fruit flies and will therefore attract and maintaing increased numbers of fruit flies.

b) To improve the experimental control, soak the control cotton ball in ~~glucose~~ pure water to eliminate moisture content as a variable, making the experimental results due strictly to glucose not ~~glucose~~ water or glucose. This will not affect the fruit fly behavior and movement if glucose is the luring factor but it will make the fly numbers more

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equitable if water is the luring factor.

Increasing the temperature ~~throughout~~ throughout the entire system or testing at different temperatures could impact the data because flies are more active at higher temperatures. As ~~ecto~~ ectotherms, their metabolic rate (cellular respiration) ~~is~~ is impacted greatly by temperature, so ~~temperature~~ temperature ~~nearer~~ nearer to their ideal body temperature would increase cellular respiration and the need for glucose, so more flies would be found in the glucose-containing chamber

d) Since there are 3 ~~possible~~ possible outcomes, there are 2 degrees of freedom. Using a p value of 0.05, the maximum chi-square that would fail to reject the null hypothesis is 5.99. In this experiment, the chi-square value equals 48.9 which is greater than 5.99. As a result, the null hypothesis ~~can be~~ can be rejected ~~in~~ in favor of the alternative hypothesis that the ~~glucose~~ glucose does have an affect on fruit fly behavior.

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e) Fruit flies, ~~crossed out~~ even if they lack the ability to smell the glucose from the insertion point, will move about randomly. Once they encounter the glucose, they recognize it as a food source and will remain by it for a longer period of time. When the flies sense the glucose, they move toward it by chemotaxis rather than moving about randomly by kinesis. Other cues like increased moisture content or increased temperature would have similar impacts of fly behavior.

PART (C): CHI-SQUARE CALCULATION

Null Hypothesis: The distribution of fruit flies in the end w/ ripe banana, the middle, or the end w/ unripe banana is due to chance			
	Observed (o)	Expected (e)	$(o - e)^2/e$
End with ripe banana	45	20	31.25
Middle	3	20	14.45
End with unripe banana	12	20	3.2
Total	60	60	48.9

a. After 10 minutes most of the fruit flies will be
in the chamber w/ the glucose soaked cotton.
This will happen because the flies need
some sort of food & the glucose can be
used by them to turn into energy to live.
It will else help them to not dry out

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b. The dry cotton ball should be soaked in water for the other chamber (experimental control). That way after the 10 minutes you can see if the fruit flies went to the glucose cotton ball for the glucose. In the original set up they may have gone there to not dry out, but if the other cotton ball is wet too then you know. If the fruit fly doesn't want either then it can stay in the middle w/ nothing.

For the environmental factor, make sure the chamber is somewhere room temperature. If it is too hot or cold the fruit flies may be influenced as to which chamber they go to.

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d. The chi-square test proves that the null hypothesis is incorrect, & the distribution of fruit flies in due to something other than chance. In other words, the fruit fly distribution is not random. $X^2 = 48.9$ which is much greater than either degree of freedom for p = 2. (dof) At .05 the DOF ~~was~~ is 5.99 & at .001 the DOF is 9.21. Since $X^2 > p$, the null hypothesis is rejected

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e. Repeat the experiment w/ a setup under a light
+ a set up by a fan. The results can be
compared to the original set up to see how
environmental factors such as wind + light/heat
affect the flies choice of chamber.

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PART (C): CHI-SQUARE CALCULATION

Null Hypothesis: The flies will have no preference of ~~to where~~ where they are and each place will have an equal amount of flies.			
	Observed (o)	Expected (e)	$(o - e)^2/e$
End with ripe banana	45	20	31.25
Middle	3	20	14.45
End with unripe banana	12	20	3.2
Total	60	60	49.9

a) After 10 minutes there will be a higher amount of flies in the side with glucose soaked cotton than the middle or dry cotton. The flies will see the glucose soaked cotton as a source of food and ~~go~~ more will want the source of food.

b) Have more ends with dry cotton balls in them. This way it will show if the flies are going for the glucose or are not affected by the glucose.
An environmental factor is different organisms such as a different species of flies already in the chamber. This will show if the flies are willing to go to the substance with other factors blocking it.
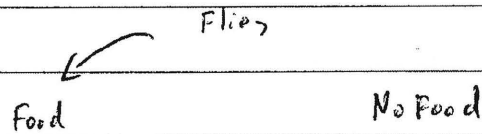
d) The null hypothesis is rejected because there needs to be a value of 5.99 and under in a 2 degree of freedom to be accepted. This

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mean, the data is scientificaly significant.

e) In the choice chamber, if one side has an environment flies prefer, it will more likely go to the side it likes.

Flies

Food   No Food

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AP® BIOLOGY
2013 SCORING COMMENTARY

Question 1

Question 1 was written to the following Learning Objectives in the AP Biology Curriculum Framework: 2.21, 2.23, 2.24, 2.38, 3.40, 3.41, 3.44, 3.45, 3.46, 4.14, and 4.16.

Overview

Question 1 asks students to apply inquiry skills to a lab-based investigation of fruit-fly behavior. Students were presented with a description of an experimental setup for investigating whether fruit-fly behavior is affected by the presence of a substance (glucose). Students were asked to make a prediction about the behaviors underlying taxis in fruit flies and to justify their prediction using reasoning that relates the presence of the glucose to specific behaviors. Students were also asked to suggest improvements to the data collection strategies that were used in the investigation and to explain how the modifications will ensure the validity and reliability of the results. Students were then asked to perform data analysis (a chi-square test) on the results of a related experiment. Finally, students were asked to propose a general model of fruit-fly behavior that is based on current scientific knowledge and understanding about how organisms detect and act on information in their environment.

Sample: 1A
Score: 10

The response earned 1 point in part (a) for predicting that there are more flies in the chamber with the glucose soaked cotton ball and 1 point for justifying the prediction by stating that the flies will be attracted to the glucose because it is an energy source.

The response earned 1 point in part (b) for proposing that an improvement to an experimental control would be to soak the control cotton ball in water and 1 point for explaining that the water-soaked cotton ball will ensure that glucose is the attractant. The response also earned 1 point for proposing that an improvement to an environmental factor would be to test the entire system at different temperatures and 1 point for explaining that using different temperatures would reveal the impact of higher temperatures on the data.

The response earned 1 point in part (c) for specifying an appropriate null hypothesis that the number of flies would be equal in all chambers and 1 point for predicting that the expected distribution of flies would be 20, 20, and 20.

The response earned 1 point in part (d) for explaining that a chi-square value of 48.9 is greater than the critical value of 5.99 and that the null hypothesis is rejected.

The response earned 1 point in part (e) for proposing that when flies sense the glucose (stimulus) they move toward it by chemotaxis (response).

Sample: 1B
Score: 8

The response earned 1 point in part (a) for predicting that most of the fruit flies will be in the chamber with the glucose soaked cotton and 1 point for justifying the prediction by stating that the distribution of flies is due to the attraction to glucose as a food source.

The response earned 1 point in part (b) for proposing that an improvement to the experimental control would be to soak the dry cotton ball in water and 1 point for explaining that using a wet cotton ball would ensure that glucose is the attractant.

The response earned 1 point in part (c) for specifying a null hypothesis that the distribution of flies in the choice chamber is due to chance and 1 point for predicting that the expected distribution of flies will be 20, 20, and 20.

The response earned 1 point in part (d) for explaining that a chi-square value of 48.9 is greater than the critical value of 5.99 and that the null hypothesis is rejected.

The response earned 1 point in part (e) for proposing that environmental factors like wind, light, and heat are stimuli that affect the choices (responses) flies make inside the choice chamber.

Sample: 1C
Score: 6

The response earned 1 point in part (a) for predicting that the there will be a higher amount of flies in the side with the glucose soaked cotton ball and 1 point for justifying the prediction by stating that the flies will want the glucose as a source of food.

The response earned 1 point in part (c) for stating a null hypothesis that the flies will have no preference of where they are and 1 point for predicting that the expected distribution of flies will be 20, 20, and 20.

The response earned 1 point in part (d) for explaining that the null hypothesis is rejected because the calculated chi-square value of 48.9 is greater than the critical value of 5.99.

The response earned 1 point in part (e) for proposing that food (stimulus) would cause the flies to go to that side (response).