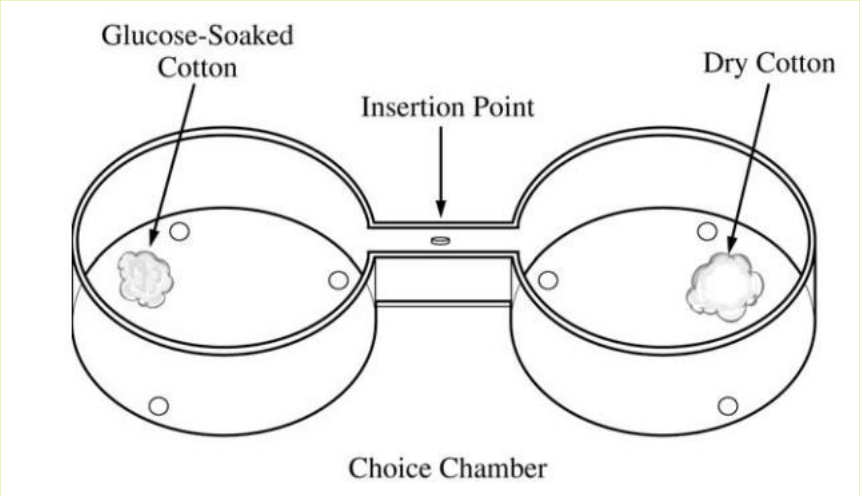
# AP Bio FRQ Fridays

## 2013 #1
## Experimental Design, Chi Square, and Fruit Flies

# FRQ Friday #26

# 2013 #1




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% 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.

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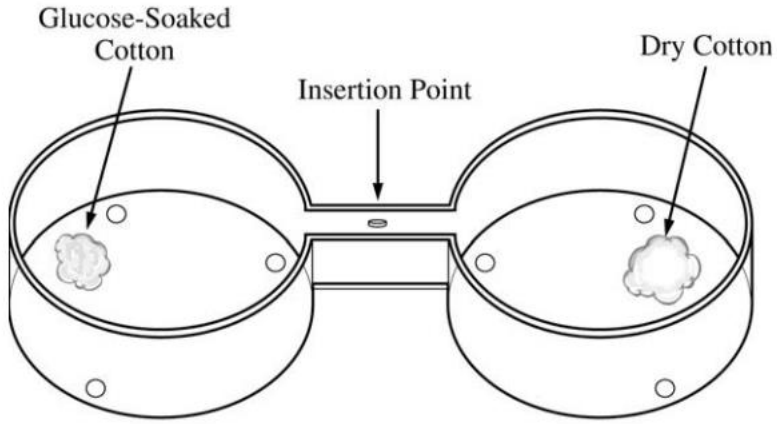
(a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction.




- 1 point for predicting the location of the flies in the choice chamber
- 1 point for justifying the prediction

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.

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(b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment.

- 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<br>• Use different temperature(s)<br>• Use different light levels<br>• Use a different choice chamber (size/shape)<br>• Vary duration of the experiment<br>• Vary time of day when experiment is performed | Attributes movement of flies only to glucose preference |

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b) To improve the experimental control, soak the control cotton ball in pure water to eliminate moisture content as a variable, making the experimental results due strictly to glucose not 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 equitable if water is the luring factor.

Increasing the temperature throughout the entire system or testing at different temperatures could impact the data because flies are more active at higher temperatures. As ectotherms, their metabolic rate (cellular respiration) is impacted greatly by temperature, so temperature 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

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(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.

## Chi Five by: J. Daily

1. Null hypothesis
2. Calculate Chi Square value
3. Find degrees of freedom
4. Find critical value
5. Conclusion (reject or fail to reject)

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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 |

## Chi Five by: J. Daily

1. **Null hypothesis**

   Independent variable has no effect on dependent variable

2. **Calculate Chi Square value**

   Use the given chart to determine the observed, expected, and calculation

PART (C): CHI-SQUARE CALCULATION

Null Hypothesis:

The presence of banana (ripe or unripe) has no effect on fruit fly position

| | Observed (o) | Expected (e) | $(o - e)^2/e$ |
|---|---|---|---|
| End with ripe banana | 45 | 20 | ((45-20)^2)/20 |
| Middle | 3 | 20 | ((3-20)^2)/20 |
| End with unripe banana | 12 | 20 | ((12-20)^2)/20 |
| Total | 60 | | |

| Treatment | Observed (O) | Expected (e) | (O-e) | (O-e)^2 | ((O-e)^2)/e |
|---|---|---|---|---|---|
| | | | | | |

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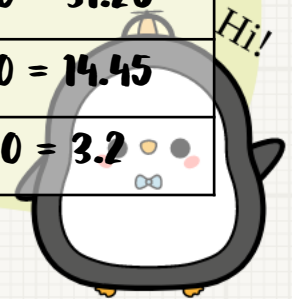
| End with ripe banana | 45 | 20 | ((45-20)^2)/20 |
| Middle | 3 | 20 | ((3-20)^2)/20 |
| End with unripe banana | 12 | 20 | ((12-20)^2)/20 |
| Total | 60 | | 48.9 |

| Treatment | Observed (O) | Expected (E) | (O-E) | (O-E)^2 | ((O-E)^2)/E |
|---|---|---|---|---|---|
| End with ripe | 45 | 20 | 25 | 625 | 625/20 = 31.25 |
| Middle | 3 | 20 | -17 | 289 | 289/20 = 14.45 |
| End with unripe | 12 | 20 | -8 | 64 | 64/20 = 3.2 |



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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.

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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 | $\Sigma = 48.9$ |

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(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation.

3. **Find degrees of freedom**

   df = n − 1 = 3 − 1 = 2

4. **Find critical value**

   at df = 2 & p = 0.05 → 5.99

5. **Conclusion (reject or fail to reject)**

PART (C): CHI-SQUARE CALCULATION

Null Hypothesis:

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| Total | 60 | | 48.9 |

## Chi-Square Table

| *p* value | Degrees of Freedom | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 0.05 | 3.84 | 5.99 | 7.81 | 9.49 | 11.07 | 12.59 | 14.07 | 15.51 |
| 0.01 | 6.63 | 9.21 | 11.34 | 13.28 | 15.09 | 16.81 | 18.48 | 20.09 |

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   5.99 < 48.9 so.... you reject the null hypothesis

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| Total | 60 | | 48.9 |

- Correct explanation with justification of why the stated null hypothesis is rejected or not rejected. Response must clarify each of the following:
  - 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)
  - how the calculated test statistic compares to the selected critical value
  - whether the null hypothesis should be rejected

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(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation.

d) Since there are 3 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 rejected in favor of the alternative hypothesis that the glucose does have an effect on fruit fly behavior.

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(e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber.

- Stimulus → Response
- Input →(possible integration) →Output

e) Fruit flies, [illegible] 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.