

AP Biology 2023-2024

Mrs. Schlusel

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Welcome to AP Biology! I am excited that you decided to take this class. AP Biology is all about living systems. This includes everything from the molecules inside cells, to the workings of whole organisms to the interactions in ecosystems. The course is organized in 8 units:

- 1. Chemistry of Life**
- 2. Cell Structure and Function**
- 3. Cellular Energetics**
- 4. Cell Communication and Cell Cycle**
- 5. Heredity**
- 6. Gene Expression and Regulation**
- 7. Natural Selection**
- 8. Ecology**

In the course, we will also focus on mastery of 6 scientific practices (skills). The exam at the end of the year will ask you to demonstrate that mastery. The scientific practices are:

- 1. Concept Explanation** – being able to explain biological concepts in writing
- 2. Visual Representations** – being able to analyze visual representations of biological concepts
- 3. Questions and Methods** – being able to determine scientific questions and experimental methods
- 4. Representing and Describing Data** – being able to describe data and construct graphs and charts
- 5. Statistical Tests and Data Analysis** – being able to perform statistical tests on data
- 6. Argumentation** – being able to develop and justify scientific arguments using evidence

AP Biology is designed to cover material that would be covered in a two-semester college-level introductory biology course for biology majors. In order to be successful, you will need to put in a lot of time and effort. This class is not about simply memorizing information, but you will be asked to think critically, read, write well, do math (eek!) and formulate your own ideas about the living world. To do well in the class, you need to ask lots of questions and think about what you are learning.

Laboratory exercises will be an integral part of the course. You will need to maintain a laboratory notebook. It must be a composition style notebook (bound not spiral) with grid paper inside (graph paper) not lined paper. Please do not hesitate to contact me if you are unsure about anything. I will check my MVA email regularly over the summer.

Part 1: GRAPHING PACKET

Objectives

Read through these pages to learn about the skills of graphing and data analysis. Then respond to the questions and try your hand at making graphs.

After completing this exercise, you should be able to

1. Explain the difference between discrete and continuous variables and give examples.
2. Use one given data set to construct a line graph.
3. Use another given data set to construct a bar graph.
4. Given a set of data, describe how it would best be presented.

Activity A: Tables

A student team performed the experiment. They tested the pulse and blood pressure of basketball players and nonathletes to compare cardiovascular fitness. They recorded the following data:

Nonathletes							Basketball Players						
	Resting pulse			After exercise				Resting pulse			After exercise		
	Trial			Trial				Trial			Trial		
Subject	1	2	3	1	2	3	Subject	1	2	3	1	2	3
1	72	68	71	145	152	139	1	67	71	70	136	133	134
2	65	63	72	142	144	158	2	73	71	70	141	144	142
3	63	68	70	140	147	144	3	72	74	73	152	146	149
4	70	72	72	133	134	145	4	75	70	72	156	151	151
5	75	76	77	149	152	153	5	78	72	76	156	150	155
6	75	75	71	154	148	147	6	74	75	75	149	146	146
7	71	68	73	142	145	150	7	68	69	69	132	140	136
8	68	70	66	135	137	135	8	70	71	70	151	148	146
9	78	75	80	160	155	153	9	73	77	76	138	152	147
10	73	75	74	142	146	140	10	72	68	64	153	155	155

If the data were presented to readers like this, they would see just lists of numbers and would have difficulty discovering any meaning in them. This is called **raw data**. It shows the data the team collected without any kind of summarization. Since the students had each subject perform the test three times, the data for each subject can be **averaged**. The other raw data sets obtained in the experiment would be treated in the same way.

Table. Average Pulse Rate for Each Subject

(Average of 3 trials for each subject; pulse taken before and after 5-min step test)

Nonathletes			Basketball Players		
	Resting pulse	After exercise		Resting pulse	After exercise
Subject	Average	Average	Subject	Average	Average
1	70	145	1	70	134
2	67	148	2	70	142
3	67	144	3	73	149
4	71	139	4	72	151
5	76	151	5	76	155
6	74	150	6	75	146
7	71	146	7	69	136
8	68	136	8	70	146
9	78	156	9	76	147
10	74	143	10	68	155

These rough data tables are still rather cumbersome and hard to interpret. A summary table could be used to convey the overall averages for each part of the experiment. For example:

Table. Overall Averages of Pulse Rate

(10 subjects in each group; 3 trials for-each subject; pulse taken before and after 5-min step test)

Pulse Rate (beats/min)		
	Before exercise	After exercise
Nonathletes	71.6	145.8
Basketball players	71.9	146.1

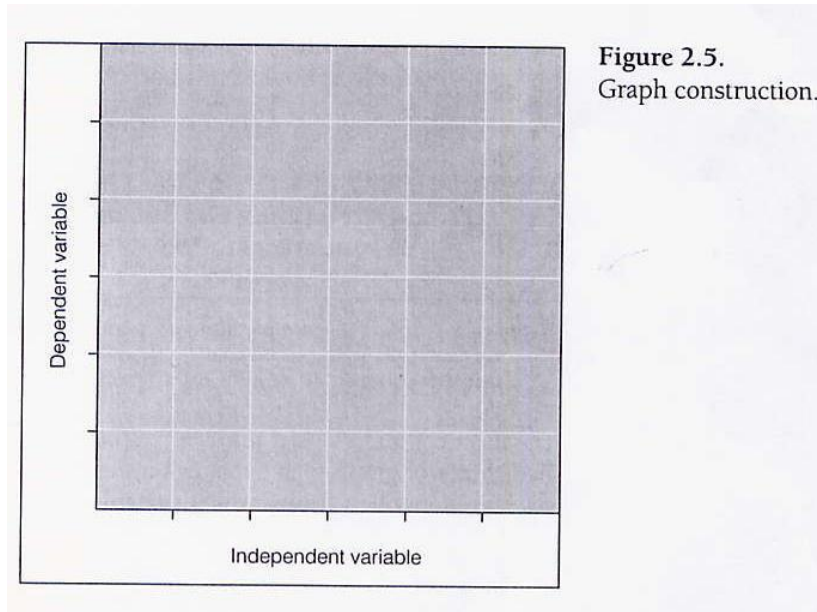
Notice that the table has a title above it that describes its contents, including the experimental conditions and the number of subjects and replications that were used to calculate the averages. In the table itself, the units of the **dependent variable** (pulse rate) are given and the **independent variable** (nonathletes and basketball players) is written on the left side of the table.

Tables should be used to present results that have relatively few data points. Tables are also useful to display

several dependent variables at the same time. For example, average pulse rate before and after exercise, average blood pressure before and after exercise, and recovery time could all be put in one table.

Activity B: Graphs

Numerical results of an experiment are often presented in a graph rather than a table. A graph is literally a picture of the results, so a graph *can often be more easily interpreted than a table*. Generally, the **independent variable is graphed on the x-axis** (horizontal axis) and the **dependent variable is graphed on the y-axis** (vertical axis). In looking at a graph, then, the effect that the independent variable has on the dependent variable can be determined.



When you are drawing a graph, keep in mind that your objective is to show the data in the clearest, most readable form possible. In order to achieve this, you should observe the following rules:

- Use **graph paper** to plot the values accurately
- Plot the independent variable on the x-axis and the dependent variable on the y-axis. For example, if you are graphing the effect of the amount of fertilizer on peanut weight, the amount of fertilizer is plotted on the x-axis and peanut weight is plotted on the y-axis.
- **Label each axis with the name of the variable and specify the units** used to measure it. For example, the x-axis might be labeled "Fertilizer applied (g/100 m²)" and the y-axis might be labeled "Weight of peanuts per plant (grams)."
- The intervals labeled on each axis should be appropriate for the range of data **so that most of the area of the graph can be used**. For example, if the highest data point is 47, the highest value labeled on the axis might be 50. If you labeled intervals on up to 100, there would be a large unused area of the graph.
- The intervals that are labeled on the graph should be **evenly spaced**. For example, if the values range from 0 to 50, you might label the axis at 0, 10, 20, 30, 40, and 50. It would be confusing to have labels that correspond to the actual data points (for example, 2, 17, 24, 30, 42, and 47).
- The graph should have a **title** that, like the title of a table, describes the experimental conditions that produced the data.

Figure 2.6 illustrates a well-executed graph

Figure 2.6.
Graph of peanut weight vs.
amount of fertilizer applied.

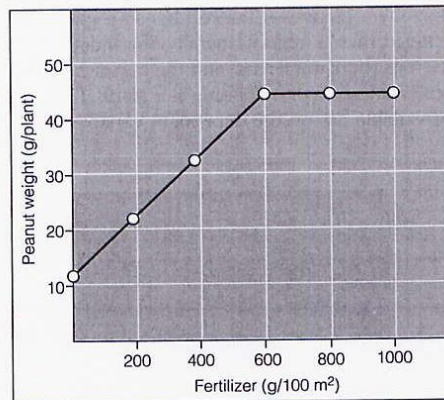


Figure 1. Weight of peanuts produced per plant when amount of fertilizer applied is varied. (Average seed weight per plant in 100 m² plots, 400 plants/plot.)

The most commonly used forms of graphs are line graphs and bar graphs.

*While this assignment does not give any examples of Pie Charts, they are also very useful tools for presenting data that represents percentages or relative amounts of something. They are not considered graphs because they do not plot independent and dependent variables against each other.

The choice of graph type depends on the nature of the independent variable being graphed.

Continuous variables are those that have an unlimited number of values between points. Line graphs are used to represent continuous data. For instance, time is a continuous variable over which things vary. Although the units on the axis can be **minutes, hours, days, months, or even years**, values can be placed in between any two values. Amount of fertilizer can also be a continuous variable. Although the intervals labeled on the x-axis are 0, 200, 400, 600, 800, and 1000 (g/100 m²), many other values can be listed between each two intervals.

In a line graph, data are plotted as **separate points** on the axes, and the points are connected to each other. Notice in Figure 2.7 that when there is more than one set of data on a graph, it is necessary to provide a **key** indicating which line corresponds to which data set.

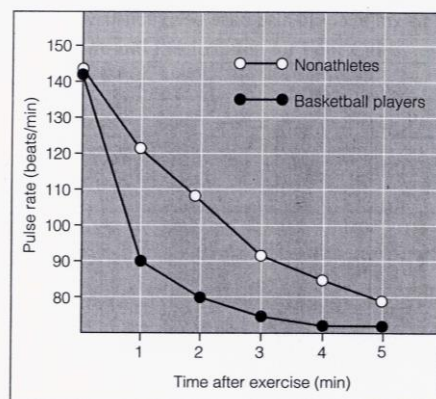
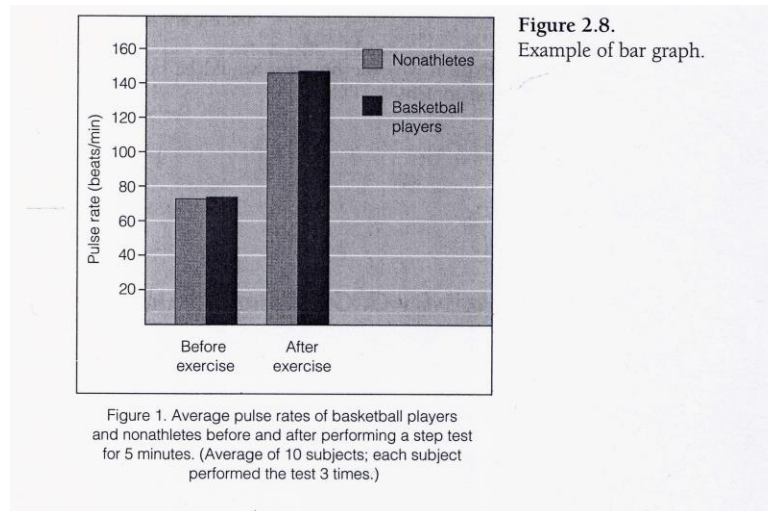


Figure 2.7.
Line graph representing two
related sets of data.

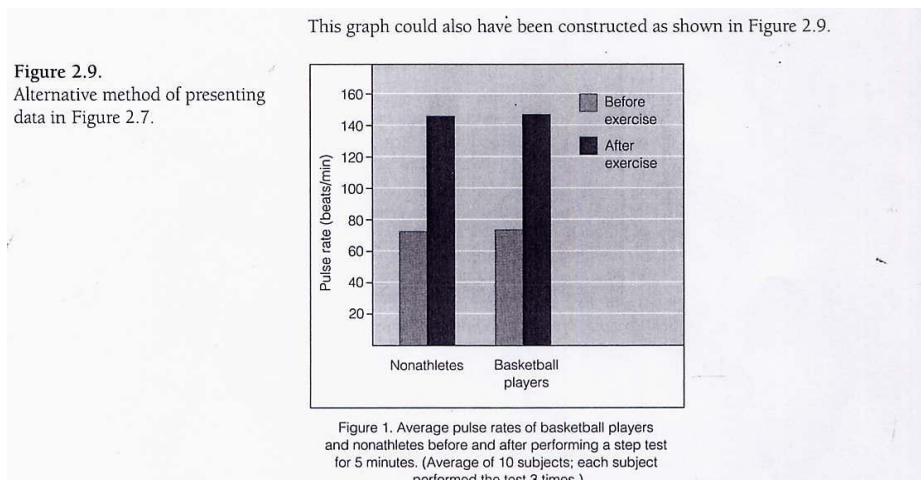
Figure 1. Recovery rate of basketball players and nonathletes after performing a step test for 5 minutes. (Average of 10 subjects; each subject performed the test 3 times.)

Discrete variables, on the other hand, have a limited number of possible values, and no values can fall between them. For example, the **type of fertilizer** is a discrete variable: There are a certain number of types which are distinct from each other. If fertilizer type is the independent variable displayed on the x-axis, there is no continuity between the values.

Bar graphs, as shown in Figure 2.8, are used to display discrete data.



In this example, before- and after-exercise data are discrete: There is no possibility of intermediate values. The subjects used (basketball players and nonathletes) also are a discrete variable (a person belongs to one group or the other).



1) What is the difference between these two graphs (figures 2.8 and 2.9)?

2) Which way would be better to convey the results of the experiment (in references to figures 2.7-2.9)? Explain why.

3) What can you infer from these results?

Activity C: Graphing Practice

Use the temperature and precipitation data provided in Table 2.6 on the next page to answer the following questions:

1) Compare monthly temperatures in *Fairbanks* with temperatures in *San Salvador*.

Can data for both cities be plotted on the same graph?

What will go on the x-axis?

Table 2.6

Average Monthly High Temperature and Precipitation for Four Cities

(T = temperature in °C; P = precipitation in cm)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Fairbanks, Alaska	T	-19	-12	-5	6	15	22	22	19	12	2	-11	-17
	P	2.3	1.3	1.8	0.8	1.5	3.3	4.8	5.3	3.3	2.0	1.8	1.5
San Francisco, California	T	13	15	16	17	17	19	18	18	21	20	17	14
	P	11.9	9.7	7.9	3.8	1.8	0.3	0	0	0.8	2.5	6.4	11.2
San Salvador, El Salvador	T	32	33	34	34	33	31	32	32	31	31	31	32
	P	0.8	0.5	1.0	4.3	19.6	32.8	29.2	29.7	30.7	24.1	4.1	1.0
Indianapolis, Indiana	T	2	4	9	16	22	28	30	29	25	18	10	4
	P	7.6	6.9	10.2	9.1	9.9	10.2	9.9	8.4	8.1	7.1	8.4	7.6

Source: Pearce, E. A., and G. Smith. Adapted from *The Times Books World Weather Guide*. New York: Times Books, 1990.

How should the x-axis be labeled?

What should go on the y-axis?

What is the range of values on the y-axis?

How should the y-axis be labeled?

What type of graph should be used?

- 2) Compare the average September temperature for Fairbanks, San Francisco, San Salvador, and Indianapolis.
Can data for all four cities be plotted on the same graph?

What will go on the x-axis?

How should the x-axis be labeled?

What should go on the y-axis?

What is the range of values on the y-axis?

How should the y-axis be labeled?

What type of graph should be used?

Interpreting Information on a Graph

Once you understand how graphs are constructed, it is easier to get information from the graphs in your textbook as well as to interpret the results you obtain from laboratory experiments. For the graphs below answer the questions that follow.

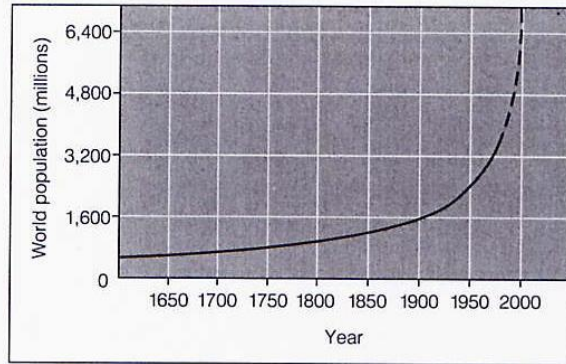
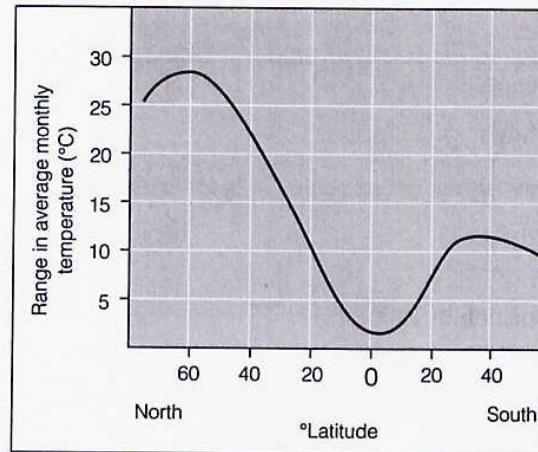


Figure 2.10.
Change in world population from
1650 to 2000.

- 1) Interpret this graph: What patterns or trends to you see?
- 2) What was the world's population in 1900?
- 3) Predict the world's population in 2000.
- 4) Why does this graph change from a solid line to a dashed line at the end?

Figure 2.12.
Change in range of average
monthly temperature as
latitude changes.



Please note that the y-axis is given as a “range” of temperatures, not actual temperatures.

8) Interpret this graph: What patterns or trends do you see?

9) At what latitude does the least variation in temperature occur?

10) Miami is at approximately 26° N latitude. From the information on the graph, what is the range in mean monthly temperature there?

11) Minneapolis is at approximately 45° N latitude. From the information on the graph, what is the range in mean monthly temperature there?

12) Sydney, Australia is at approximately 33° S latitude. From the information on the graph, what is the range in mean monthly temperature there?

13) Look at any map or photographs of the world to try and explain the temperature patterns in the graph.

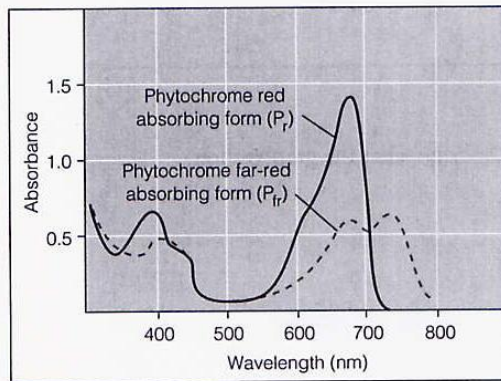


Figure 2.13.
Absorption of light by the pigments P_r phytochrome and P_{fr} phytochrome.

Please note that the y-axis has no “units”. Absorbance is a type of measurement used in spectroscopy that we will discuss later this year.

14) Interpret this graph: What patterns or trends to you see?

15) At what wavelengths does P_r phytochrome absorb the most light?

16) At what wavelengths does P_{fr} phytochrome absorb the most light?

Part 2: DESIGN AN EXPERIMENT USING PLANTS

For the second part of your summer assignment, you will design and conduct an experiment using plants. You may choose to investigate something to do with plant growth, light, fertilizer, root development, pollination, or seed germination. Any topic about plants is okay.

Go online and search for ideas. Don't stress about this, instead have fun while learning! It is okay if everything doesn't turn out perfectly. This assignment is meant for you to begin to think like a scientist, ask questions, and try to find answers.

I suggest that you choose plants or seeds that you can commonly find at a local nursery or Home Depot. If you choose to germinate seeds, try to choose some that germinate and grow quickly so you can get quick results. If you have any problems accessing the plants you need please let me know and I can help you brainstorm ideas. I will be answering email and Teams messages throughout the summer.

For this assignment, you will be designing your own experiment. An experiment is an organized series of steps used to test a theory or an idea. Experimental design is a specific set of steps that is organized such that the results are as valid as possible. The purpose of experimental design is to eliminate experimental error and to ensure that the results are due to the factor or factors being tested. The experiment, based on a testable hypothesis that was inferred from research, must be repeatable.

To complete this assignment, please follow these experimental steps:

Step 1: Stating the Problem or Question

What do you want to find out? Write a statement that describes what you want to do. It should be as specific as possible. It is important to also do some background research on the Internet. Scientists always read relevant information pertaining to their experiment beforehand.

The purpose/problem will most likely be stated as a question such as: "What are the effects of _____ on _____?"

Step 2: Defining Variables

INDEPENDENT VARIABLE (IV) (also called the manipulated variable) — the variable that is changed on purpose for the experiment; you may have several levels of your independent variable.

DEPENDENT VARIABLE (DV) (also called the responding variable) — The variable that acts in response to or because of the manipulation of the independent variable.

CONSTANTS (C) — All factors in the experiment that are not allowed to change throughout the entire experiment. Controlling constants is very important to assure that the results are due only to the changes in the independent variable; everything (except the independent variable) must be constant in order to provide accurate results.

CONTROL GROUP - For some experiments, a control (standard of comparison for checking or verifying the results of an experiment) is necessary. All variables must be held constant in the control group.

EXPERIMENTAL GROUP — The group(s) being tested with the independent variable; each experimental group has only one factor different from each other, everything else must remain constant.

REPEATED TRIALS — The number of times that the experiment is repeated. The more times you repeat the experiment, the more valid your results will be. Repeated trials can be done simultaneously or sequentially.

Step 3: Forming a Hypothesis

A hypothesis is an inferring statement that can be tested. The hypothesis describes how you think the dependent variable will be affected by the independent variable. It is based on research and is written before you conduct the experiment. It may include an explanation such as the example below.

For example: When given the option of staying in the light or the dark, crickets will spend more time in the dark because their natural habitat is under fallen logs and brush where it is dark.

In order to write a reasonable hypothesis, you will need to do some research on the Internet. Do not skip this step, as you want your experiment to make sense.

Step 4: Designing an Experimental Procedure

You should select only one thing to change in each experimental group (independent variable). Change a variable that will help test the hypothesis.

The written procedure must tell how the variable will be changed (very specifically what you are doing). The procedure must explain how the change in the variable will be measured.

The procedure should indicate how many trials would be performed (the more the better).

It must be written in a way that someone can replicate your experiment.

Step 5: Data Analysis and Results

Before analyzing your data, you will need to write down all your observations and measurements. You may have both qualitative observations (non-numerical such as texture or color) and quantitative observations (measurements using numbers such as height in centimeters or number of leaves). Be sure to include both.

The results of your experiment will then need to be compiled into a table or chart for easy interpretation.

You will also need to prepare an appropriate graph of the quantitative data to observe trends more easily. Use graph paper for this. It should be drawn by hand; do not use a graphing program for this step.

Step 6: Conclusion

For your conclusion, you will write (in sentences) what have you discovered from this experiment. Describe the conclusions you can make about the results. How does your data specifically support this conclusion? Refer to your hypothesis and write about whether the data you collected supports your original idea. We do not refer to hypotheses as “right” or “wrong”, but instead we talk about whether the data agrees with the hypothesis. You should also indicate any flaws in the research and errors or problems that were encountered. How could this experiment be improved? What ideas do you have for future study?

I would like you to complete the experiment and the write up before school starts in the fall. This does not need to be perfect, but it should be your own original idea and the data and graphs should be original as well.

Be sure to include the following in your write up:

- Background research about plant topic is included
- Question / problem is clearly stated
- Hypothesis is clearly stated
- Independent variable(s), dependent variable(s), and controls are clearly stated
- Procedures are clearly listed including materials; drawings or photos are included as needed
- Data has been recorded in a chart or table and graphed appropriately
- Analysis of data is described
- Errors or problems encountered are described
- Conclusions are clearly stated

Part 3 - Free Response Question

An integral part of the AP Biology class is to prepare you to take the AP Biology exam which takes place at the end of the year. The exam consists of both multiple-choice questions and free response questions. To help you get a head start, please carefully read through this sample free response question. The original question is highlighted. Please answer the associated (not highlighted) questions.

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

Treatment	Memory (Average probability of revisiting a nectar source)	
	10 minutes	24 hours
Control	0.72	0.41
Caffeine	0.83	0.78

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).

What is the dependent variable (what is the responding variable)? _____

That should go on the Y-axis.

What is the independent variable (what is the manipulated variable)? _____

That goes on the X- axis.

Check your scale. Make sure it makes best use of the space and has equal steps between numbers.

Label your axes.

Now go ahead and plot the data on your graph.



(b) Based on the results, describe the effect of caffeine on short-term (10 minute) memory of a nectar source.

Use the information from your own graph to describe what happened to the bee memory with and without caffeine after 10 minutes. Was there any real difference?

(c) Based on the results, describe the effect of caffeine on long-term (24 hour) memory of a nectar source.

Use the information from your own graph to describe what happened to the bee memory with and without caffeine after 24 hours. What happened and how was this different from the results after 10 minutes?

(d) 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 hypothesis, an appropriate control treatment, and the predicted results.

Think of an experiment in which you could use artificial flowers, added nectar (its just sugar water after all), and added caffeine in different amounts to control everything.

Write out your hypothesis:

What will you use for your controls (similar but without caffeine, since that will be your IV)?

Describe the results you would expect from this experiment – just make it up but use your understanding of the sample experiment to guide your thoughts.

- (e) 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. How do plants produce sugar? What does it cost the plant to go through that process? Is it better for the plant to make less sugar and caffeine or more sugar and no caffeine?

Why does the plant make the nectar in the first place (what is the benefit for the plant)?

Propose one cost to bees that visit the flowers of plants that produce nectar with caffeine and a lower sugar content.

What is the drawback to bees if they get less sugar?

What is the cost to the entire hive?