EXERCISE 2.3 **Data Presentation**

Objectives

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 unwieldy 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.

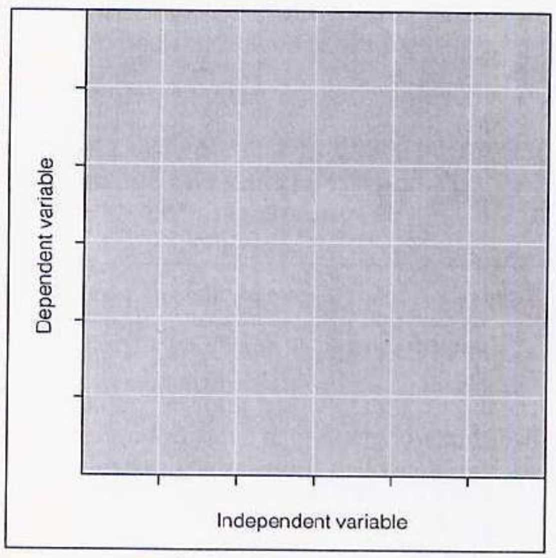


Figure 2.5.
Graph construction.

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.

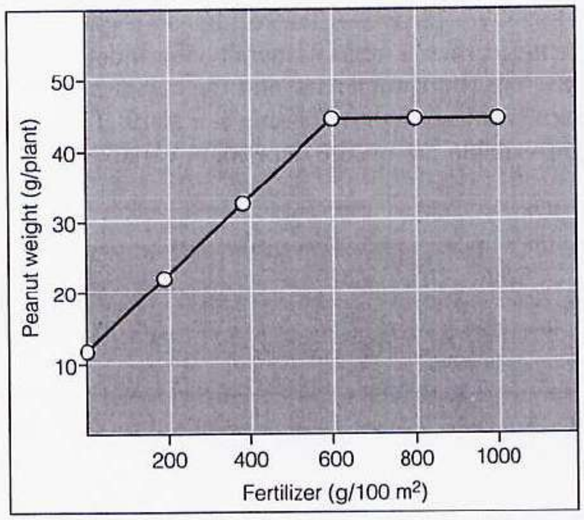


Figure 1. Weight of peanuts produced per plant when amount of fertilizer applied is varied. (Average seed weight per plant in 100 m^2 plots, 400 plants/plot.)

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 such as growth will 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.

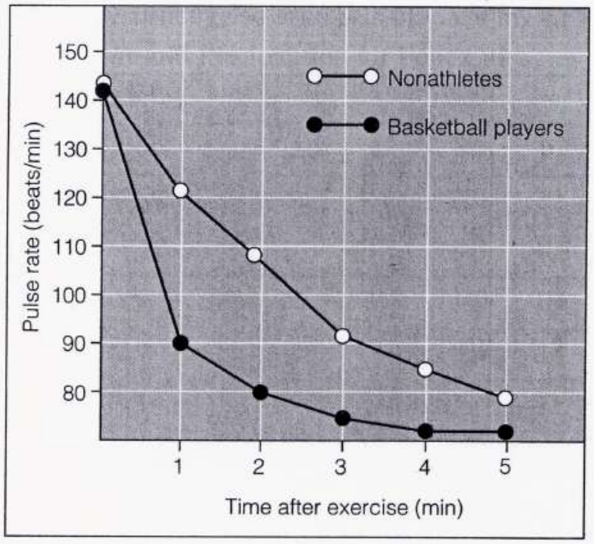


Figure 1. Recovery rate of basketball players and nonathletes after performing a step test for 5 minutes. (Average of 10 subjects; each subject performed the test 3 times.)

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

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.

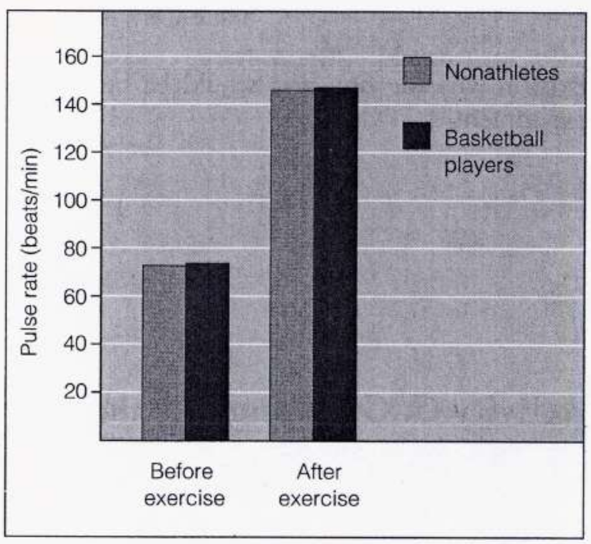


Figure 1. Average pulse rates of basketball players and nonathletes before and after performing a step test for 5 minutes. (Average of 10 subjects; each subject performed the test 3 times.)

Figure 2.8.
Example of bar graph.

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).

This graph could also have been constructed as shown in Figure 2.9.

Figure 2.9.
Alternative method of presenting data in Figure 2.7.

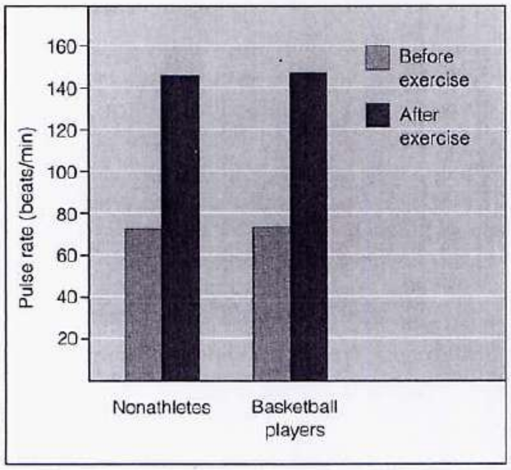


Figure 1. Average pulse rates of basketball players and nonathletes before and after performing a step test for 5 minutes. (Average of 10 subjects; each subject performed the test 3 times.)

What is the difference between the two graphs?

Which way would be better to convey the results of the experiment?
Explain why.

What can you infer from these results?

Activity C: Graphing Practice

Use the temperature and precipitation data provided in Table 2.6 to complete 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?

3. Graph the temperature and precipitation data for San Francisco.

Can both sets of data be plotted on the same graph? *See pg 1148 in your Biology Textbook before answering and drawing the 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 temperature axis?

How should this axis be labeled?

What is the range of values on the precipitation axis?

How should this axis be labeled?

What type of graph should be used?

EXERCISE 2.4

Interpreting Information on a Graph

Objective

After completing this exercise, you should be able to

1. Interpret graphs.

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, write a sentence or two describing what each graph shows, and answer the questions.

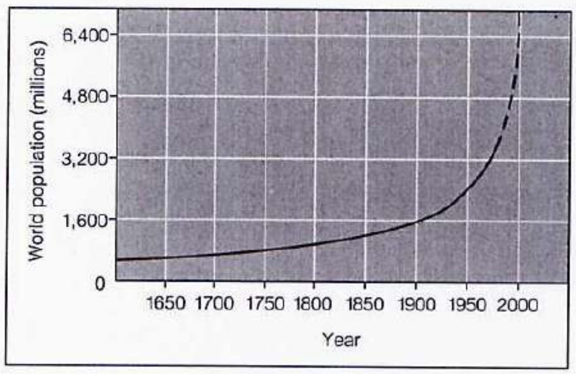


Figure 2.10. Change in world population from 1650 to 2000.

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

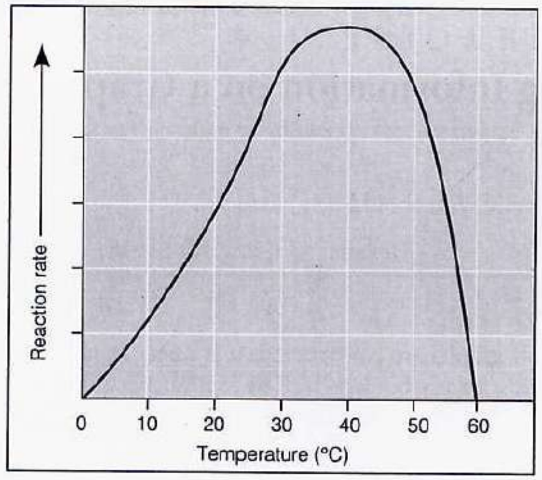
What was the world's population in 1900?

Predict the world's population in 2000.

Why does this graph change from a solid line to a dashed line at the end?

* Remember that Rate = amount / time.   In this case it should be product / minute.

Figure 2.11.
Rate of an enzymatic reaction at different temperatures.

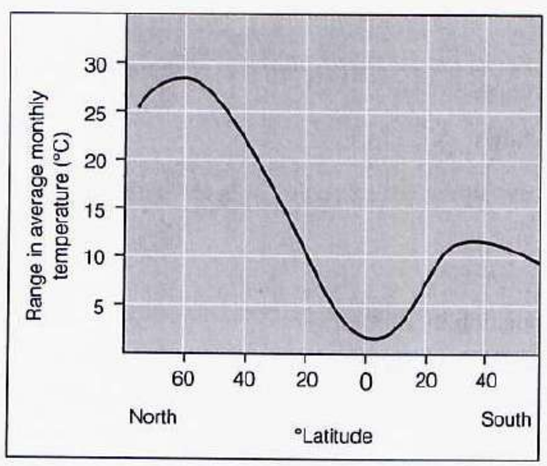


Interpret this graph: What patterns or trends to you see?

At what temperature is reaction rate the highest?

Can you explain why this is not a "bell curve" with different patterns on each side of the apex?

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

At what latitude does the least variation in temperature occur?

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

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

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

Look at any map or photographs of the world (Pg 1088 in Biology) to try and explain the temperature patterns in the graph. Hint: think H-bonds.

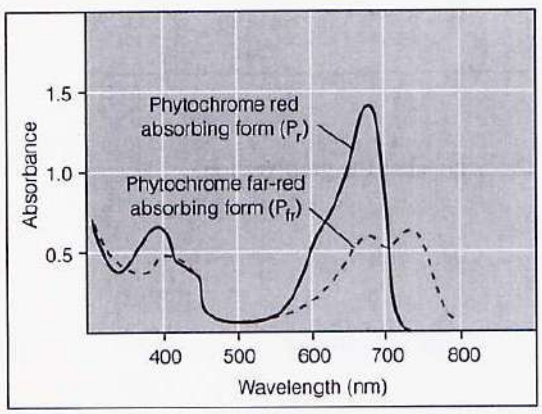


Figure 2.13. Absorption of light by the pigments P_r phytochrome and P_{fr} phytochrome.

Please note that the y-axis has no "units" Absorbance is a type of measurement used in spectroscopy that we will discus in great detail later this year. For a simple explanation see Pg 187 in *Biology*.
We will also be looking at the significance of P_r and P_{fr} in Ch. 39, Plant Physiology.

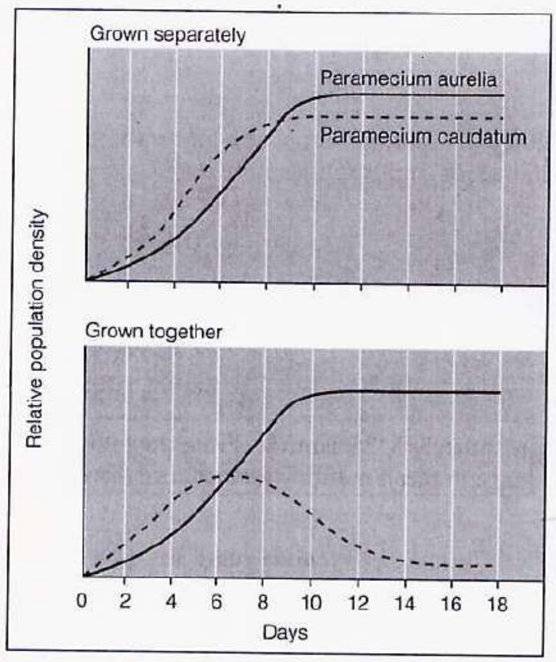
Interpret this graph: What patterns or trends to you see?

At what wavelengths does P_r phytochrome absorb the most light?

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

Use this graph to explain why (how) the pigments were named.
A visible light spectrum can be found on Pg 186 in *Biology.*

Figure 2.14.
Population growth of *Paramecium aurelia* and *Paramecium caudatum* when grown separately and together.



On what day does *Paramecium aurelia* reach its maximum population density?

Does *Paramecium caudatum* do better when it is grown alone or when it is grown in a mixture with *Paramecium aurelia?*

Interpret these graphs: What patterns or trends to you see?

This is a classic experiment, after you interpret the results, you should read about it on Pg 1160 in *Biology*

Questions for Review

Convert the following measures. See Appendix B in *Biology* for conversions and units. In biology we frequently use the measurements micro (μ) and nano (n) when discussing cells.

2.8 mm =	nm	4.67 m =	μm
1.3 nm =	μm	67 cm =	m
12 μg =	ng	1.6 g =	kg
300 μg =	g	250 mg =	μg
83 mL =	L	250 mL =	L
175 μL =	mL	0.5 L =	mL
75 °F =	°C	50 °c =	°F

***In the following questions you will be constructing graphs without plotting data. By practicing how to construct graphs, you will learn how to graph your own data in later labs. Use the regularity and size intervals to determine if a variable is continuous or discrete.**

1. A team of students hypothesizes that the amount of alcohol produced in fermentation depends on the amount of sugar supplied to the yeast. They want to use 5, 10, 15, 20, 25, and 30% sugar solutions. They propose to run each experiment at 40°C with 5 mL of yeast.
   What type of graph is appropriate for presenting these data? Explain why.

   Sketch the axes of a graph that would present these data. Mark the intervals on the x-axis and label both axes completely. Write a title for the graph.

2. Having learned that the optimum sugar concentration is 25%, the students next decide to investigate whether different strains of yeast produce different amounts of alcohol. If you were going to graph the data from this experiment, what type of graph would be used? Explain why.

   Sketch and label the axes for this graph and write a title.

3. A team of students wants to study the effect of temperature on bacterial growth. They put the dishes in different places: an incubator (37°C), a lab room (21°C*),* a refrigerator (10°C) and a freezer (0°C). Bacterial growth is measured by estimating the percentage of each dish that is covered by bacteria at the end of a 3-day growth period.
What type of graph would be used to present these data? Explain why

Sketch the axes below. Mark the intervals on the x-axis, and label both axes completely. Write a title for the graph.

4. A team of scientists is testing a new drug, XYZ, on AIDS patients. The scientists monitor patients in the study for symptoms of 12 different diseases. What would be the best *way* for them to present these data?
Explain why

5. A group of students decides to investigate the loss of chlorophyll in autumn leaves. They collect green leaves and leaves that have turned color from sugar maple, sweet gum, beech, and aspen trees. Each leaf is subjected to an analysis to determine how many mg of chlorophyll is present.
What type of graph would be most appropriate for presenting the results of this experiment? Explain why