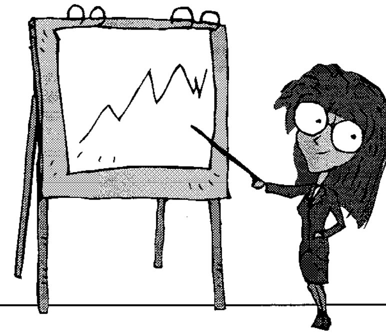
Analyzing Scientific Experiments

Section 3.1 Using Line Graphs to Organize and Interpret Data



Pre-View 3.1

- **Line graph** – a visual representation of data showing how something has changed over a period of time

After data has been gathered, you must interpret the information and present it in such as way that it makes sense to others. One way you saw in Section 2.3 was to summarize the information in a table. Another way to represent data is to use one or more graphs or diagrams. Graphs and diagrams present information in a way that makes data easier to interpret visually. There are different types of graphs and diagrams that can be used to display data, and each type has a specific use. Remember, you always want to choose the best way to display your data that makes it easiest to interpret.

All graphs or diagrams have several important features in common. They should always have a *title* that describes the data being presented. They should also have *labels* that identify the different parts of the graph or diagram, and they may have a *legend* (sometimes called a *key*) to identify different types of data.

Line Graphs

Line graphs are frequently used to show how something changes over time. Line graphs have an x-axis and a y-axis. The horizontal, or x-axis, is used to show the time frame or some other independent variable. The vertical, or y-axis, is used to show the dependent variable. Line graphs have several features described below:

Title: The title of a graph should give an explanation of the data given by the graph.

Axes: The x-axis is a horizontal line that is usually labeled in some unit of time. The y-axis is a vertical line, normally on the left, that is labeled with the dependent variable.

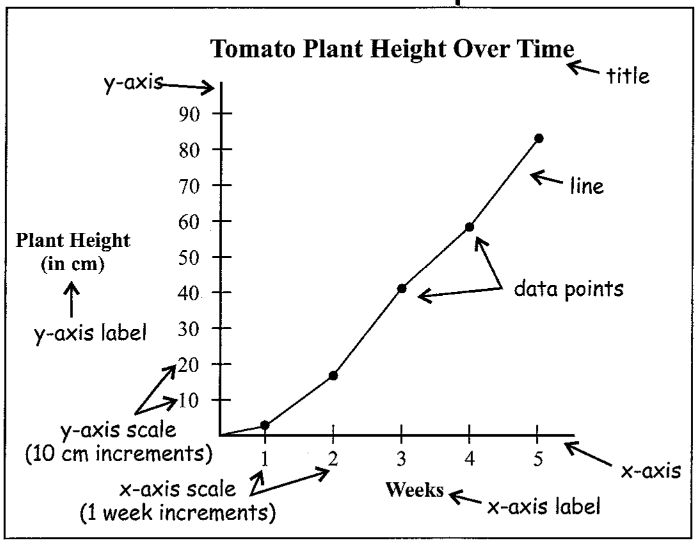
Labels: The x and y axes should be labeled to show what kind of data is being given. The units for the data should also be given.

Scale: The scale is shown by the numbers that are labeled on the x and y axes. The scale is the increment of the data given on the x and y axes.

Data points and Line(s): Data points are normally marked on a line graph to show where the experimental data falls on the graph. Data points are plotted from experimental data. For example, one data point may represent the plant height on a particular day. A line graph also has one or more lines that connect the data points. Sometimes the line connects from point to point. Other times, it is more appropriate to draw a straight or smoothly curved trend line that goes through the data points but does not connect each point.

Legend (or **Key**): If several lines are shown on the same graph, the data points may be shown using different types of symbols. The legend (sometimes called a key) will explain how the symbols correspond to the data.

Well-Constructed Graph



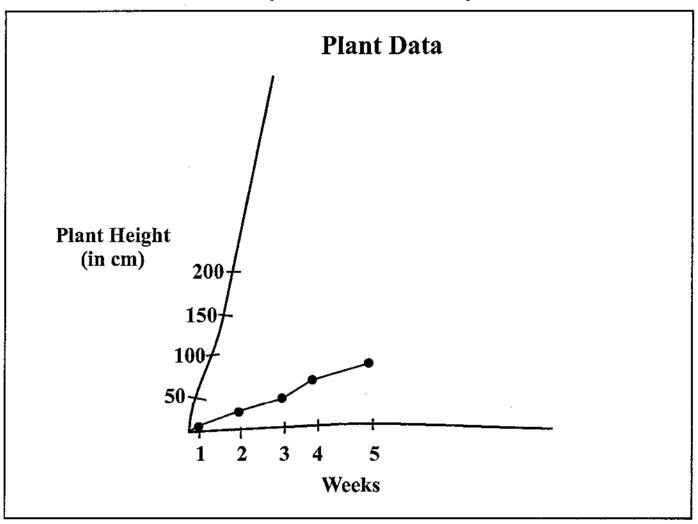
The graph on the left is a good example of how a line graph should be drawn.

Title: The title of a graph should give a general explanation of the data shown by the graph. In this example, the title is "Tomato Plant Height Over Time."

Axes and Labels: The x and y axes should be labeled to show what kind of data is being given. In this case, the x-axis represents "weeks" and the y-axis represents "plant height in centimeters."

Scale: The scale is shown by the numbers that are labeled on the x and y axes. In this example, the x-axis has a scale of one week per increment. The y-axis has a scale that is marked in 10-centimeter increments.

Poorly-Constructed Graph



Do you recognize all the reasons this graph is poorly constructed?

Title: Although this graph does have a title, it is not very descriptive of the data represented. For example, it doesn't tell what kind of plant.

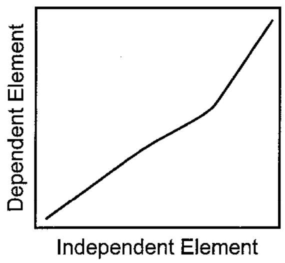
Axes and Labels: The x-axis and the y-axis are correctly labeled, but they are crooked. Be sure that you use a straight edge when drawing graphs by hand, and you will probably want to use graph paper as well.

Scale: When constructing a graph, choose a scale so that your data fills the space. In this example, the poorly chosen scale causes the data to fill only a small corner of the graph. Also, increments should be equally spaced. Notice that the spacing between the weeks is not equal.

When constructing line graphs, remember the following: Use a descriptive title that explains the data. Label the x and y axes and give the units. In the examples above, labeling the y-axis as "Plant Height" is useless unless you also give the units. Likewise, labeling the x-axis as "Time" would not be an appropriate label. No one would know what the 1, 2, 3, 4, or 5 represented — days, weeks, months, etc. Use an appropriate scale so that your data is spread out over the length and width of the graph. And of course, be very neat by drawing straight lines to represent your axes.

Trends

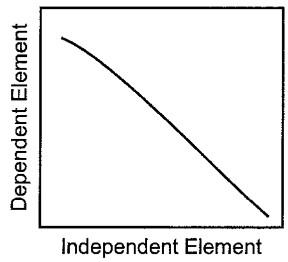
One of the most important features of line graphs is to be able to see *trends*. You can often take a trend and match it to the graph that represents the data. Take a look at five types of trends: an upward trend, a downward trend, a peaking trend, an unstable trend with ups and downs, and an unchanging data trend. The general type of line for each trend is given below. Make sure you read each example, which shows the type of data that would give that type of trend.



Upward Trend

The dependent element increases as the independent element increases.

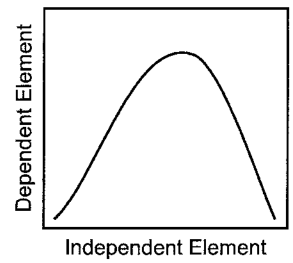
Example: A simple example of an upward trend would be the height of plants over time. As the time increases, the height of the plants also increase. This type of data would fit the pattern of an upward trend graph.



Downward Trend

The dependent element decreases as the independent element increases.

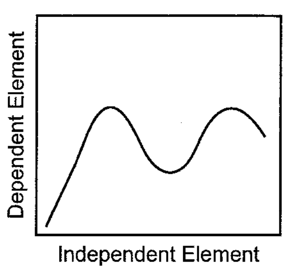
Example: A downward trend in data would be like the decrease in a bacteria population as an antibiotic increases. The line would go down as the bacteria population decreases over time.



Peaking Trend

The dependent element increases to a point and then begins to decrease as the independent element increases.

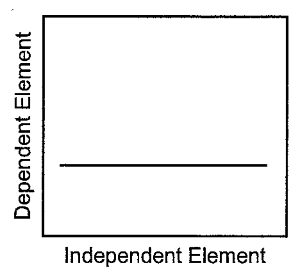
Example: A peaking trend would fit data like pain medication effectiveness. The effectiveness increases for awhile and then begins to decrease as the time increases.



Unstable Trend

The dependent element increases and decreases several times as the independent element increases.

Example: An unstable trend might be seen in a deer population during a year. The population may go up and down each season based on the births of offspring, the abundance of food, populations of predators that eat deer, and deer season for hunters.



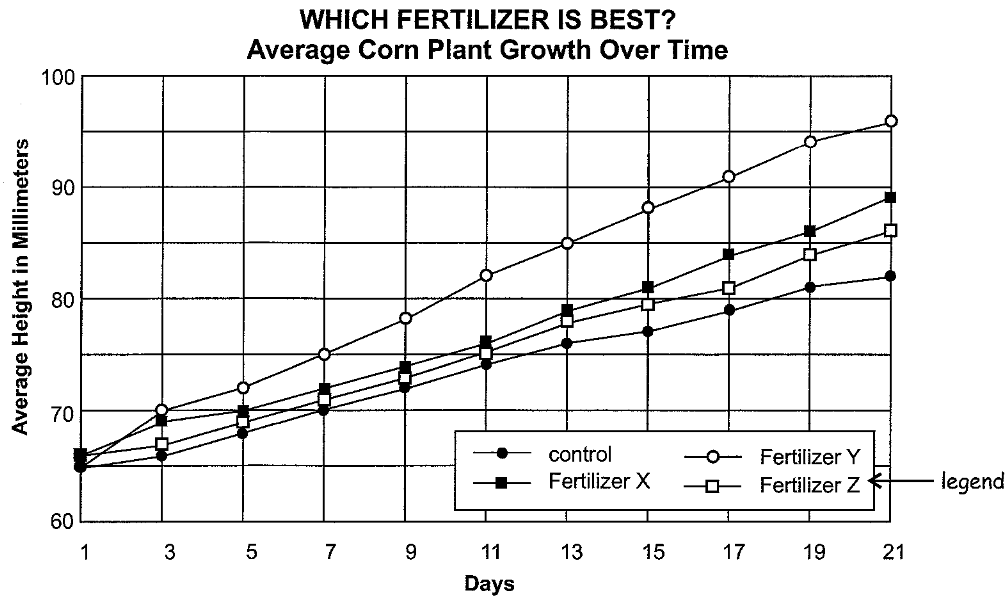
Unchanging Data Trend

The dependent element does not change (stays constant) as the independent element increases.

Example: An unchanging data trend would be seen in the height of most adults over time. As years go by, height stays the same.

Analyzing Line Graphs

Do you remember Waldo's corn plant experiment in Section 2? A line graph would be an excellent way for Waldo to present the results from his experiment. His graph might look something like the following.



Can you see that this line graph is easier to interpret than the summary table given in Section 2.3? By graphing the lines, the data is easier to visualize.

In Waldo's experiment, Waldo has four different groups of data, one for each experimental group plus one more for the control group. Notice that in the graph above, Waldo uses a different symbol for each group's data points. For example, black dots represent the control group data points, but the data points for the Fertilizer Y group are represented by open circles. Waldo uses a legend to show which symbols he uses for each group.

You should be able to see that one line is consistently above all the others, and that line indicates the group with the greatest growth. Likewise, one line is below all the others and represents the group with the least growth. Look at this graph and see if you can answer the following questions.

All the lines show an upward trend. What does that upward trend indicate?
The upward trend shows that each group of plants is increasing in height. In other words, the plants are growing. If one of the lines was sloping down, you'd notice that perhaps that group was dying. A straight line would indicate no growth.

Which group is showing the greatest increase in height? Which shows the least increase?
The line marked with open circles shows the greatest increase in height. The legend shows that the open circles represent the Fertilizer Y group. The control group represented by the bottom line shows the least growth.

On what day were the average heights of the Fertilizer X group and the Fertilizer Y group the same?
The heights are the same at any point where the lines cross. Look at the lines representing Fertilizer X and Fertilizer Y. They intersect (cross) on day 2. On day 2, these two groups were the same height.

Does this graph support Waldo's hypothesis?
Waldo's hypothesis is that plants fertilized with Fertilizer Y would grow the fastest. This data supports his hypothesis.

Analyzing Scientific Experiments

Section 3.2
Using Bar Graphs to Organize and Interpret Data

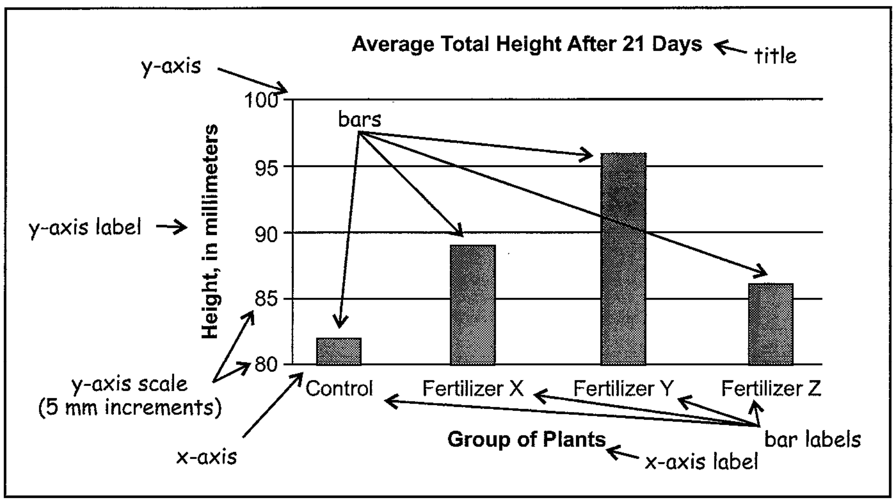
Pre-View 3.2

- **Bar graph** – a visual representation of data used to show different quantities between different groups especially when data is not continuous

Bar graphs are best used to present groups of data that are not continuous. They are used to show different amounts or quantities between different groups.

Like a line graph, a bar graph should also have a descriptive title. A bar graph also has an x-axis and a y-axis that is labeled, but usually only one of the axes has a scale. The other axis normally has each bar labeled. Instead of data points and a line shown on a line graph, a bar graph contains bars that represent quantities. Look at an example.

Example 1: If Waldo wanted to compare the total average height of each group of corn plants, a bar graph would be a good graph to use.



This is a simple bar graph, but it quickly gives the reader some important information about Waldo's experiment.

First, what is this graph showing?

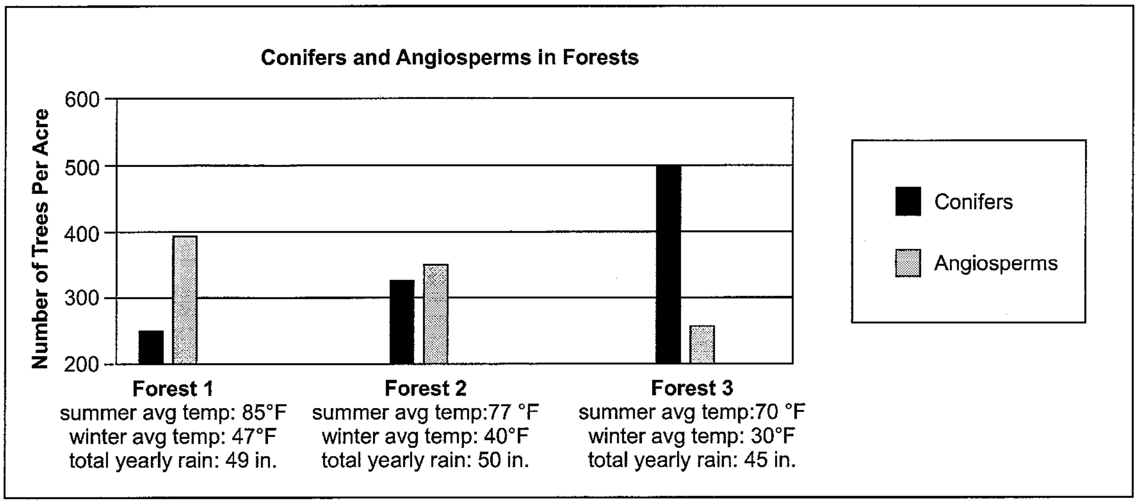
The title tells the reader what data the graph is giving. Waldo had four groups of plants, each group having 5 plants. Waldo averaged the final heights of the 5 plants in each group to create this graph.

Which group averaged the greatest height? Which averaged the lowest?

From this graph, you can quickly and easily see that the control group had the shortest plants, and Fertilizer Y group had the tallest plants.

Bar graphs can also compare more than one factor or variable. A legend is usually needed for these types of bar graphs to show how the different bars represent the data. Consider one more example below.

Example 2: An ecologist counts the average number of conifer trees versus the average number of angiosperm trees growing on an acre in three different forests in the United States. He researches and notes the climate of each forest.



Which forest had the greatest number of conifers growing per acre?
From the legend, you see that the black bars represent conifers. The tallest black bar is shown for Forest 3, so Forest 3 has the greatest number of conifers per acre.

Which forest had the greatest number of trees growing per acre?
To answer this question, you must estimate the number of conifers and the number of angiosperms for each forest and add the two numbers together. Forest 1 has about 390 angiosperms and 250 conifers for a total of 640 trees. Forest 2 has about 675 trees. Forest 3 has about 750 trees, so Forest 3 has the greatest number of trees growing per acre.

Can you draw any conclusions about conifer and angiosperm growth based on the climate information given?
Forest 1 has more angiosperms than conifers and has the warmest climate. Forest 3 has more conifers than angiosperms and has the coldest climate. Based on this observation, you might conclude that more angiosperms than conifers tend to grow in warmer climates, and more conifers grow in colder climates.

Now look at the total number of trees growing in each forest. Forest 1 has the fewest trees per acre, and Forest 3 has the most trees. Forest 2 is in the middle. From this observation, you may conclude that conifers can grow closer together than angiosperms. Or you may conclude that colder climates have more trees per acre than warmer climates.

Analyzing Scientific Experiments

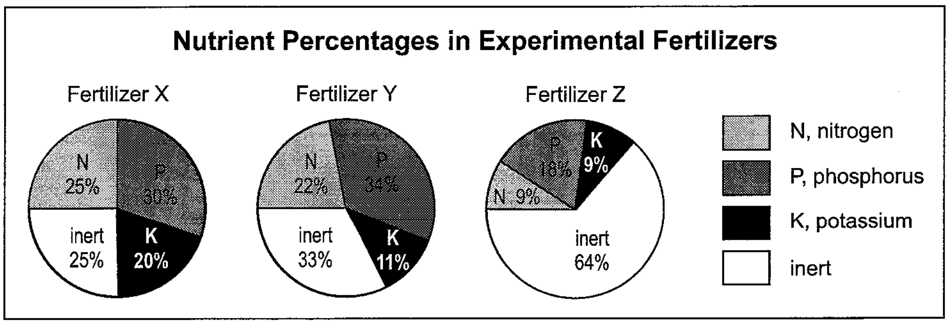
Section 3.3
Using Pie Graphs to Organize and Interpret Data

Pre-View 3.3

- **Pie graph** (or **circle graph**) – a visual representation of data used to show parts (or percentages) of a whole

Pie graphs, also known as **circle graphs**, are used to show percentages of a whole. The size of each "slice" is proportional to the percentage of that item, and all of the "slices" in the pie can be added together to equal 100 percent. A single pie graph will emphasize the percentages of items as compared to other items. Multiple pie charts can be used to compare the percentages of items in different sets of data.

The fertilizers that Waldo used in his corn growth experiment were composed of nitrogen, phosphorus, potassium, and inert ingredients. If he wanted to show the percentages of each ingredient in each fertilizer, he could use the following pie graphs.



Notice that the set of pie graphs have a title, and each pie graph also has a title or label that identifies the fertilizer. Also notice that the segments, or pieces of pie, are labeled with the percentage that each segment represents. For example, Fertilizer X is labeled as 25% N, 30% P, 20% K, and 25% inert. If you add these percentages, they equal 100%. Finally, notice that the legend identifies the nutrient represented by each color.

Consider the following questions about the pie graphs given above.

Look at just Fertilizer X. Which component makes up the greatest percentage?
The "slice" that represents P, phosphorus, is the largest, so it represents the greatest percentage.

Look at just Fertilizer Y. Which nutrient is present in the least percentage?
Potassium, K, is the smallest sector of the pie graph and makes up the smallest percentage of nutrients in Fertilizer Y.

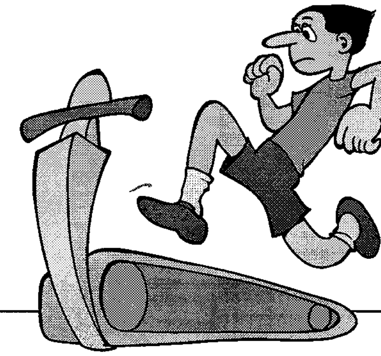
Look at just Fertilizer Z. Which two components are equal in percentages?
You should notice that nitrogen, N, and potassium, K, are equal in size, so they have equal percentages in Fertilizer Z.

Now consider all of the graphs. Which fertilizer has equal percentages of nitrogen, N, and inert ingredients?
Fertilizer X does; it has 25% nitrogen and 25% inert ingredients. Notice that the "slices" of these two ingredients are equal in size for Fertilizer X. Also notice that 25% is one-quarter of the pie.

All the fertilizers shown above (X, Y, and Z) are recommended for vegetable gardens. What might you conclude about vegetables from this data?
To answer this question, study each graph to see what they have in common. All of the fertilizers have a higher percentage of phosphorus than the other two nutrients. Therefore, you might conclude that vegetables generally need a greater amount of phosphorus than they do nitrogen and potassium.

Analyzing Scientific Experiments

Section 3.4
Using Diagrams to Organize and Interpret Data



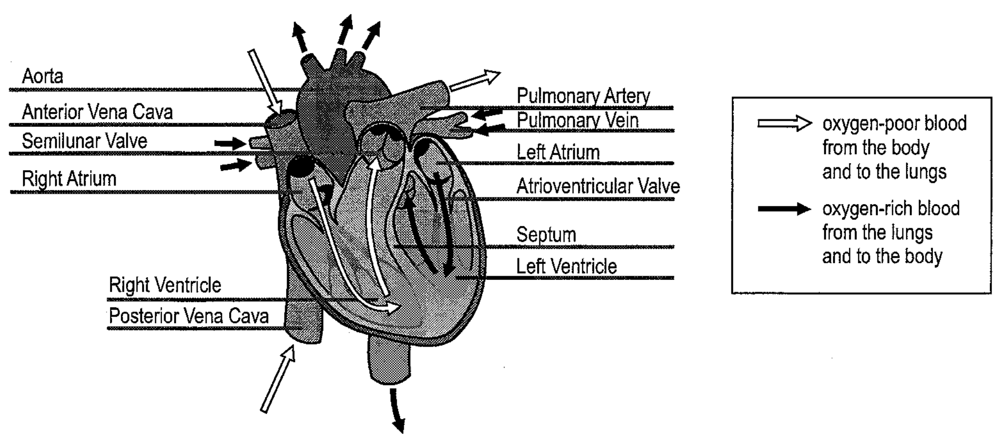
Pre-View 3.4

- **Diagrams** – labeled pictures that show relationships between objects or parts

Diagrams are labeled pictures that show relationships between objects or parts. Diagrams can be used to communicate data in an experiment or to give general information about a biology topic.

Example: A research scientist is studying the effects of Vitamin E on oxygen levels in the blood. The scientist includes the following diagram of the heart to explain the terms used in his report and to show the path of blood through the heart.

Blood Flow Through The Human Heart



By studying the diagram above, you should be able to answer the following questions.

After blood enters the right atrium, where does it travel next?
From the diagram, you can see that blood goes from the right atrium to the right ventricle.

Which valve is located between the left atrium and the left ventricle?
The diagram shows that the atrioventricular valve is between the left atrium and left ventricle.

Through which vein or artery does oxygen-poor blood leave the heart?
To answer this question, first you must recognize that the white arrows represent oxygen-poor blood. Next, look for the white arrow going from the heart, and identify the name of that part. From the diagram, you should see that oxygen-poor blood leaves the heart through the pulmonary artery.

You learn that "pulmonary" means "relating to the lungs." Knowing this, which structure takes blood from the lungs and into the heart?
The pulmonary vein brings blood from the lungs back into the heart.