

Scientific Process Skills

Observing

Observing is using one or more of your senses--sight, hearing, smell, taste, and touch--to gather information about the world. Information you gather from observations is called **evidence** or **data**. When you make observations in science, you want them to be **accurate** and **objective**. An accurate observation is an exact report of what your senses tell you. An objective observation avoids opinions, or bias, based on specific points of view.

Examples: Sixteen students were in class when the bell rang and five students arrived afterward. (accurate and objective)
 Half the class was late for class. (not accurate)
 The friendliest people were there first. (not objective)

There are two types of observations: qualitative and quantitative. **Qualitative observations** are descriptions that are gathered using your senses; they do not use numbers. For example, if you observed an object's color, smell, taste, texture, or sound, you are recording qualitative observations.

Examples: The classroom walls are yellow.
 The classroom floor is shiny.

Quantitative observations are descriptions that are based on measurements or counts and do include numbers. If you count objects or measure them with standard units, you are making quantitative observations.

Examples: There are 28 students in the room.
 The blackboard is 1 meter high and 2 meters wide.

Observations vs. Inferences: **observations** are directly observable, while **inferences** are explanations of what's been observed.

Examples: There's an empty aquarium in the classroom. (observation)
 The tank is 50 cm long, 30 cm wide, and 18 cm deep. (observation)
 The inside of the tank is dry. (observation)
 The tank used to contain live fish. (inference; not directly observable)
 The tank is waterproof. (inference)

Tips for Making Observations:

- ◇ Use your senses of sight, hearing, touch, and smell to make qualitative observations.
- ◇ Review your observations to be sure they are accurate and objective.
- ◇ Whenever possible, count or use instruments to make quantitative observations. Be sure to include units with your measurements.
- ◇ Check your observations to be sure that they are statements about information gained through your senses, not explanations of what you observed.

Inferring

When you make an **inference** about observations you have made, you are **logically explaining** what your observations may mean.

(Observation)		(Inference)
For example: You hear a dog barking	—————▶	Someone's at the door
You see someone who is sunburned.	—————▶	They were at the beach

You can make many inferences about the same set of observations. The key is that any inferences must be reasonable and logical.

For example:

Reasonable inference: makes sense, given what you know

Unreasonable inference: assumes too much from evidence

Inferences must be checked through investigations to find out if they are right or not.

Sometimes inferences prove to be wrong and that's okay.

Tips for Making an Inference:

- ◇ Base your inference on accurate qualitative or quantitative observations.
- ◇ Combine your observations with knowledge or experience to make an inference.
- ◇ Try to make more than one logical inference from the same observation.
- ◇ Evaluate the inferences. Decide what new information you need to show whether your inferences are true. If necessary, gather more information.
- ◇ Be prepared to change, reject, or revise your inferences.

Predicting

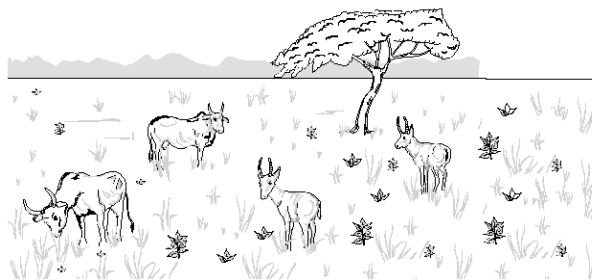
Predictions are simply **inferences about a future event** based on current evidence or past experience. To help you with your predictions, **look for patterns in your evidence**. When you predict, **be as specific as possible**. **Use all available information** when you make your predictions. It is important to **test** your predictions to see if your predictions are correct.

Other Scientific Process Skills

Classifying: organizing objects and events into groups according to a system (for example: the way animals are classified using groups such as kingdom, family, species, etc.).

Making Models: pictures, diagrams, or other representation of objects (for example, a globe is a model) or scientific process (for example, a picture of the water cycle).

Communicating: any type of message that is sent from one person(s) to another person(s); these can be messages sent through talking or writing.



For example, suppose you are on a photo safari in Africa. In a region bordering some small farms, you see some domestic cattle sharing space with some wild antelope. Some people in your group make the following observations and inferences.

Observation: The cattle and the antelope are standing quietly together.

Inference 1: The cattle and antelope do not attack each other. (reasonable)

Inference 2: None of the animals in this region attack each other. (unreasonable, because you have no evidence about any other animals)

Observation: Some of the cattle are eating grass.

Inference 3: The grass is food for the cattle and antelope. (reasonable)

Inference 4: Most of the grass in this area is eaten by the cattle. (unreasonable, because you have no evidence about the amounts eaten)

Experimental Design

In some ways, scientists are like detectives, piecing together clues to learn about a process or event. One way that scientists gather clues is by carrying out experiments. An experiment tests an idea in a careful, orderly manner.

RESEARCH QUESTION

Scientists design experiments to answer questions or solve problems. The **research question** guides what the scientist tests and is answered using data gathered through testing. The research question usually states the relationship between the independent variable and the dependent variable, like this: “What affect will (independent variable) have on the (dependent variable)?”

For example, “What affect will shorter wings have on the flight of a paper helicopter?”

(independent
variable)

(dependent variable)

INDEPENDENT VARIABLES

In an experiment (investigation), you change something to see what will happen. Things in an experiment that change are called variables. In *Helicopter Happenings*, you purposely changed one part of the helicopter’s design to see what affect that change would have on the helicopter’s flight. Scientists call the factor or condition that is purposely changed the **independent** or **manipulated variable**. In an experiment you have one independent variable--the design of the helicopter. In another experiment, *Hot Solutions*, you will test to see how different amounts of a substance called calcium chloride will affect water. You will test 0 scoops, 1 scoop, 2 scoops and 3 scoops of calcium chloride. The four amounts of calcium chloride are called the **levels of the independent variable**.

When designing an experiment as a beginning researcher, you choose only one variable that you purposely change. Why? If you change more than one variable, such as add mass to the base of the helicopter AND clip the wings, you may never know which variable caused the response you observe when testing.

DEPENDENT VARIABLES

In the helicopter experiment, there was also a second variable--how well the helicopter flew. The helicopter flew better or worse as a result of the change you made to the design of the helicopter. The variable that responds and is measured in an experiment is the **dependent** or **responding variable**.

CONSTANTS

Certain things were kept the same throughout helicopter experiment. You used the same paper to construct the helicopter and each lab group used the same helicopter pattern. In addition, the helicopters were always dropped from the same height. Everyone tested the helicopters in the science room so that wind was not a factor. Conditions that are kept the same in an experiment are called **constants**.

OPERATIONAL DEFINITION

To help you (or someone else) repeat your experiment under the same conditions each time, you need to write an operational definition for any key terms that do not have one, clear meaning. The **operational definition** clarifies vague terms and explains how the results (dependent variable) will be measured. For example, in *Helicopter Happenings*, as a class we had to decide what the term “best” meant so that everyone was measuring results in the same way. We could define “best” as the straightest flight path from start to finish; we also could define it as the highest number of complete rotations; it could mean the fastest flight time in seconds from start to finish. Stating how we measured the “best” flight ensures that each lab team measured the results using the same criteria.

CONSTRUCTING HYPOTHESES

Before you conduct an experiment, you should try to predict what is going to happen based on research and/or past experience; this prediction is called a **hypothesis**. In writing your hypothesis, you need to think about how changing your independent variable may affect your dependent variable. An example of a hypothesis for the helicopter experiment is: “If I add mass to the base, then the helicopter will drop straighter because the mass

stabilizes the helicopter.” To write such a hypothesis, use an “If..., then..because...” sentence: **If** the (independent variable) is (describe how you changed it), **then** the (dependent variable) will (describe the effect you predict will happen) **because** (give the reason for your prediction). For *Investigation 1: Helicopter Happenings*, a hypothesis might be:

If the wings of the helicopter are shorter, then the flight time will decrease because shorter wings will catch less air.

(independent variable)
(describe how you changed it)
(dependent variable)
(describe the effect you predict will happen)
(reason for your prediction)

When scientists conduct an experiment, they usually make a hypothesis about what they think will happen. A hypothesis is a prediction that is sometimes called an educated guess. It’s called an educated guess because most hypotheses are based on careful study. Hypotheses are based on observations, previous experimental results, and information from books and/or meetings with other scientists.

SUPPORT FOR THE HYPOTHESIS

When the hypothesis and the experimental results agree, scientists say the hypothesis was supported by the results. When the hypothesis and the results do not agree, the hypothesis is not supported. Scientists do not say they were right or wrong or that their hypothesis was correct or incorrect, and neither should you. In the same way, scientists do not say that a simple experiment proves or disproves a hypothesis. Each experiment provides evidence that a hypothesis is supported or not supported; however, sometimes the results are not definitive and more testing must be done to reach a conclusion about the hypothesis. Such results are said to be **inconclusive**. Many experiments must be conducted before results are accepted as fact. For example, you would need to do many experiments to determine the effect of wing length on how well a paper helicopter flies. You would need to do even more experiments if you wanted to know how wing length affected the flight of a helicopter made of construction paper, cardboard, cardstock, and newspaper.

CONTROL GROUP

When the independent variable is not changed, then the dependent variable should not change. If the independent variable is unchanged and the dependent variable changes considerably, this means something that should stay the same is changing. Experiments need a way to find “hidden variables,” in other words, factors that should be kept constant but which change accidentally. In *Hot Solutions*, you needed a way to determine if some factor other than the amount of calcium chloride was affecting the results. This is the reason for having one trial with no calcium chloride. The trials in which you used only tap water are called controls. A **control** is used as a standard of comparison. In an experiment, a control is important because it is used to detect “hidden variables” that are changing when they should not.

In *Hot Solutions*, the plain tap water was used as the control. The temperature changes caused by mixing different amounts of calcium chloride in water were compared to the temperature of plain tap water to find out if the added calcium chloride affected the temperature of the water. Each time the amount of calcium chloride was increased, the temperature of the water increased; therefore, the amount of calcium chloride did affect the temperature of the water. Most experiments include a **control group**. All other experimental groups are compared with the control group to determine experimental effects.

In some experiments, all test groups receive a treatment. In such situations, the experimenter must select one of the levels of the independent variable being tested as the control. In *Penny Predictions*, you will examine the effect of coin size on the number of drops that coin will hold. You will work with pennies, nickels, dimes, and quarters; it will be impossible to conduct a trial with no coin--so a “no treatment” control won’t work. Instead, you must pick one of the coins to act as the control, and then state the reasons for your choice. For example, you could choose the penny because it is the medium-sized coin. This kind of control is called an **experimenter selected control**.

You may be tempted to ask, “Since I know that plain tap water will not increase in temperature on its own, then why did I need to test 0 scoops of calcium chloride as part of the experiment?” The answer is that testing the zero

scoops of calcium chloride was needed as a control or standard of comparison. Before you can determine the effect of putting calcium chloride into water, you need to know the answer to several questions: "Does stirring the water cause a change in temperature?" "How quickly does the temperature of tap water change to match the air temperature?" If the temperature of plain water stays the same each time it is stirred, you can be sure that any effects that you observe are a result of adding calcium chloride, and not something else. Zero scoops of calcium chloride is your control or standard of comparison.

REPEATED TRIALS

In both *Helicopter Happenings* and *Hot Solutions*, you tested each level of the independent variable three times, then combined your results with those of your classmates so that there were many results to analyze. Despite your best efforts in making measurements, mistakes can happen. No matter how careful you are, some measures of calcium chloride were a little larger or a little smaller. Perhaps you stirred just a little longer or shorter than two minutes. The angle from which you looked at the thermometer may have affected your measurements. To reduce the effect of such chance errors, you conducted repeated trials. For example, you stirred plain tap water three times, with 1 scoop of calcium chloride three times, with 2 scoops of calcium chloride three times, and with 3 scoops of calcium chloride three times. Repeated trials reduce the effect of chance errors. Repeated trials increased your confidence in the results of the experiment. **Repeated trials** are the number of times each level of the independent variable is tested. Each amount of calcium chloride scoops (0, 1, 2, 3 scoops) was tested three times, so there were three repeated trials for each amount of calcium chloride. When you combined your results with those of your classmates, you increased the number of repeated trials. If four lab groups conduct three trials under the same conditions then combine those results, the total number of repeated trials is 4 lab groups x 3 repeated trials = 12 repeated trials. The greater the number of repeated trials, the more accurate your data will be.

Usually, differences in measurements tend to be small and happen by chance; they are unavoidable. There is no such thing as a perfect measurement or a measurement that is free from error. Repeated measurements are made assuming that some errors make an individual measurement too high and that some make the individual measurement too small. By averaging results, chance errors that are too high or too low will balance or cancel each other out. The average is as close to a perfect, error-free measurement as you can get. Collecting three measurements for each level of the independent variable, combining those results with those of your classmates, and averaging them helps balance out the measurements that were high with those that were low.

"How many repeated trials do I need?" is a common question. The answer is, it depends on the experiment. Generally, there is very little difference in the amount of temperature change when 1 scoop of calcium chloride is added to water. When you investigate such nonliving things, you tend to get very similar data. For this reason, you can use a smaller number of trials, such as 3 or 4. However, there are lots of differences in living things, you tend to get a greater variety in your data; therefore, more trials are needed. With human studies, you should generally conduct as many trials as time, money, and space will allow. The more repeated trials you do, the more likely you will reduce the effect of chance errors. The larger the number of repeated trials, the more confidence you can place in your data when you say that the hypothesis was or was not supported.

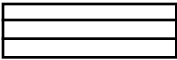
MAKING AN EXPERIMENTAL DESIGN DIAGRAM

What did you learn about the effect of number of scoops of calcium chloride on the temperature of water? Is this experiment a good one? Is it fair? Can you trust your results? Does it include all of the parts of a good experiment?

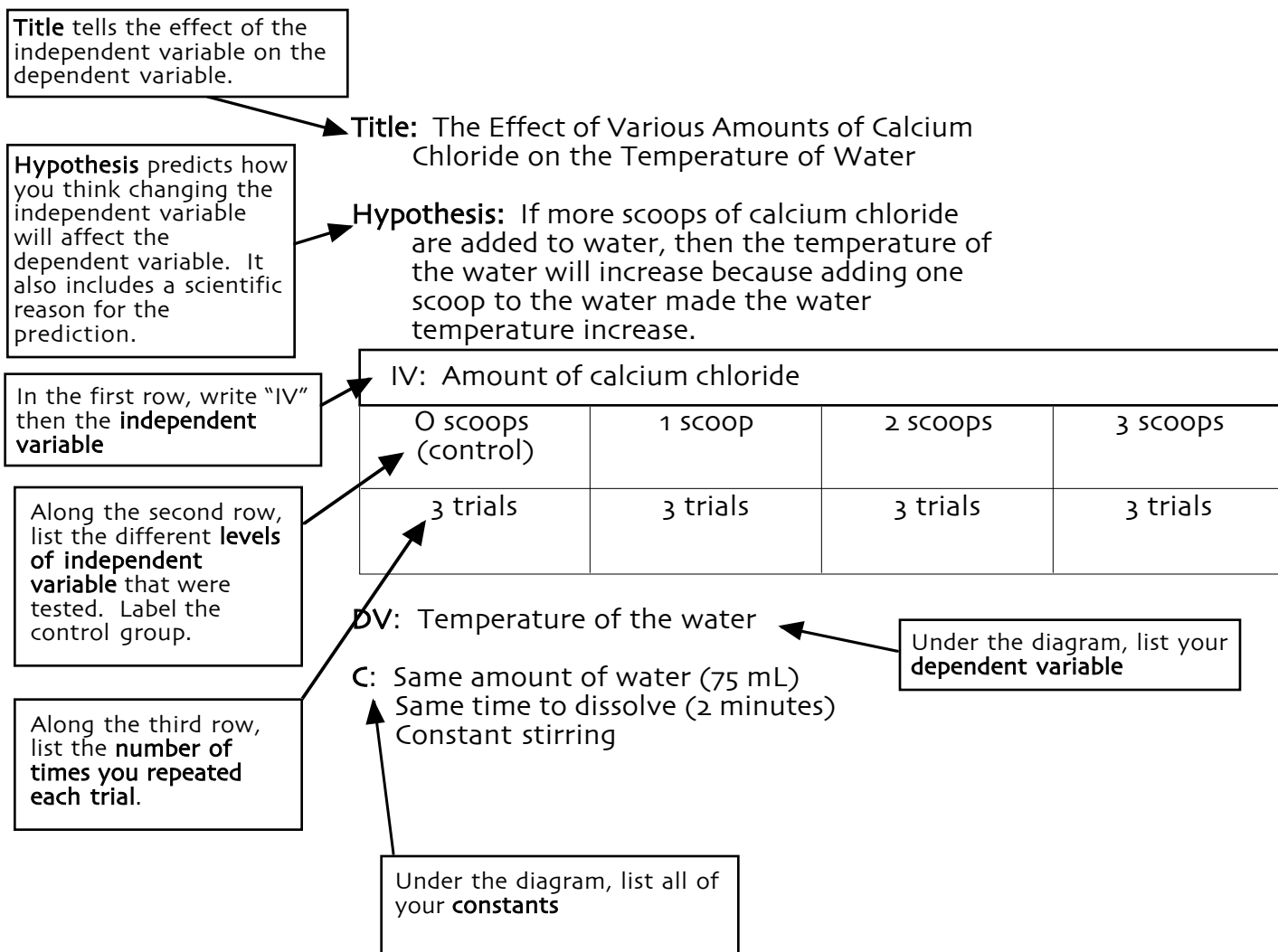
A diagram of this experiment would make these questions easier to answer. Many scientists use an **experimental design diagram** to help them organize or outline their experiments to be sure they have included all the parts. This diagram also helps to identify ways to improve the design of an experiment even before the experimenting begins. An experimental design diagram of *Hot Solutions* would look like this:

To create an **experimental design diagram**, follow these steps:

1. First, write a **title**: *The Effect of Various Amounts of Calcium Chloride on the Temperature of Water*

- Next, state a **hypothesis**: If the independent variable is (increased/decreased), then the dependent variable will (increase/decrease/stay the same) because (reason for your prediction).
- Draw a rectangle and divide it into three rows. 
- Write your **independent variable** (IV) in the top row.
- Divide the bottom two rows into columns; one column for each level of the independent variable. Place the word "**control**" below your the level of independent variable that will be used as your standard of comparison.
- In each column, write the number of **repeated trials** conducted for each level of the independent variable.
- Below the rectangle, write your **dependent variable**.
- Below your dependent variable, write your **constants**.

Example of an Experimental Design Diagram



Because each part of an experiment has its place in an experimental design diagram, you can spot missing or weak parts quickly and easily.

DATA TABLES

Before collecting data from your experiment, you should first plan ways to organize and display your data in the form of a chart called a **data table**. Although there are no absolute rules for constructing a data table, there are general guidelines to help you. In *Hot Solutions*, we used the following data table:

For example, the independent variable is almost always recorded in the left column and the dependent variable in the middle column. When repeated trials are conducted, the middle column is divided into smaller columns. The number of smaller columns should be equal to the number of repeated trials. Additional information, such as the average or the range, is recorded in the column to the right of the dependent variable column. Information you figure out from data, like an average, is called a **derived quantity**.

The Effect of Calcium Chloride on the Temperature of Water

Amount of chemical (scoops)	Change in temperature (°C)			Average change in temperature (°C)
	Trials			
	1	2	3	
0				
1				
2				
3				
Column for the Independent Variable	Columns for the dependent variable			Column for the Derived Quantity

EXAMPLE OF A DATA TABLE

When recording data in a table, the values of the independent variable are ordered. These are usually ordered from smallest to largest. Organizing the data in this way creates a pattern of change in the independent variable. If there is any pattern of change in the dependent variable, it will be easier to see if the levels of independent variable are put in order.

When labeling the columns in the data table, include the units of measurement in parentheses, for example, *Change in Temperature (°C)*. The title of the data table should clearly communicate the information contained in the table. The variables that were investigated are usually included in the title, such as *"The Effect of Calcium Chloride Amounts on Water Temperature."* Notice that all major words in the title are capitalized. The Effect of the (*Independent Variable*) on the (*Dependent Variable*) is an easy way to write a title.

SUMMARIZING MEASUREMENTS AND COUNT DATA

When repeated measurements or counts are made, you need a way to summarize the data. One way is to find the average or mean. To calculate the average (mean), find the sum and divide by the number of trials.

$$\text{Average (mean)} = \frac{\text{Sum of measurements}}{\text{Number of trials}} \text{ or } \frac{\text{Sum of counts}}{\text{Number of trials}}$$

CONSTRUCTING GRAPHS

If a picture is worth a thousand words, then so is a graph. Because graphs communicate data in picture form, they show patterns or information better than a data table. The type of graph you choose to display data depends on the type of data. The data from experiments can be displayed as either a bar graph or a line graph, depending on whether the data is continuous or discrete.

Continuous means that the values of a variable are not separate categories and the intervals between the values have meaning. For example, suppose you dropped a ball from different heights (70, 80, 90, and 100 cm) to see how drop height affects bounce height. Because drop height is a continuous variable, you could also drop the ball from other heights, such as 72 cm or 75 cm. The interval between 70 and 80 cm has meaning. Other examples of continuous variables are amounts of water, mass of apples, and temperature of air. When the variables in an investigation are continuous variables, you can display the data as a **line graph**. The line graph helps you predict the data for in between values (those that fall between the amounts you test) so that you do not have to test all of the possible values.

When a variable consists of **discrete categories**, such as kinds of paper--newspaper, paper towel, and notebook paper, you must display the data as a **bar graph**, not a line graph because the spaces or intervals between the categories have no meaning. There is no kind of paper that is halfway between newspaper and paper towels. Examples of discrete data are the days of the week, kind of animal, gender, brands of paper towels and types of vehicles.

To construct a **line graph**, follow these steps:

STEP 1: First draw and label the X and Y axes. Place the independent variable (Time Paper Towel Submerged) on the X axis. Place the dependent variable (Height Liquid Rose in Towel) on the Y axis. Remember to include the units of measurements in parentheses--X axis (sec) and Y axis (mm).

STEP 2: Write your **data pairs** on your graph (usually a corner will work). When writing data pairs, the first number in the pair is for the independent variable, while the second number is for the dependent variable. In the example of (10,11), the 10 is the IV value and the 11 is the DV value (X,Y).

STEP 3: Determine the scale to use for the **horizontal (X) axis** by first finding the range of the data to be graphed. Subtract the smallest value (10) from the largest value (40): $40 - 10 = 30$. Divide this difference by the number of intervals you want. If you want 5 intervals, divide by 5. Be sure to keep the number of intervals you choose manageable: too many intervals crowds a graph, while too few makes it difficult to plot points. A good number of intervals for your X axis is generally between 5 and 7. In this case, $30 \div 5 = 6$. Because counting by 5s is easier than counting by 6s, you should round down to intervals of 5.

Using 6 to make intervals might be too hard, so make the job easier by rounding 6 to an easy counting number like 5. Other good counting numbers are multiples of 5, such as 10 or 20, or other numbers such as 2. Use the rounded number to mark off the intervals. Begin with a multiple of 5 that is less than the smallest value (10) to be plotted and continue until you have reached or gone above the highest value (40).

Determine the scale to use for the **vertical (Y) axis** by first finding the range of the data to be graphed. Subtract the smallest value (11) from the largest value (19): $19 - 11 = 8$. Divide this difference by the number of intervals you want. If you want 5 intervals, divide by 5. Be sure to keep the number of intervals you choose manageable: too many intervals crowds a graph, while too few makes it difficult to plot points. A good number of intervals for your X axis is generally between 5 and 7. In this case, $8 \div 5 = 1.6$, which you should round up to intervals of 2 to make your job easier.

STEP 4: Plot the data. For the first data pair (10,11), locate 10 on the X axis and 11 on the Y axis. Imagine a vertical line drawn straight up from the 10 and a horizontal line drawn straight across from the 11. Where these two imaginary lines meet is a point representing that data pair; draw a point to record where these two values intersect.

STEP 5: Look for patterns in the data points and record what you notice. For example, you could write, "As the length of time the paper towel was submerged increased, the height the liquid rose also increased."

To construct a **bar graph**, follow these steps:

STEP 1: First draw and label the X and Y axes. Place the independent variable (Brand of Paper Towel) on the X axis. Place the dependent variable (Water Absorbed) on the Y axis. Remember to include the units of measurements in parentheses--Y axis (mL).

STEP 2: Write your **data pairs** on your graph (usually a corner will work). When writing data pairs, the first number in the pair is for the independent variable, while the second number is for the dependent variable. In the example of (A,34), the A is the IV value and the 34 is the DV value (X,Y).

STEP 3: Because you tested four brands of paper towel, divide the **horizontal (X) axis** into 4 equal parts.

Determine the scale to use for the **vertical (Y) axis** by first finding the range of the data to be graphed. Subtract the smallest value (17) from the largest value (36): $36 - 17 = 19$. Divide this difference by the number of intervals you want. If you want 5 intervals, divide by 5. Be sure to keep the number of intervals you choose manageable: too many intervals crowds a graph, while too few makes it difficult to plot points. A good number of intervals for your X axis is generally between 5 and 7. In this case, $19 \div 5 = 3.4$, which you should round up to intervals of 4 to make your job easier.

STEP 4: Plot the data. For the first data pair (A,34), locate A on the X axis and 34 on the Y axis. Imagine a vertical line drawn straight up from the A and a horizontal line drawn straight across from the 34. Where these two imaginary lines meet is a point representing that data pair; draw a point to record where these two values intersect.

STEP 5: Look for patterns in the data points and record what you notice. For example, you could write, *"Brand A and D were the most effective water absorbers. The least effective absorber was Brand B. Brand C absorbed intermediate amounts of water."*

ANALYZING DATA/ LOOKING FOR PATTERNS

After plotting all the points for the data pairs, look for a pattern in the points. Is there a general upward trend of the points? Is there a trend downward? Do the points go up and then level off? Or do the points gradually increase, reach a peak, and then gradually decrease? Notice on **Graph a** above that the data points tend to move up as you look from left to right on the graph. This means that as the independent variable increases, the dependent variable also increases. The pattern on graph a is called a **direct relationship** or a **positive association**.

In other graphs, such as **Graph b**, the reverse is true. This means that as the independent variable increases, the dependent variable decreases. The pattern shown on Graph b is an **inverse relationship** between the variables, also known as a **negative association**.

Other patterns of data, as in Graphs c and d, indicate both positive and negative associations in the same graph. **Graph c** starts with a positive association between the variables, but then becomes a negative association. **Graph d** shows an opposite trend; there is first a negative association between the variables that changes to a positive association.

Sometimes there does not appear to be any pattern in the points on a graph. When no pattern exists, this is called **no association** (**Graph e**).

LINES OF BEST FIT

After you have identified a pattern or trend in the data points, try drawing a line that shows that trend. Do not make a zigzag line connecting the points. Instead, draw the line so that about half of the points are on one side of the line and half are on the other side of the line. Some points may actually be on the line. You can draw a better line-of-best-fit by collecting and plotting more points. Examples of lines-of-best-fit are shown on **Graphs a - d** above.

SUMMARIZING TRENDS

Graphs display data in picture form. You can turn that picture into words by writing a sentence or two that summarizes the general trend of the data as shown by the **line-of-best-fit**. When writing a sentence, describe the effect of changing the independent variable on the dependent variable. For example, you could say, "*As the length of time the paper towel was submerged increased, the height the liquid rose also increased.*" Be sure you describe the general trend on the graph rather than write sentences that just repeat the data points.

WRITING A SIMPLE LAB REPORT

Why do scientists bother to write a report about their experiments? Is it necessary for you to write a lab report about your experiment? You did the experiment. You tested the hypothesis. You've learned what you wanted to learn. Why not get on with something else?

The answer is simple and straightforward. Experimental results must be shared. Each shared experiment adds to our knowledge about the world God has created. Unreported experiments do not add to this knowledge because only the investigator knows about them. No one else can learn from unreported results. Unreported experiments are so useless that scientists say, "The unreported experiment is an undone experiment."

Major Lab Report Components

The six major components of a simple lab report are:

- Title
- Introduction
- Experimental Design Diagram
- Procedures
- Results (Data Tables, Graphs)
- Conclusions

Title

The title of the lab report is generally the relationship between the independent and dependent variable: *The Effect of (IV) on (DV)*.

Introduction

The introduction section of the report tells the reader what the research problem was all about. It states your reason (or why you decided to study the topic you investigated). It also states your purpose (or what you hoped to learn by doing the experiment). Finally, the introduction states your hypothesis. The introduction to a lab report provides the answers to three questions:

1. Why did you conduct the experiment? (**Reason**)
2. What did you hope to learn? (**Purpose**)
3. What did you think would happen? (**Hypothesis**)

Conclusions

A **conclusion** is a summary of an experiment. Someone who reads only the conclusion section of your report should be able to understand what your experiment was about. The summary should give your results, describe what those findings mean, and suggest new questions that should be investigated. A good conclusion can be written by answering six questions:

1. What was the purpose of the experiment?
2. What were the major findings?
3. Was your hypothesis supported or not supported by the data? Or were your results inconclusive?
4. How did your findings compare with the results of others in your class, or with information in your textbook?
5. What possible explanations can you give for your results?
6. What recommendations do you have for further study and for improving the experiment?

Scientific Process Skills Vocabulary:

1. observations: _____

2. qualitative observations: _____

3. quantitative observations: _____

4. inferences: _____

5. evidence/ data: _____

6. predicting: _____

7. *Also know the definitions for classifying, making models, and communicating*

Experimental Design Vocabulary:

1. research question: _____

2. independent (manipulated) variable: _____

3. dependent (responding) variable: _____

4. constants: _____

5. operational definition: _____

6. hypothesis: _____

7. control: _____

8. repeated trials: _____

9. experimental design diagram: _____

10. data table: _____

11. mean: _____

12. *materials: _____

13. *procedures: _____

14. *analysis: _____

15. *conclusions: _____

**definitions will be given in class*