ACTS Science Guide to Science Fair Projects

1. **General Rules for scientific writing**:
   a. Use the third person – do not use "I", "we", "you," "my," "our," etc
      Ie Do write – 25 plants were watered with 20 ml of water…
      Do not write – I watered my plants with 25 ml of water

      Do write – It was hypothesized…
      Do not write – I hypothesized…
   b. Use **effect** as a noun "the effect of the acid"
      Use **affect** as a verb – "the acid affected the plant…"
   c. Use metric measurements – liters, millimeters, degrees Celsius instead of standard measures like ounces, inches, degrees Fahrenheit, etc
   d. Type all portions of your project if at all possible and use double spaced simple black fonts (except for eye catching informal title on display board).

2. **Learning about your topic**
   a. **Choosing a topic** - The best topic for a science fair project is one that you are very interested in studying. A topic can begin by being very broad, such as "sports" or "plants." The "4 Question Strategy" (Appendix B) will be used in class to narrow the topic down. If nothing comes to mind, here are a few hints to get you going:
      * Increase your awareness of scientific issues by reading the paper or magazines. What kind of articles are you drawn to? Which ones are fun for you to read?
      * Keep your eyes open. Look around nature. Walk outside. Observe pets and people. Take some time to wonder!
      * Look for things you cannot explain –ie. Why does heat turn an egg hard, but jello soft? Spend one day just analyzing everything you observe!
      *Brainstorm with family members – they can help to get you thinking!
      *As a last resort, look through books or go online to find topics others have studied. Do not copy someone else's topic exactly. Think of ways you can change what others have done!

      Write the broad science fair topic you are excited about on your milestones page!

   b. **Learning about your topic** – In elementary grades you will not be required to create a full blown research paper about your topic (in later years you will) Instead, you should find at least two articles- either online or in magazines, or find several pages in a book that deal with your broad topic. After reading them, create at least two one-page summaries using the guidance on how to create a summary (Appendix A). Include bibliographic info about the source of your info at the end of each summary.

   c. **Narrowing your topic**– Use the 4 Question Strategy (Appendix B) to list all of the possibilities for a specific experiment. Take your time here as the more things you can list under each question, the more creative your experiment can be! After compiling all these ideas, choose one item (variable) from the Question #3 list – this will be called your <u>independent variable</u> or "you change it variable." It is the one you will deliberately change or vary in your experiment. Choose one way of measuring the response or effect of this change from Question #4 – this will be called your <u>dependent variable</u> or the "it changed variable." Remember as you choose this variable that you barely have **3 weeks** to complete your experiment. This means, for example, that you must choose a very fast growing plant if you want to measure height as your dependent variable

3. Designing your experiment

a. Title: Write a scientific title for your experiment using the following format:
The Effect of (the independent variable) **on the** (dependent variable).
Fro example: The Effect of Plant Density on the Height of Plants
Remember to capitalize the first and last words of the title and all other words except for small articles and prepositions, etc.
*Place your correctly written title on the milestones page.
(A fun, attention-getting, informal title can be included on your display board at the top of the middle section above your scientific title. This can be done in color and in much larger colorful font! Here is your chance to be creative. An experiment which tested the effect of different brands of sneakers in cushioning an egg was informally titled "The Yolks on Shoe!)

b. Problem/Question: Turn this title into a problem statement or a question to summarize the purpose for your experiment ("Does the density of plants per container affect the height of plants?)

c. Hypothesis: Write the hypothesis using the following "If- then" format:
If the (independent variable) is (describe how you will change it), **then** the (dependent variable) will (describe the effect you propose will occur.)
Ie: If the number of plants per container is increased**, then** the height of the plant will decrease.
Remember-don't use personal pronouns here even though it is what YOU think will happen!
*****Add your correctly written hypothesis to your milestones page.

d. Experimental design diagram: Create a diagram summarizing your experiment using the instructions given in the packet (see Appendix C) To create this diagram, you will need to decide on how many "levels" of your independent variable you are going to test. For example, if your independent variable is the density of plants, you need to decide **how many different numbers** of plants you will want to test. For example – if you decide to use 1 plant, 4 plants, 8 plants and 12 plants, that would be 4 levels because you are testing 4 different plant densities. Then you need to decide how many trials you will conduct for each of these "levels" or sizes of pots. It is a good idea to conduct as many trials as possible because that makes your results more valid. If money, space and time permit, conducting 10 trials is a great place to begin. For the experiment above, this would mean having 10 pots that had 1 plant in it, 10 pots that had 4 plants each in them, 10 pots that had 8 plants each in them and 10 pots that had 12 plants each in them. In this case, 10 trials is probably too cumbersome, so you would need to decide whether to cut back on the number of "levels" you test or the number of trials you conduct. Make sure you work with your parents on this step so they know how much space and how many materials you are planning to need!!! Sometimes, it is clear that one level can be the **control** – or the standard you are using for comparison. It is often the variable that you start with and do not change. In the example of the pots, there is no clear control, but you can designate the smallest pot as the control if you want to. You will also need to list the **constants** at the bottom of your diagram. These are all the variables you did not choose from Question #3 in the 4 Question Strategy! All variables except for the one you chose must be kept the same between trials and between levels. The more constants you list, the more scientific your findings will be. For example, if you choose to vary the number of plants per pot, you must keep things like the amount of water given, the amount of light given, the temperature, the amount of soil, the material of the pots, etc all THE SAME. If you do not do this, then there is no way of knowing whether the results you got were because of the variable you were testing, or from another variable that you did not keep the same.

4. Writing the materials/procedure –the important details!

d. Following the ideas on writing a procedure in this packet (Appendix D), you will write out every step. You must be very specific and include every detail. Your goal is to be so precise that anyone could read your directions and repeat your experiment just the way you did it. Please note that it is easiest to write out your procedure as though it was for just one level and one trial. Then add a step to indicate how many trials of that level. ("Repeat steps 1-7 for 5 more trials.") Then add one final step to indicate how many other levels you will be testing. ("Repeat steps 1-8 using 20cm pots, 30 cm pots and 40 cm pots".) This keeps your procedure concise and eliminates the need to write the out the steps involved for every level and every trial! At regional science fairs, judges especially like to see safety procedures included in your procedure, so get in the habit of including them ("Make sure to use gloves when handling soil from the ground as it may contain germs.")

e. Write out your complete materials list after you have written your procedure. Make sure to include details such as what kind? (brand, etc) how much (5 cm) how long? (after 2 days) where? (include location or site – south facing kitchen window, etc) Itemize your materials in a numbered list- capitalizing the first word.

5. Doing the experiment!

In the 5/6th grade science explore classes, we will be walking through a science fair project together and you will have about a month to conduct your experiment beginning in Oct. Those in other grades may get started earlier if you have completed all the steps up to this point and have shown them to your teacher. Make sure you take **LOTS of PICTURES** of your set up, of your experiment underway, and of your results! These will be very important to the appeal of your display board! Make sure to record your observations each day. It may be that something goes wrong – your two year old brother upsets all your plant containers while throwing a ball in the kitchen! Just remember to document what happened and pick up the pieces and start again. If nothing appears to be happening at all, keep thinking about why this may be so. Perhaps there is an unforeseen factor coming in to play. Maybe your cat eats the sprouts of your plant every day while you are not looking – maybe your plants are under a vent that makes the temperature change wildly – maybe the seeds you used were expired. These thoughts will be important in your analysis write up!

6. Making data tables and graphs

a. Data tables are described in the packet and will be explained in class. Follow the example contained at Appendix E in the packet and create a data table. With help from computer wise parents, these tables can be drawn on the computer, but they can easily be made on graph paper as well. Make sure to title your data table and make it large enough that it can be easily read on your display board.

b. Graphs (Appendix F) are made when information from the data tables is transferred to either a line graph or a bar graph using either the computer or graph paper. Make sure to title your graph. Make sure to create a key if you use colors or letters to represent different trials or levels. Make sure to label each axis and give units. The horizontal axis is usually labeled with the independent variable –"number of plants per 25 cm container.." The vertical axis is usually labeled with the dependent variable – "height of plants in centimeters." Try to make the graph fill most of a letter size piece of graph paper so that it can be easily read. Use colors inside graph, but label using black. For the display board, only the AVERAGE of all the trials will be graphed. Graphs of individual trials may be added to the written report, but are not necessary on the board.

7. Analysis

This is a detailed description of what happened and why. Summarize the information from your data table or graph using words instead of numbers. Explain what you thought was going to happen and tell whether it did or did not. Explain the reason for why things happened as you expected or why things did not go as expected. If you are not sure, make an educated guess using words such as perhaps or possibly. Describe any errors you are aware of that might have affected your results. Remember to use double spaced typing.

8. Conclusion

This is a short answer to your problem/question. Summarize what happened. Tell whether your results supported or did not support your hypothesis.

9. Application

Explain how these results can be used. Try to find places from real life where what you learned can be helpful. ("Since plants grew the tallest in the 30 cm pots, it is a good idea to transplant plants bought at a nursery that are in pots smaller that 30 cms") Judges will often ask you how you can apply your results, so think this through carefully!

10. Further research

This is a short paragraph describing new or different experiments you could do to learn more about your topic. Describe other independent variables you would like to try, or explain how you would change your experiment to correct any mistakes you came across during this experiment.

11. The Written Report

Although elementary students will not be doing advanced background research or writing abstracts of their work, all parts of the project described up to this point, including the two summaries, should be placed in a folder with a title page (the title of your project typed in size 36 font) and a table of contents (this means you will need to number your pages). You may include in this folder your daily observation log and photos if you wish. These reports can be placed in front of your display board during the science fair and can also be kept as a witness to your hard work (whereas your display board may be too large to keep for the long term!)

12. Putting together your display board – the last step! (Appendix G)

a. You should use a three paneled, self standing presentation board. (Available inexpensively at Michael's with 40% off coupon in weekly paper)

b. The board should be laid out roughly as follows:

LEFT PANEL:	Purpose or Question
	Hypothesis
	Materials
	Procedure
CENTER PANEL:	Informal catchy title
	Scientific title
	Experimental design diagram
	Photos or drawings
	Data table
	Graph
RIGHT PANEL:	Analysis
	Conclusion
	Application
	Further research

c. Use rubber cement if possible to attach papers to board. (Elmers will cause wrinkling, glue sticks tend to lose their "stick" after a time and items fall off board.
d. Use a paper cutter to make straight cuts or draw lines in very light pencil. Do not try to cut free hand! Do back the white typed sections onto colored paper that will provide a nice contrast with the color of your board.
e. Do make the subtitles for each section readable from across the room (Things such as "HYPOTHESIS" or "CONCLUSION") Then use the largest font you can for the actual text under each subtitle ensuring that each section is double spaced and will fit nicely on the board without crowding. Keep the font size consistent for all text used on the board.
f. You may want to bring in part of your set up to place in front of your tri-fold board. For example, you could bring in a few pots to show the differences in plant heights. You will only have the space in front of your board, so whatever you bring must fit in that space. For safety reasons, you should not bring anything breakable, flammable, poisonous, etc.
f. Remember to put your name on the back of the board!

On the day of the science fair, you may choose to bring in non-hazardous materials or set ups used in your experiment. These may be displayed in front of your tri-fold board. Avoid bringing in glass containers. If you are planning to display living organisms other than plants, obtain prior approval from your instructor.

APPENDIX A

The Winston Grammar Guide to Writing a Summary

A summary is a brief composition that covers the main ideas and important supporting details of a piece of writing. It should be about one third the length of the original piece and should be written in your own words. Here are some steps to help you learn how to write a summary:

1. Read through the article or work quickly once.
2. Read the selection again closely to find the main ideas.
3. Read through the work once more to locate important supporting details. Look up any words that are unfamiliar and begin to take notes/outlines.
4. Use complete sentences to write out a summary – including ONLY the main ideas and important supporting details – making sure you use your own words.
5. Revise your summary eliminating any unnecessary words or repetitions or examples until your summary is 1/3 the length of the original article.

Here is an example of how a summary is done: The original article said:

"To a scientist, a fossil is any trace or impression or remains of plant or animal life of long ago that has been preserved by burial in the earth's crust. It may be the imprint of a shell, the skeleton of a bird, the scales of a fish, the outline of a leaf, the track of a dinosaur, or the petrified limb of a tree. All of these belong to things that lived and died many, many, many years ago. By studying their traces in layers of rock, scientists discovered what the earth was like in the past.

Word count of original writing: _____

Place a check by the sentence that contains the main idea of this passage.

Eliminate multiple examples and repeated words by crossing them out.

Find a supporting detail you think is important and place a check by it.

Write your summary here:

_____
_____
_____
_____
_____

Word count of your summary: _____

Is your summary 1/3 the length of the original piece? _____

(A fossil is the trace, impression, or remains of ancient life preserved in the earth's crust. By studying fossils, scientists learn about the earth of long ago.)

APPENDIX B

The Four Question Strategy

By using this series of four questions, you can narrow a general topic like "PLANTS" down to a specific experimental idea.

General topic: PLANTS

QUESTION #1: What materials are readily available/ necessary for conducting experiments on plants?

Water
Plants
Seeds
Fertilizers
Soil
Light
Heat
Containers

QUESTION #2: How do plants act? Or what kinds of things do plants do?

Germinate	Grow fruit	Grow flowers
Grow roots	Photosynthesize	
Grow stems	Turn toward the sun	

QUESTION #3: How can I change the set of plant materials to affect the action?
(Take each item listed from question #1 and make a list underneath it – This is the time for brainstorming – the longer the list, the better!!)

Water	**Containers**	**Plants** **etc!**
Amount, pH	Shape	Kind, size
Frequency, temp	Size	Spacing
Time of day applied	Material	Number/density
Method of application	# holes in bottom	Variety
Source: tap, pond, bottled	Color	Brand name
Composition: soft, hard,	Location of holes	Age

QUESTION #4: How can I measure or describe the response of plants to the change I've chosen from question #3?

Measure the speed of germination	Measure the length of roots
Measure the height of the plant	Measure the weight of the fruit
Count the number of flowers, or leaves	Quantify the deepness of the color green
Measure the diameter of the stem	Determine the rate of growth

**To decide upon a specific science fair topic, choose one item from Questions 3 you want to test – this becomes your Independent Variable (IV) – the "you change it variable" or the thing you will change on purpose ie the density of your plants

**Now choose one item from Question #4 as a way to measure the response – this becomes your Dependent Variable (DV) – the "it changed variable" ie the height of plant

Your specific topic is now **"The Effect of Plant Density on the Height of Plants"**

APPENDIX C

Experimental Design Diagrams

Experimental design diagrams give those looking at your projects a way of understanding what you did in a quick glance. To create a diagram, follow these steps:

1. **Write the title :** The Effect of the Independent Variable on the Dependent Variable
2. **State the hypothesis:** If the (independent variable) is (describe how you changed it), then the (dependent variable) will (describe the effect you predict)

3. Write your independent variable (IV)
4. Divide the bottom two rows into columns; one column for each level of the independent variable. Write the levels of the IV in the columns. If one of those levels is the control for the experiment, put the word control under that level..
5. In each column write the number of repeated trails conducted for each level of the independent variable.

6. **Put your dependent variable (DV) below the rectangle.**
7. **Write your list of constants (C).**

For example:

Title: The Effect of Plant Density on the Height of Plants
Hypothesis: If the number of plants increases,, then the height of the plants will decrease.

IV: Number of plants in 25 cm container			
1	**4**	**8**	**12**
4 trials	**4 trials**	**4 trials**	**4 trials**

DV The Height of plants in cm in 21 days
C: Same amount, type, brand, composition of soil
Same amount, type, frequency, source, pH, temperature of water
Same amount, source, color, direction light
Same type, age, size of plants
Same size, shape, composition, # holes, location of holes in containers

APPENDIX D

Writing a Procedure

POPPING CORN

1st DRAFT: Visualize the steps you follow when popping corn. List the main steps on paper. Show your list to another student and compare lists. Modify if necessary.

1. Obtain popper.
2. Measure the popcorn.
3. Measure the oil.
4. Put the oil in the popper.
5. Heat the popper.
6. Add popcorn.
7. Cook.

2nd DRAFT: Note that in the first draft, for some steps such as 1-3, the sequence is NOT important. In other steps, however, the sequence is critical. Now modify your list to include the specific independent variable and constants and the specific response of the dependent variable identified from the 4 question strategy. Include brand names and specific amounts and times.

1. Obtain popper "Cor- Pop"
2. Measure popcorn "Pop-Rite Corn 100 kernels"
3. Measure oil "0, 10, 20, 30 ml"
4. Put oil in popper.
5. Heat popper "2 minutes"
6. Add the popcorn "100 kernels"
7. Cook "4 minutes"
8. Measure "Number of kernels popped"

3rd DRAFT: By looking over question #3 in the 4 Question strategy, important constants and variables or materials that may have been omitted can be caught. For example, an instrument to measure the oil must be included. Now write a step by step procedure. You will write the procedure for one value of the IV such as 10 ml of oil and for one trial. A statement to repeat the steps for additional trials and another statement to repeat steps for the additional levels of the IV should be included as the last two steps.

1. Obtain one "Cor-Pop" popcorn popper.
2. Count out 100 kernels of fresh "Pop-Rite" Corn.
3. Measure 10 ml of "Pazol" oil with a graduated cylinder.
4. Put the oil in the popper.
5. Heat the oil for 2 minutes.
6. Add the popcorn.
7. Cook the popcorn for 4 minutes.
8. Count the number of popped kernels.
9. Repeat steps 108 for 3 trials.
10. Repeat steps 1-9 for the other amounts of oil: 0, 20, 30 ml.

4th DRAFT: Make sure to let someone else reads your 3rd draft to catch any missing steps. Also pay special attention to any safety precautions that may be necessary ie Place the hot popcorn on a surface and allow to cool before counting the kernels.

Appendix E

Creating a Data Table

To make a data table, use the following steps:

1. Make a table containing vertical columns for the independent variable, dependent variable and the derived quantity which is another way of saying the average quantity.
2. Subdivide the column for the dependent variable to reflect the number of trials performed.
3. Order the values of the independent variable – preferably from smallest to largest.
4. Record the values of the dependent variable that correspond to each value of the independent variable.
5. Calculate the average of all trials and enter the value into the derived quantity column.

Column for IV (independent variable)	**Column for DV (dependent variable)**				**Column for derived quantity (average)**
	Trials				
	1	2	3	Etc.	
First level of IV					
Second level of IV					
Third level of IV					

For example:

Density of Plants (Number of plants in 25 cm wide container)	**Height of Plants in cm (after 3 weeks)**				**Average Height of Plants in cm**
	Trials				
	1	2	3	4	
1	10	12	14	12	12
4	8	8	10	10	9
8	5	6	7	6	6
12	2	4	3	3	3

To make this data table on the computer, you can use Microsoft word:

1. On the top menu, click Table, Insert, Table
2. In the pop up box that appears,
   For # of columns: click 2 plus the number of trials you conducted
   (for example, in the above data table, there were 4 trials plus 2 = 6 columns.
   For # of rows, click 3 plus the number of levels for your IV
   (for example, in the above data table, there were 4 levels of IV plus 3 = 7 rows.

3. When table appears, all of the columns will be the same size. Move the cursor over the lines separating the columns to resize the columns so that the first and last columns are large and the middle ones are smaller. When cursor is over line you wish to move, wait until you see the symbol that shows arrows pointing in opposite directions. Then left click the mouse and drag the line to the place where you want it to be.

4. Highlight the first 3 vertical cells in the first column and then click Table, Merge Cells. This will combine the cells and make one large box for you to type in the IV. Do the same thing in the last column. Then combine horizontal cells in the middle columns to make one large box for the DV and one large box for the word trials.

Appendix F

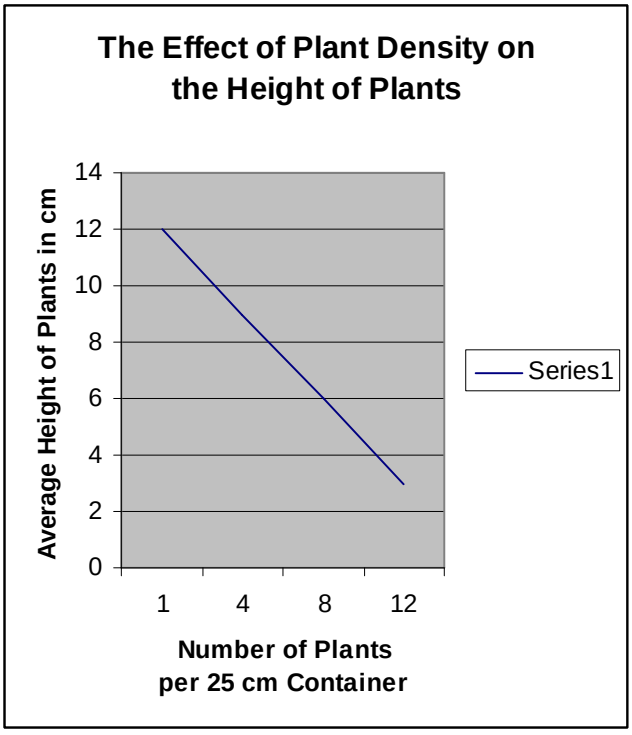
Creating Graphs

Graphs create a visual representation of your data and make it easier to see your results. Graphs can be Line Graphs or Bar Graphs (others are possible, but these are the most often used.) The type of graph you choose depends on the type of data collected. The measurements for your dependent variable can be classified as either discrete or continuous data.

Discrete data are categorical like colors, gender, kinds of animals, brand of paper towels, number of children, etc. Notice that each category is separate and apart from the next. Bar graphs are appropriate for these types of variables.

Continuous data are associated with measurements and involve a standard scale and equal intervals. Examples include the height of plants in cm, the length of time in sec or the amount of fertilizer in grams. When the data can be any value in a continuous range of measurements, a line graph is a better way to depict the data. Line graphs enable one to interpolate values on the graph that were not directly measured.

To construct the graphs, graph paper should be used or the graph should be generated on the computer. Create a horizontal line (called the "X axis" or the IV axis) Label this line with the Independent Variable including units taken from the first column of the data table. Next add a vertical line going up from the left most end of the horizontal line. This is the "Y axis." It should be labeled with the Derived Quantity taken from the last column of the data table. NOTE: you will only be graphing the **AVERAGE** value of your trials for your board. If you would like to create a graph of each trial's results, you may do this and put it in your written report, but it does not need to be on your board.



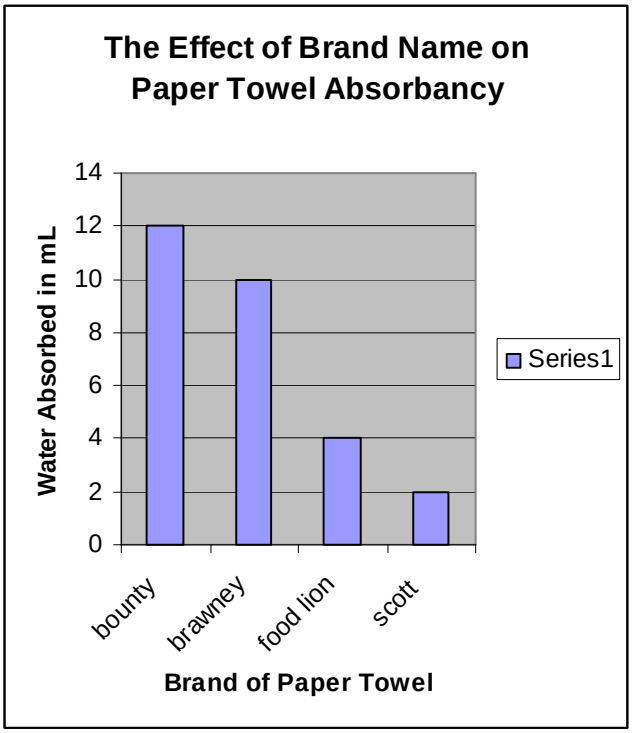
Note that the graph should be titled the same as the title of your project.

This graph was created on the computer using Microsoft excel. Data can be typed into a spread sheet and then Insert, Chart or simple Chart clicked. There are prompts that allow you to choose bar vs line graphs and prompts that ask you to label the axis and the points.

If you do not make your graph on the computer, make sure that you make you take into consideration your data range before labeling the points on the vertical axis. For example, in this graph, the lowest value derived was 3 cm and the largest was 12. If you take the difference (9) and divide by 5 (number which seems to always work well for finding an interval for labeling your axis) you get 1.8 which rounds up to 2. This tells you to make your interval 2cm along your vertical axis. Start your interval with 0.

Appendix E Cont'd

Creating Graphs



Notice that on the line graph, you can extrapolate the value for the height plants would reach should there be 10 plants per container as about 4.5 cm even though you did not test this number of plants.

In a bar graph, this is not possible. There is no value between brands of towels.

When labeling categories along the X axis or IV axis, it is customary to put them in abc order ie **Bo**unty, **Br**awney, **F**ood Lion, then **S**cott.

To type in the data for your bar graph on the computer, go to excel and on the spreadsheet, type your IV categories in the cells under column A. Then in column B type the derived quantity or average for each category in column A. The program will automatically put these into a bar graph when you highlight this info and click Insert, Chart and then bar graph. It will prompt you to make labels and titles for your graph as well.