**The Scientific Method**

- **Chemistry:**

 - chemistry—the study of the composition of matter and the changes it

 undergoes

 - chemistry focuses on what makes up matter, how it interacts with other

 matter and how energy is involved in the process

 - Branches of Chemistry:

 1) inorganic chemistry—the study of compounds that do not contain

 Carbon

 2) organic chemistry—the study of compounds that contain Carbon

 3) biochemistry—the study of compounds within living organisms

 4) analytical chemistry—the study of the composition of a substance

 5) physical chemistry—the study of how energy is involved in

 changes of matter

 6) chemical engineering—the study of the practical application of

 chemistry to solve problems

 7) environmental chemistry—chemistry associated with soil, air,

 water and human impact on natural systems

 8) nuclear chemistry—study of nuclear reactions and isotopes

- **The Scientific Method:**

 - scientific method—an organized and structured approach to solving

 problems and answering questions in science

 - 6 Steps of the Scientific Method:

 1) Ask a QUESTION

 - must have a “yes/no” or simple answer

 2) Do background RESEARCH

 - see what other scientists have done (don’t repeat other’s

 mistakes)

 - also helps with experimental design

3) Form a HYPOTHESIS

 - an educated guess as to what the answer to the question is

 - the hypothesis is formed BEFORE the experiment begins

 - the hypothesis must be TESTABLE!!!

 - form a prediction “IF [hypothesis is true], THEN [what will

 the data show in the experiment?]”

 4) Test the Hypothesis by EXPERIMENTATION

 - run an experiment with only ONE variable changing

 - all other variables should be CONTROLLED

 5) ANALYZE your data and decide if the hypothesis is true or false

 - if hypothesis is rejected, then start over with a new

 hypothesis

 - if the hypothesis is supported, then do further experiments

 to strengthen the hypothesis

 6) COMMUNICATE your results

 - publish your results so that other scientists can benefit from

what you have learned or discovered



Image couresty of

 <http://mswillardsclassblog.blogspot.com/2011/10/scientific-method-madness-yo.html>

- **Scientific Statements:**

 - there is a progression of trustworthiness in scientific statements

 - hypothesis – an educated guess answer to a scientific question (LOW

 trust level)

 - theory -- A set of statements or principles devised to explain a group of

 facts or phenomena, especially one that has been repeatedly tested or is

 widely accepted and can be used to make predictions about natural

 phenomena (MEDIUM trust)

 - scientific law—a statement that has NO CONTRADICTORY evidence

 (HIGHEST trust)

 - ***THE ONLY ABSOLUTE TRUTH IS THAT THERE ARE NO ABSOLUTE TRUTHS!***

- **Experimental Design:**

- there are MANY different experimental designs (all vary in setup and

 what is actually being tested)

 - we will focus on “true experimental design” that is utilized in chemistry

 - sample groups must be assigned RANDOMLY

 - must have a viable CONTROL GROUP

 1) positive control – expected to show a (+) result [to be sure that

 the test is working]

 2) negative control – expected to show a (-) result [to eliminate bias

 and be sure that there is no confounding variable that SHOULD

 have been controlled for]

 - only ONE VARIABLE is manipulated and tested at a time

 - DEPENDENT variable—the variable that is MEASURED

 - INDEPENDENT variable—the ONE variable that is manipulated or changed

 during the experiment

 - *the independent variable is changed in order to measure the effect on*

 *the dependent variable*

 - CONTROLLED variables—variables that CAN have an effect on the

 dependent variable but they are held CONSTANT so the only thing

 affecting the dependent variable should be the independent variable

 - can be difficult to control for everything

- **Graphing:**

- graph—a pictorial representation of data in order to see overall trends

 - a picture is worth 1,000 words!!!

 - graphs must be done the RIGHT way!!

 1) should have a clear title as to what the graph shows

 - “The effect of [independent var.] on [dependent var.]”

 2) should be the proper TYPE according to the data that is being

 shown

 - almost always this means a LINE GRAPH

 3) should take up at least 75% of the page

4) axes should be LABELED with the UNITS that are measured

 - DEPENDENT VARIABLE goes on the Y AXIS

 - INDEPENDENT VARIABLE goes on the X AXIS

 5) the SCALE must be consistent all the way through the graph!!!

 6) must be easy to read and interpret

 7) do NOT connect the dots – DO a line of “best fit”



BAD GRAPH: No title, no label on axes, no UNITS!!!, and by connecting the dots you are implying a scientific relationship where one might not exist!!



GOOD GRAPH: axes are labeled with units, graph has a clear title so you know exactly what you are looking at and the line of BEST FIT is drawn (not connect the dots!)

Images courtesy of Ian Guch

<http://misterguch.brinkster.net/graph.html>

**Types of Graphs:**

1) PIE CHARTS – good for showing percentages

 - shows the sizes of parts that make up a whole



Image courtesy of Wikipedia

[http://en.wikipedia.org/wiki/File:Pie\_chart\_EP\_election\_2004.svg](http://en.wikipedia.org/wiki/File%3APie_chart_EP_election_2004.svg)

 2) LINE GRAPH – good for showing the relationship between 2 variables

 - pure scientific line graphs should be a linear regression (LINE OF

 BEST FIT) but sometimes it is also helpful to see overall trends in

 data

 - the DEPENDENT VARIABLE always goes on the Y AXIS

 - the INDEPENDENT VARIABLE always goes on the X AXIS



Image courtesy of Wikipedia

[http://en.wikipedia.org/wiki/File:ScientificGraphSpeedVsTime.svg](http://en.wikipedia.org/wiki/File%3AScientificGraphSpeedVsTime.svg)

 3) BAR GRAPH – good for showing magnitude and overall trends (as well as

 a comparison between 2 groups of data)

 - consists of a set of vertical or horizontal bars that represent the

 frequency of some category of measured data



Image courtesy of Wikipedia

<http://upload.wikimedia.org/wikipedia/commons/d/df/Adobe_Flex_ColumnChart.png>

 4) HISTOGRAM – similar to a bar graph but a histogram contains a RANGE

 of independent variable values rather than just a single value



Image courtesy of Wikipedia

[http://commons.wikimedia.org/wiki/File:Black\_cherry\_tree\_histogram.svg](http://commons.wikimedia.org/wiki/File%3ABlack_cherry_tree_histogram.svg)