The Scientific Method

- The scientific method involves the search for truth in an objective manner and comprises 3 key steps:
  - Setting up a hypothesis
  - Testing the hypothesis
  - Interpreting and reporting the results

Setting up the hypothesis

- This is a description of the problem and may take the form of a statement or a question.
- “What is the effect of cooking time on the tenderness of broccoli?”
  - Hypothesis will generally include both the independent and dependent variables
Variables

- The independent variable is something you control, such as time of cooking.
- The dependent variable is something you observe or measure, such as tenderness.

Testing the hypothesis

- To do this we normally employ objective and/or subjective methods. In our broccoli case, an objective method could be a shear press or the Texture Analyzer. The subjective method would be a taste panel.

Testing the hypothesis

- Note that it is extremely important, in both subjective and objective testing, to change only one variable at a time.
Replication

• In doing your testing, you need to consider the concepts of both precision and accuracy.

Precision

• Precision is how close repeated measures of a particular characteristic come to each other and is normally reflected in the variance or standard deviation of a set of measurements

• Put another way, precision is “The ability to tell the same story over and over again”

Accuracy

• Accuracy is how close a measurement (or the average of a set of measurements) is to the “true” or “real” value.

• Or, as some might say, “The ability to tell the truth”
Precision and Accuracy

- Precise, not accurate
- Average is accurate but measurements are not precise.
- Accurate and precise

Standardization

- In testing your hypothesis, you should also consider standardization, that is, use of something of known value to see if you can get this value (an NBS standard) or in the calibration of an instrument (such as a pH meter). This will make an accurate result much more likely.

Randomization

- To help insure the validity of your data, you should randomize treatments as much as possible to protect against favoring one treatment over another.
Randomization

- This is especially important in sensory studies, where you need to randomize presentation to the panelists.
  - That is, they get the control sample first once, then the test sample first.

Interpreting and reporting results

- This is where conclusions are drawn and shared.
- “If it's not published, it's not finished!” F. A. Cotton, Texas A&M University
- Tables and graphs will greatly aid and speed interpretation of your data.

Tables and graphs

- Tables and graphs should be understandable without reference to the text in which they are found. Therefore, you need a title.
- In graphs, axes need to be labeled with units.
- In tables, columns and rows need to have appropriate units.
Table Example

Table 1  Eating Habits each Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Fat</th>
<th>Sugar</th>
<th>Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>58</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>56</td>
<td>14</td>
<td>9.1</td>
</tr>
<tr>
<td>1981</td>
<td>66</td>
<td>13</td>
<td>9.6</td>
</tr>
<tr>
<td>1985</td>
<td>56</td>
<td>13</td>
<td>10</td>
</tr>
</tbody>
</table>

Graphs

- In graphs, the dependent variable is usually plotted on the y-axis and the independent variable is plotted on the x-axis.
- Use a line graph for continuous data and a bar graph for discontinuous data.

Bar Graph Example

Graph 1 Eating Habits each Year
Graph 2: Eating Habits each Year

- Statistical analysis does not increase the validity of your data. It expresses a level of significance or correlation between the dependent and independent variables.
- Statistics will not improve bad data. 
  – “Garbage in, garbage out.”

Statistics

- Correlation is not causation

Sources:
U.S. NHTSA, DOT HS 801 052
U.S. Department of Agriculture

Total U.S. Highway Fatalities

Fresh Lemons Imported to USA from Mexico (Metric Tons)
Statistics-Take 2

• "If your experiment needs statistics, then you ought to have done a better experiment"

Ernest Rutherford
Nobel prize for chemistry 1908