STATISTICS

The Nature of Statistic

- **Definition (Statistics)**

  Statistics is concerned with

  - the collection of data,
  - their description, and
  - their analysis, which often leads to the drawing of conclusions.

  Statistics: The science of collecting, describing, and interpreting data.

Two areas of statistics:

Descriptive Statistics: collection, presentation, and description of sample data.

Inferential Statistics: making decisions and drawing conclusions about populations.

Introduction to Basic Terms

Population: A collection, or set, of individuals or objects or events whose properties are to be analyzed.

Two kinds of populations: *finite* or *infinite*.

Sample: A subset of the population.

Variable: A characteristic about each individual element of a population or sample.

Data (singular): The value of the variable associated with one element of a population or sample. This value may be a number, a word, or a symbol.

Data (plural): The set of values collected for the variable from each of the elements belonging to the sample.

Experiment: A planned activity whose results yield a set of data.

Parameter: A numerical value summarizing all the data of an entire population.

Statistic: A numerical value summarizing the sample data.

Example: A college dean is interested in learning about the average age of faculty. Identify the basic terms in this situation.

The *population* is the age of all faculty members at the college.

A *sample* is any subset of that population. For example, we might select 10 faculty members and determine their age.

The *variable* is the "age" of each faculty member.

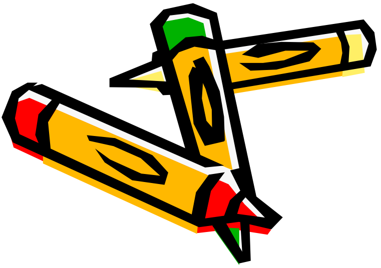
One *data* would be the age of a specific faculty member.

The *data* would be the set of values in the sample.

The *experiment* would be the method used to select the ages forming the sample and determining the actual age of each faculty member in the sample.

The *parameter* of interest is the "average" age of all faculty at the college.

The *statistic* is the "average" age for all faculty in the sample.



Two kinds of variables:

Qualitative, or Attribute, or Categorical, Variable: A variable that categorizes or describes an element of a population.

Note: Arithmetic operations, such as addition and averaging, are *not* meaningful for data resulting from a qualitative variable.

Quantitative, or Numerical, Variable: A variable that quantifies an element of a population.

Note: Arithmetic operations such as addition and averaging, are meaningful for data resulting from a quantitative variable.

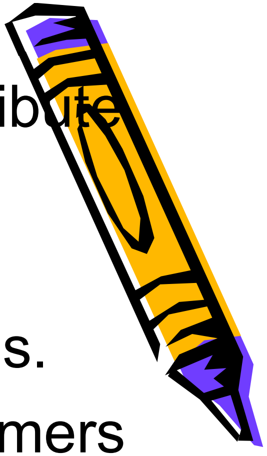
Quantitative Data

- Number of TV sets owned by a family
- Number of books in the library
- Time spent on travel to school
- Amount of rainfall
- Weight of an apple

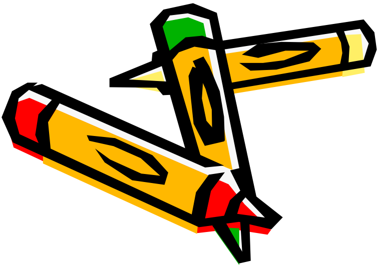
Qualitative data

- Eye color
- Gender
- color of an apple
- taste of an apple
- smell of an apple

Example: Identify each of the following examples as attribute (qualitative) or numerical (quantitative) variables.



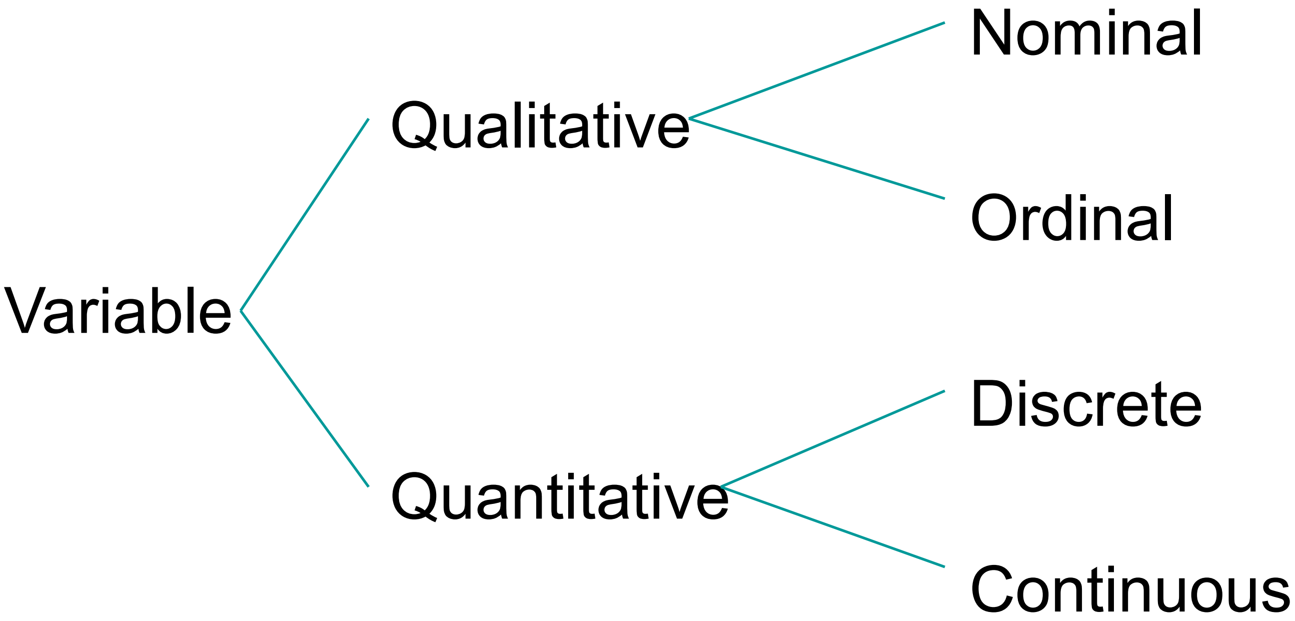
1. The residence hall for each student in a statistics class.
2. The amount of gasoline pumped by the next 10 customers at the local NE Mall.
3. The amount of radon in the basement of each of 25 homes in a new development.
4. The color of the baseball cap worn by each of 20 students.
5. The length of time to complete a mathematics homework assignment.
6. The state in which each truck is registered when stopped and inspected at a weigh station.



Example: Identify each of the following as examples of qualitative or numerical variables:

1. The temperature in Baler, Aurora at 12:00 pm on any given day.
2. The make of automobile driven by each faculty member.
3. Whether or not a 6 volt lantern battery is defective.
4. The weight of a lead pencil.
5. The length of time billed for a long distance telephone call.
6. The brand of cereal children eat for breakfast.
7. The type of book taken out of the library by an adult.

Qualitative and quantitative variables may be further subdivided:



Variable

Qualitative

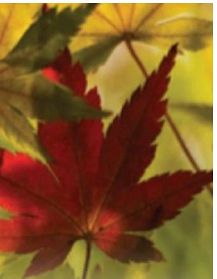
Nominal

Ordinal

Quantitative

Discrete

Continuous



Nominal Variable: A qualitative variable that categorizes (or describes, or names) an element of a population.

Ordinal Variable: A qualitative variable that incorporates an ordered position, or ranking.

Discrete Variable: A quantitative variable that can assume a countable number of values. Intuitively, a discrete variable can assume values corresponding to isolated points along a line interval. That is, there is a gap between any two values.

Continuous Variable: A quantitative variable that can assume an uncountable number of values. Intuitively, a continuous variable can assume any value along a line interval, including every possible value between any two values.

Statistics deals with numbers

- Need to know nature of numbers collected
  - Continuous variables: type of numbers associated with measuring or weighing; any value in a continuous interval of measurement.
    - Examples:
      - Weight of students, height of plants, time to flowering
  - Discrete variables: type of numbers that are counted or categorical
    - Examples:
      - Numbers of boys, girls, insects, plants

Note:

1. In many cases, a discrete and continuous variable may be distinguished by determining whether the variables are related to a count or a measurement.
2. Discrete variables are usually associated with counting. If the variable cannot be further subdivided, it is a clue that you are probably dealing with a discrete variable.
3. Continuous variables are usually associated with measurements. The values of discrete variables are only limited by your ability to measure them.

Example: Identify each of the following as examples of (1) nominal, (2) ordinal, (3) discrete, or (4) continuous variables:

1. The length of time until a pain reliever begins to work.
2. The number of chocolate chips in a cookie.
3. The number of colors used in a statistics textbook.
4. The brand of refrigerator in a home.
5. The overall satisfaction rating of a new car.
6. The number of files on a computer’s hard disk.
7. The pH level of the water in a swimming pool.
8. The number of staples in a stapler.

1.3: Measure and Variability

- No matter what the response variable: there will always be **variability** in the data.
- One of the primary objectives of statistics: measuring and characterizing variability.
- Controlling (or reducing) variability in a manufacturing process: statistical process control.

Example: A supplier fills cans of soda marked 12 ounces. How much soda does each can really contain?

- It is very *unlikely* any one can contains exactly 12 ounces of soda.
- There is variability in any process.
- Some cans contain a little more than 12 ounces, and some cans contain a little less.
- On the average, there are 12 ounces in each can.
- The supplier hopes there is little variability in the process, that most cans contain *close* to 12 ounces of soda.

1.4: Data Collection

- First problem a statistician faces: how to obtain the data.
- It is important to obtain *good*, or *representative*, data.
- Inferences are made based on statistics obtained from the data.
- Inferences can only be as good as the data.

Biased Sampling Method: A sampling method that produces data which systematically differs from the sampled population. An **unbiased sampling method** is one that is not biased.

Sampling methods that often result in biased samples:

1. **Convenience sample**: sample selected from elements of a population that are easily accessible.
2. **Volunteer sample**: sample collected from those elements of the population which chose to contribute the needed information on their own initiative.

Process of data collection:

1. Define the objectives of the survey or experiment.

   Example: Estimate the average life of an electronic component.

2. Define the variable and population of interest.

   Example: Length of time for anesthesia to wear off after surgery.

3. Defining the data-collection and data-measuring schemes. This includes sampling procedures, sample size, and the data-measuring device (questionnaire, scale, ruler, etc.).

4. Determine the appropriate descriptive or inferential data-analysis techniques.

Methods used to collect data:

Experiment: The investigator controls or modifies the environment and observes the effect on the variable under study.

Survey: Data are obtained by sampling some of the population of interest. The investigator does not modify the environment.

Census: A 100% survey. Every element of the population is listed. Seldom used: difficult and time-consuming to compile, and expensive.

Sampling Frame: A list of the elements belonging to the population from which the sample will be drawn.

Note: It is important that the sampling frame be representative of the population.

Sample Design: The process of selecting sample elements from the sampling frame.

Note: There are many different types of sample designs. Usually they all fit into two categories: judgment samples and probability samples.

Judgment Samples: Samples that are selected on the basis of being "typical."

Items are selected that are representative of the population. The validity of the results from a judgment sample reflects the soundness of the collector's judgment.

Probability Samples: Samples in which the elements to be selected are drawn on the basis of probability. Each element in a population has a certain probability of being selected as part of the sample.

Random Samples: A sample selected in such a way that every element in the population has a equal probability of being chosen. Equivalently, all samples of size *n* have an equal chance of being selected. Random samples are obtained either by sampling with replacement from a finite population or by sampling without replacement from an infinite population.

Note:

1. Inherent in the concept of randomness: the next result (or occurrence) is not predictable.
2. Proper procedure for selecting a random sample: use a random number generator or a table of random numbers.

Example: An employer is interested in the time it takes each employee to commute to work each morning. A random sample of 35 employees will be selected and their commuting time will be recorded.

There are 2712 employees.

Each employee is numbered: 0001, 0002, 0003, etc. up to 2712.

Using four-digit random numbers, a sample is identified: 1315, 0987, 1125, etc.

Systematic Sample: A sample in which every *k*th item of the sampling frame is selected, starting from the first element which is randomly selected from the first *k* elements.

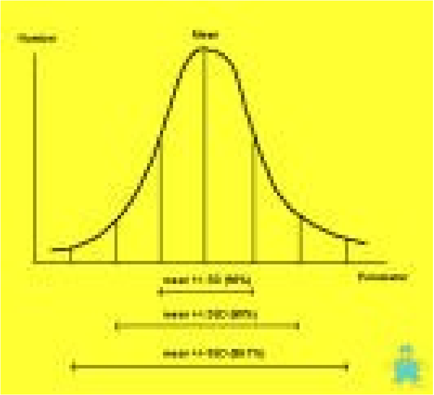
Note: The systematic technique is easy to execute. However, it has some inherent dangers when the sampling frame is repetitive or cyclical in nature. In these situations the results may not approximate a simple random sample.

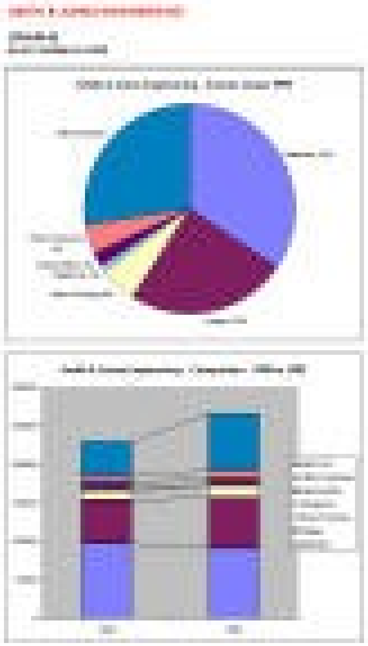
Stratified Random Sample: A sample obtained by stratifying the sampling frame and then selecting a fixed number of items from each of the strata by means of a simple random sampling technique.

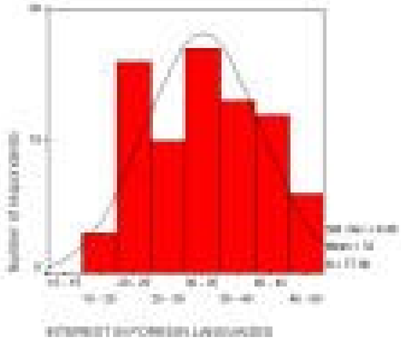
Proportional Sample (or Quota Sample): A sample obtained by stratifying the sampling frame and then selecting a number of items in proportion to the size of the strata (or by quota) from each strata by means of a simple random sampling technique.

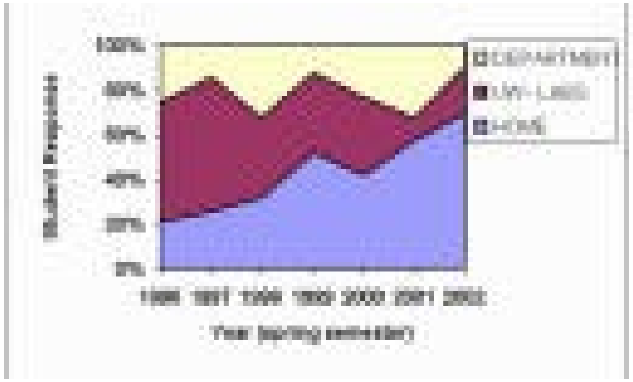
Cluster Sample: A sample obtained by stratifying the sampling frame and then selecting some or all of the items from some of, but not all, the strata.

Organizing and Graphing Data









Goal of Graphing?

1. Presentation of Descriptive Statistics
2. Presentation of Evidence

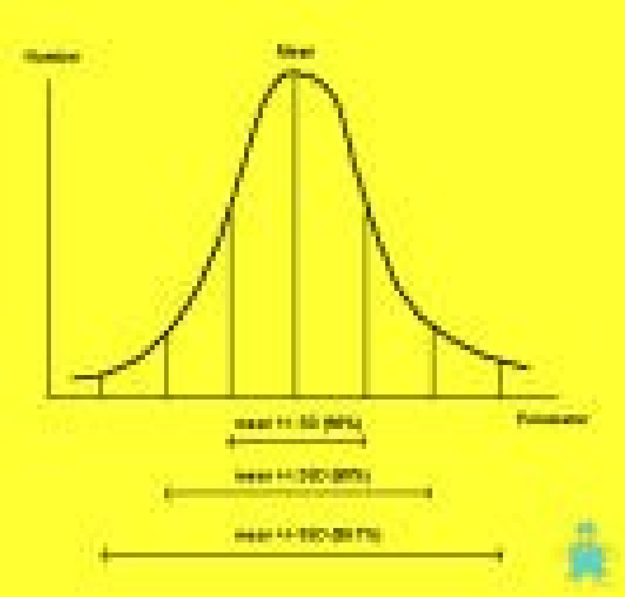
3. Some people understand subject matter better with visual aids

4. Provide a sense of the underlying data generating process (scatter-plots)

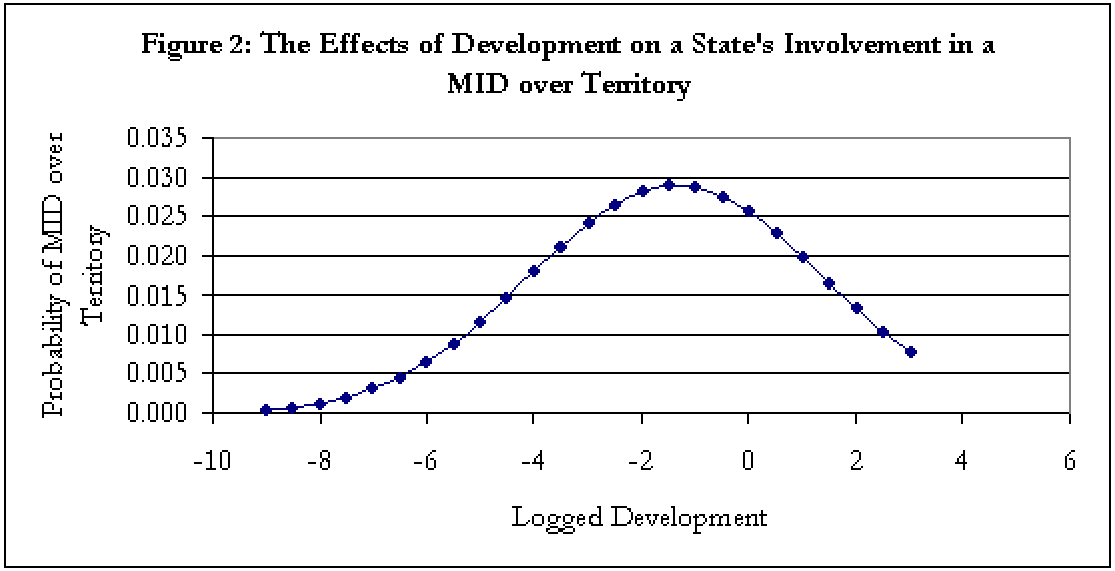
What is the Distribution?

- **Gives us a picture of the variability and central tendency.**

- **Can also show the amount of skewness and Kurtosis.**



Graphing Data: Types



Creating Frequencies

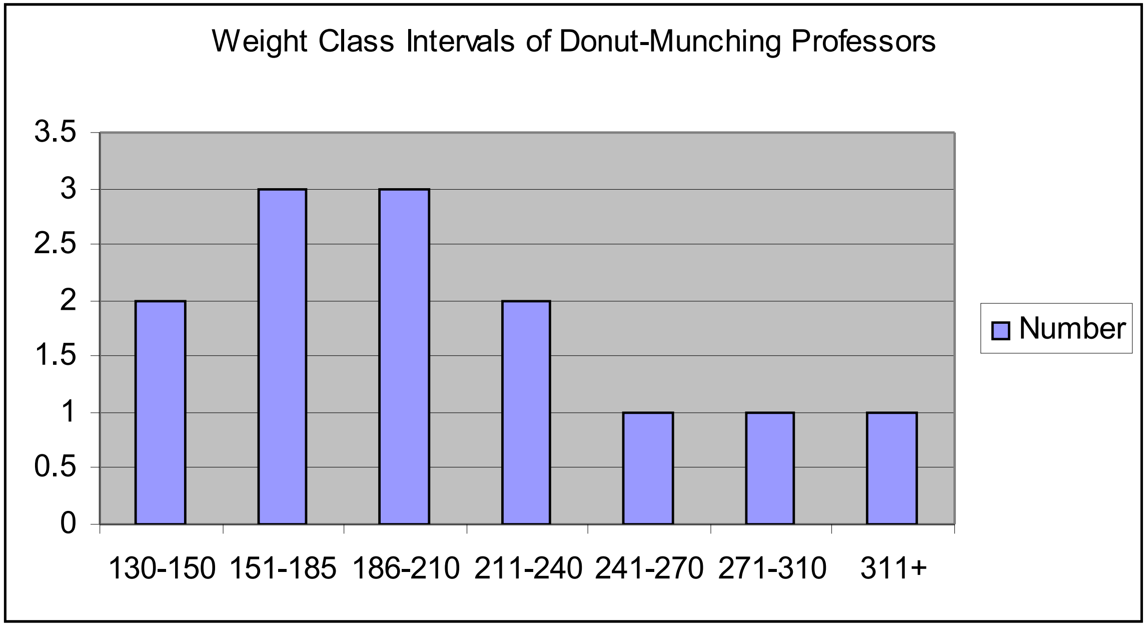
- **We create frequencies by sorting data by value or category and then summing the cases that fall into those values.**

- **How often do certain scores occur? This is a basic descriptive data question.**

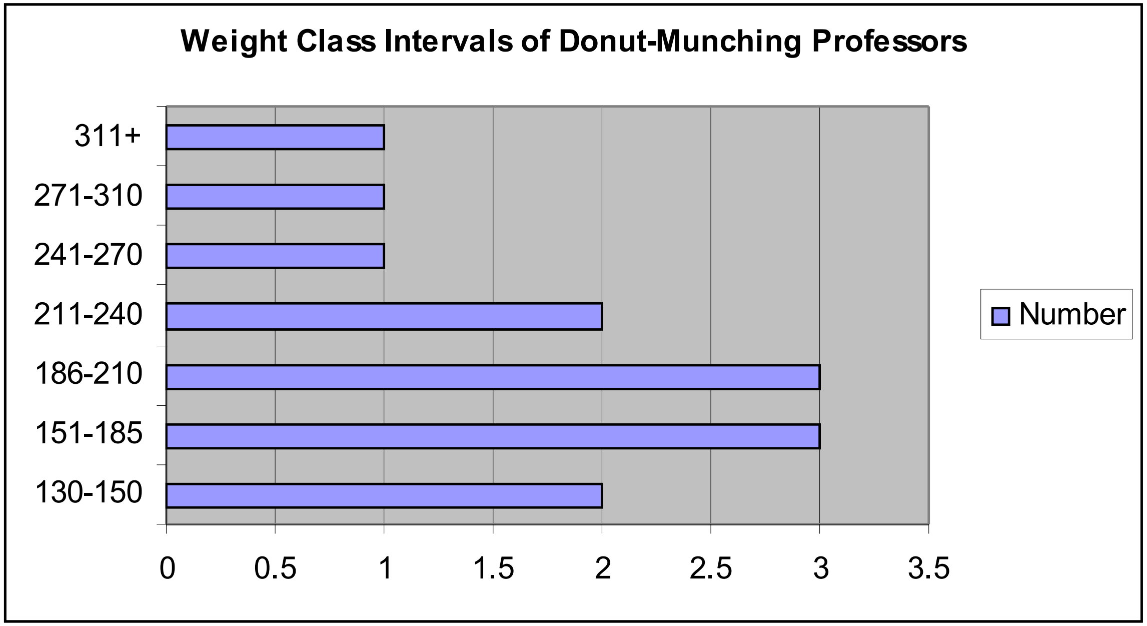
Ranking of Donut-eating Profs. (most to least)

Zingers	308
Honkey-Doorey	251
Calzone	227
Bopsey	213
Googles-boop	199
Pallitto	189
Homer	187
Schnickerson	165
Smuggle	165
Boehmer	151
Levin	148
Queeny	132

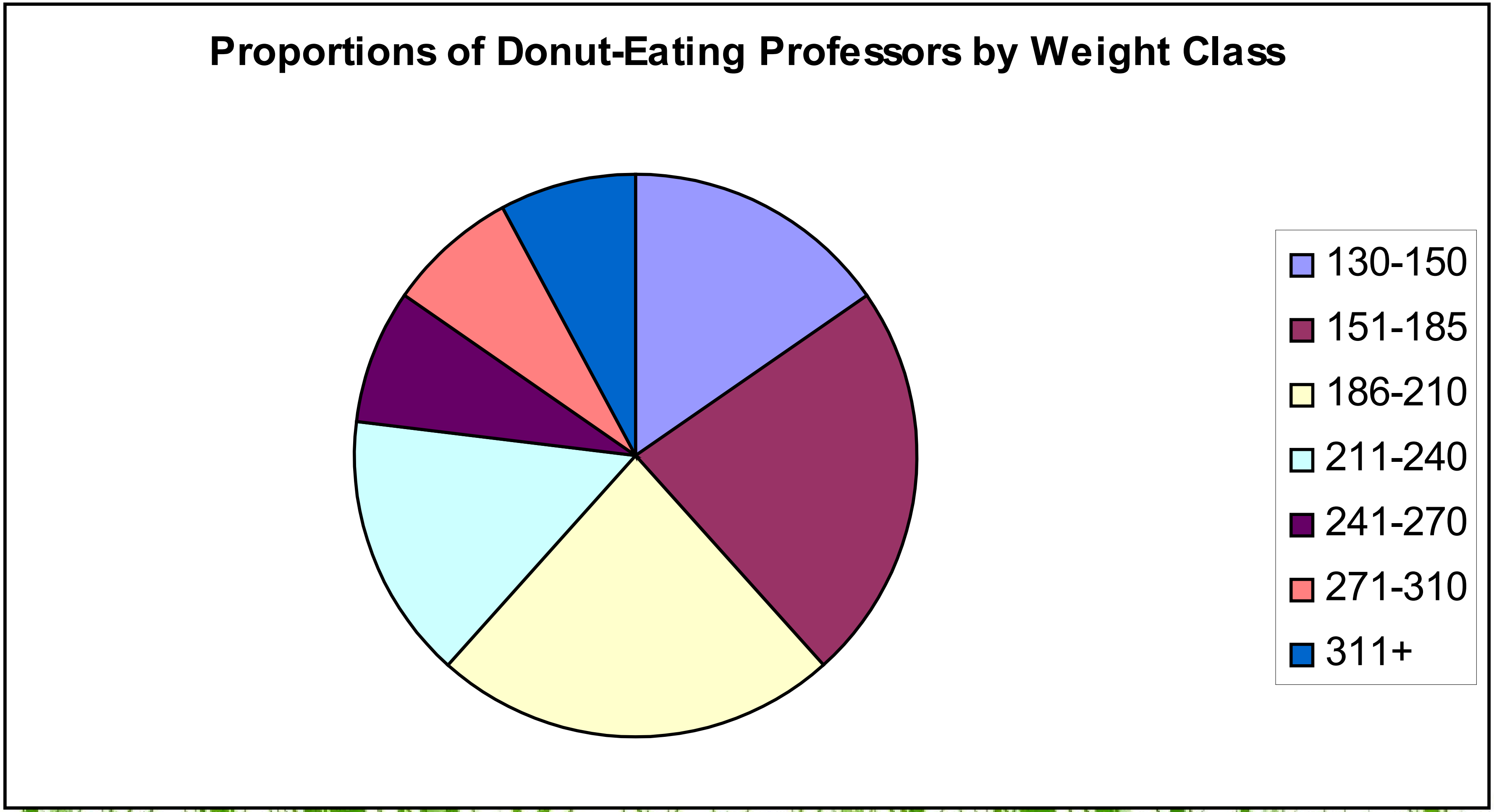
Here we have placed the Professors into weight classes and depict with a histogram in columns.



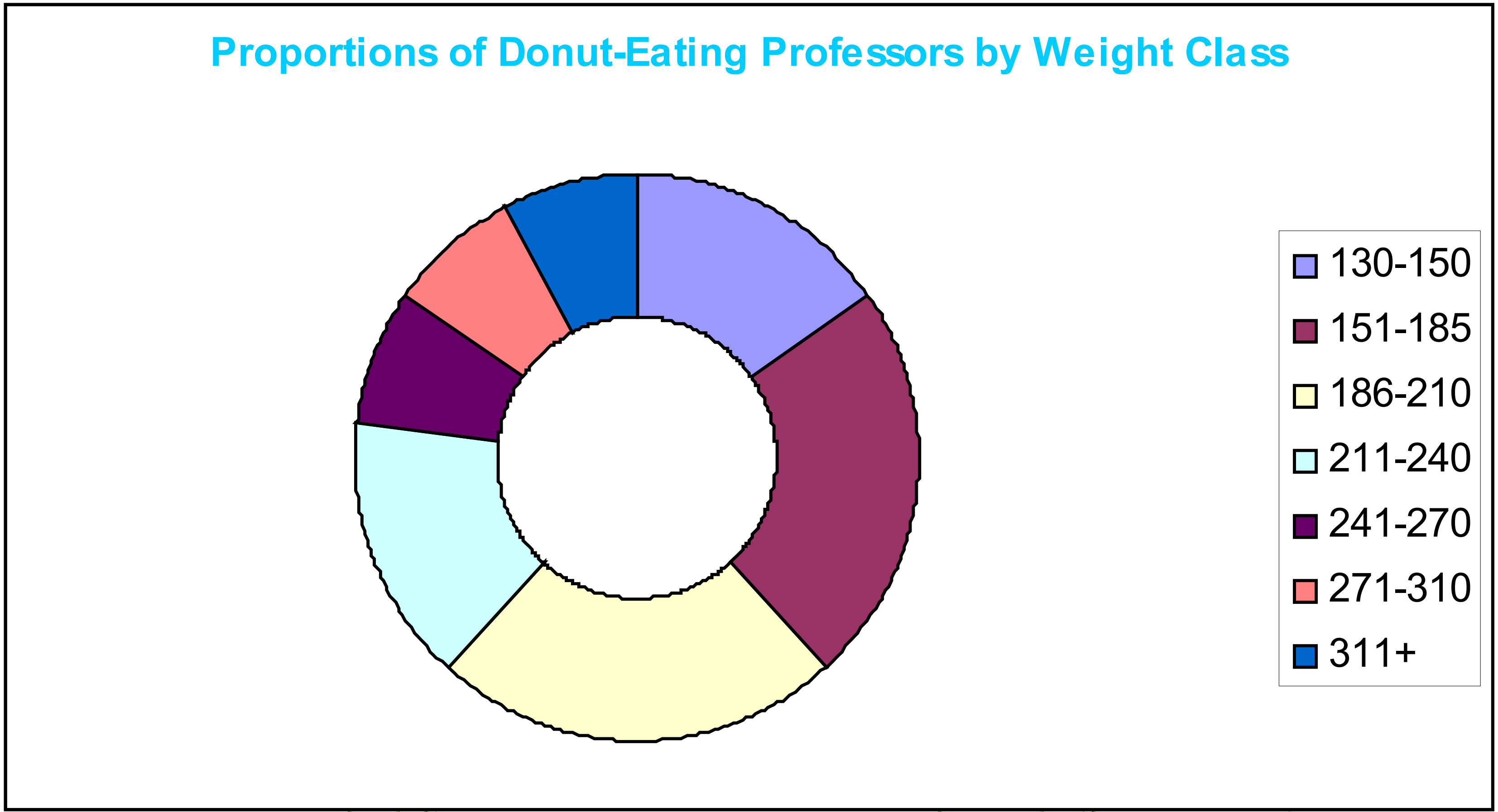
Here it is another histogram depicted as a bar graph.



Pie Charts:

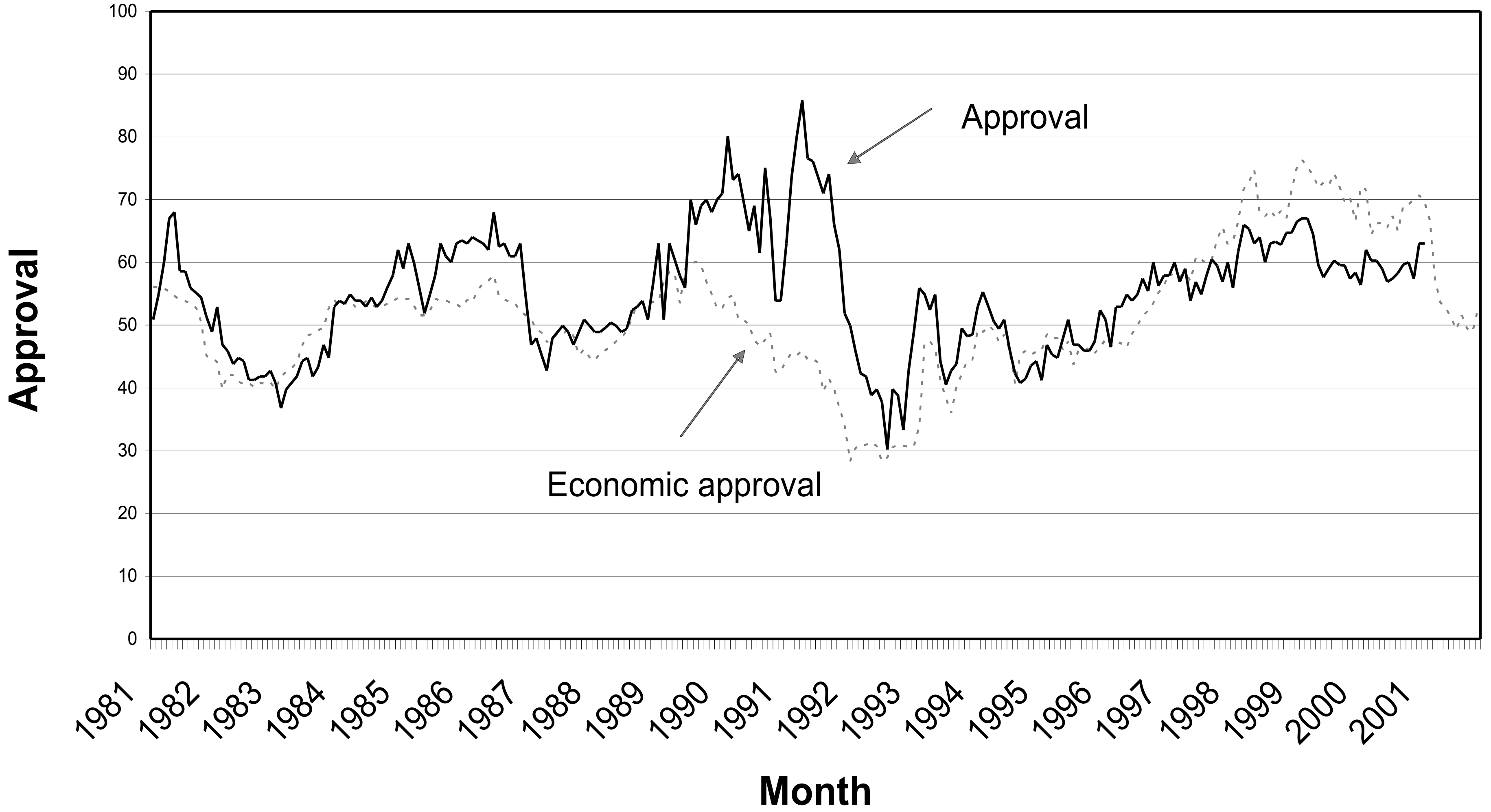

Proportions of Donut-Eating Professors by Weight Class
130-150
151-185
186-210
211-240
241-270
271-310
311+

Actually, why not use a donut graph. Duh!

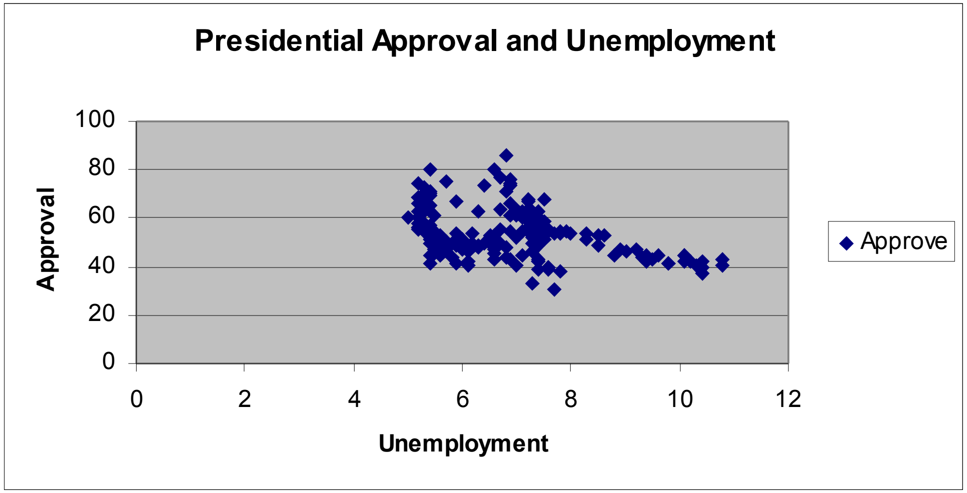


See Excel for other options!!!!

Line Graphs: A Time Series



Scatter Plot (Two variable)



1. Terminology
Populations & Samples

- **Population**: the complete set of individuals, objects or scores of interest.
  - Often too large to sample in its entirety
  - It may be real or hypothetical (e.g. the results from an experiment repeated ad infinitum)

- **Sample**: A subset of the population.
  - A sample may be classified as **random** (each member has equal chance of being selected from a population) or **convenience** (what's available).
  - Random selection attempts to ensure the sample is **representative** of the population.

Variables

- **Variables** are the quantities measured in a sample.They may be classified as:
  - **Quantitative** i.e. numerical
    - **Continuous** (e.g. pH of a sample, patient cholesterol levels)
    - **Discrete** (e.g. number of bacteria colonies in a culture)
  - **Categorical**
    - **Nominal** (e.g. gender, blood group)
    - **Ordinal** (ranked e.g. mild, moderate or severe illness). Often ordinal variables are re-coded to be quantitative.

Variables

- Variables can be further classified as:
  - **Dependent**/**Response**. Variable of primary interest (e.g. blood pressure in an antihypertensive drug trial). Not controlled by the experimenter.
  - **Independent**/**Predictor**
    - called a **Factor** when controlled by experimenter. It is often nominal (e.g. treatment)
    - **Covariate** when not controlled.
- If the value of a variable cannot be predicted in advance then the variable is referred to as a **random variable**

Parameters & Statistics

- **Parameters**: Quantities that describe a population characteristic. They are usually unknown and we wish to make *statistical inferences* about parameters. Different to **perimeters**.

- **Descriptive Statistics**: Quantities and techniques used to describe a sample characteristic or illustrate the sample data e.g. mean, standard deviation, box-plot

2. Frequency Distributions

- An (**Empirical**) **Frequency Distribution** or **Histogram** for a continuous variable presents the counts of observations grouped within pre-specified classes or groups

- A **Relative Frequency Distribution** presents the corresponding proportions of observations within the classes

- A **Barchart** presents the frequencies for a categorical variable

Example – Serum CK

- Blood samples taken from 36 male volunteers as part of a study to determine the natural variation in CK concentration.

- The serum CK concentrations were measured in (U/I) are as follows: