Objectives:

- To learn to distinguish between *response* variables and *explanatory* variables.
- To understand the distinction between *observational studies*, *surveys*, and *controlled experiments*.
- To recognize the need for carefully designed *experiments* in order to detect a cause-and-effect relationship between variables.
- To identify some *principles* through which experiments achieve control.
- To investgate the concept of *confounding* and the effects of *randomization*.

Four examples of Studies

- *Anecdotes:* The investigator recounts instances known to him or her. Unreliable since these may be hearsay, things that stick out in the mind, etc therefore may be biased and misleading and has no control.
- *Surveys:* The investigator asks people to answer questions based on their opinions or practices. Used often to get quick information from people who might "know" and pool the results.
- *Observational studies:* The investigator passively studies variables already in place and observes and records information based on this. Susceptible to confounding variables since there may be reasons we are not accounting for that the variables are in place.
- *Experiments:* The investigator deliberately imposes the variable conditions on subjects (*experimental units.*) He then observes and records the results from these variables. Best since the investigator has control over whether the variable exists and thus reducing the effect of possible confounding variables.
- *Cause-and-effect:* An experiment is necessary to establish and/or assess a *cause-and-effect* relationship between the *explanatory* and *response* variables. In the experiment, the experimenter actively imposes the treatment on the subjects to see if there is a direct effect on the response variable from the explanatory.
- *Explanatory variable:* Also known as the *independent variable*, This is the variable affecting or causing the result of the other variable. This is the variable being controlled in an experiment, or the variable that decides the observational unit in an observational study.
- *Response variable:* Also known as the *dependent variable*, The variable being affected by the explanatory variable. The result of this variable is measured in an observational study or an experiment.
- *Control:* A well-designed experiment exerts *control* on the subjects to minimize the effects of extraneous variables that may be confounding. This way we can be more assured that the change in the response variable is or is not indeed directly attributed to the explanatory variable.
- *Comparison:* Comparison is a fundamental form of control in an experiment. For example, the control often is to randomly select people from a population and then randomly select half to receive the treatment and the other half to not receive the treatment. Then compare the measurement of the response variable between the two groups (no outside confounding variable is changed and therefore the only the actual treatment made the change)
- *Lurking variable:* unmonitored variables that have an effect on the measurement of the response variable. These lurking variables have a confounding effect on the response.
- *Confounding variable:* A variable that's affect on the response is indistinguishable from the affects of the explanatory variable. This prevents the investigator from isolating the effects of each variable.
- Randomization: (Random Assignment) A way of assigning subjects and treatments to attempt to eliminate any effect on an experiment by lurking or confounding variables (Their effects "balance out"). By randomly assigning subjects to treatments systematic bias is eliminated from the data set and therefore we can begin establish cause-effect relationships since any *significant* difference

between the treatment and control more than likely would result from the treatment, not from inherent differences that were randomly distributed.

- *Randomized Comparative Experiment:* An experiment that utilizes randomization to create treatment and control groups and comparison between the two to make a determination of effect.
- *Causal Relationship:* A causal relationship may only be said to exist if the data come from a well designed, controlled experiment. Any lurking or confounding variable needs to be balanced out or eliminated by the design of the study should have some sort of randomization to accomplish this.
- **Placebo Effect:** Randomization often is not enough. When dealing with humans, who have a strong susceptibility to the power of suggestion, we need to make the subjects either think they are also getting the treatment or not know they are receiving the treatment. When a subject thinks they are getting the treatment but aren't it is called a *placebo*.
- **Blind:** Is a method of control in which the subject does not know whether they received the treatment or not. This is used to allow for or eliminate the influence of the *placebo effect*. The placebo effect is a phenomenon that occurs when a person thinks they are getting a treatment and as a result, the response variable is affected. (1 out of every 3 people receiving a sugar pill report they feel better, even though it should have had no medical impact on the patient. As the book states on page 286, the placebo effect is especially strong with Parkinson's patients.)
- **Double Blind:** Neither the subject nor the experimenter is aware whether a particular subject has received the experimental treatment. This way the evaluator's judgment does not affect their interpretation of the results on a given subject.
- **Blocking:** Similar to Stratified sampling. We separate subjects into similar groups before administering the treatment. This allows changes between obvious delineation of groups to be eliminated from affecting the outcome of a study. Blocking reduces variation. If pooled together these groups may have large variations, but separating them into logical groups reduces the variation allowing us to more easily see the effect of the treatment. For example we may want to study a growth stimulate for humans. If we pooled men and women together, the height differences between men and women would create a large variation, so we separate the men and women, the separated groups will have a lower variation in height, this way a variation caused by the treatment will be more apparent. (*Important concept not mentioned in text*)