Part 3-Chapter 13	**Experiments and Observational Studies**
Observational study Retrospective Prospective	A study based on data in which no manipulation of factors has been employed (researchers don't assign choices). Usually focuses on estimating differences between groups but is not possible to demonstrate a causal relationship. Often used when an experiment is impractical. Subjects are selected and then their previous conditions or behaviors are determined. Subjects are followed to observe future outcomes. No treatments are deliberately applied.
To prove a cause-and-effect relationship we need to perform ___________	a valid experiment.

An experiment ______________ to create treatments, __________ to these treatment levels, and then ________________________ across treatment levels.	manipulates factor levels randomly assigns subjects compares the responses of the subject groups (boxplots are often a good choice for displaying results of groups)
Factor	A variable whose levels are controlled by the experimenter.
Level	The specific values that the experimenter chooses for a factor.
Treatment(s)	The process, intervention, or other controlled circumstance applied to randomly assigned experimental units. They are the different levels of a single factor or are made up of combinations of levels of two or more factors.
_____ are individuals on whom an experiment is performed. Usually called ___________ or ___________ when human.	Experimental units Subjects Participants
Response	A variable whose values are compared across different treatments.
The 4 principals of experimental design:	1. **Control** sources of variation other than the factors we are testing by making conditions as similar as possible for all treatment groups. 2. **Randomize** subjects to treatments to even out effects that we cannot control. 3. **Replicate** over as many subjects as possible. Would like to get results from a representative sample of the population of interest. 4. **Block** and then randomize within to reduce the effects of identifiable attributes of the subjects that cannot be controlled.
Control group	The experimental units assigned to a baseline treatment level, typically either the default treatment, which is well understood, or a null, placebo treatment. Their responses provide a basis for comparison.
Statistically significant	When an observed difference is too large for us to believe that it is likely to have occurred naturally (only by chance).

If we are to infer causation we must try to ensure that the only possible explanation for the difference in outcomes is the difference in treatments. We control every source of variation we can think of. We use a control group to help insure that some other unnoticed factor might be confounding the outcome. We randomize to equalize unknown sources of variation. If we cannot control something important (like gender) we can at least block to reduce the variability. And we replicate to have as much data as possible, leaving us less at the mercy of some unusual and unknown issue present in a few subjects.

When our objective is to learn something about a population we must start with a random sample of that population [Sampling]. When our objective is to see if there is a difference in the effects of two treatments we use available subjects and divide them randomly into groups [Experimentation]. At other times we just use an existing situation, neither choosing subjects at random nor imposing treatments [Observational Studies]. These are all very different situations.

Only when we have a random sample of a population can we generalize the findings of our study to the entire population. A well-designed experiment can tell us that a certain treatment caused a certain response in our group of subjects, something a sample or an observational study can never do. Such experiments may require replication on several other groups of subjects before the results are generalized, though. And while observational studies can be useful, they are in many ways the worst of both worlds. They are neither based on random samples nor do they randomly imposed treatments. The results then cannot be generalized across the population nor can they be attributed to cause-and-effect. While there are many circumstances where observational studies provide us the best information we have, at best they can suggest the existence of an association between two variables.