Example 10-1: Handwriting
An article about handwriting appeared in the October 11, 2006 issue of the *Washington Post*. The article mentioned that among students who took the essay portion of the SAT exam in 2005-6, those who wrote in cursive style scored significantly higher on the essay, on average, than students who used printed block letters.

a) Identify the observational units in this study, as well as the explanatory and response variables. Also classify each variable as categorical (also binary?) or quantitative.

   Observational units:

   Explanatory variable:       Type:
   Response variable:          Type:

b) Is it reasonable to conclude that using a cursive writing style *caused* higher scores on the essay, or can you think of an alternative explanation for why students who wrote in cursive style scored higher on average than students who write with block letters? In other words, can you think of other ways in which the cursive and block letter groups might have systematically differed?

The same *Washington Post* article also mentioned a different study in which the identical essay was shown to many graders, but some graders were randomly chosen to see a cursive version of the essay and the other graders were shown a version with printed block letters. The average score assigned to the essay with the cursive style was significantly higher than the average score assigned to the essay with the printed block letters.

c) How does this study differ from the original one? Explain.
d) Can you legitimately draw a different conclusion from this study as compared to the original study? Explain.

- An experiment is a study in which the experimenter actively imposes the explanatory variable group on the subjects (observational units).
  - The explanatory variable group is called a treatment.
- Random assignment gives each subject an equal chance of being assigned to any of the treatment groups.
  - This creates treatment groups that are similar in all respects other than the explanatory variable.
  - So if the groups differ significantly on the response variable, the researcher can legitimately draw a cause-and-effect conclusion between the explanatory and response variables.

Two crucial questions to ask of any statistical investigation:
- To what population can we reasonably generalize the results of this study?
- Can we reasonably draw a cause-and-effect connection between the explanatory variable and the response variable?

Ideal studies make use of two kinds of randomness to address these questions:
- Random sampling from the population allows for generalizing results from the sample to the larger population.
- Random assignment to treatment groups permits cause-and-effect conclusions to be drawn.

**Example 10-2: Back Pain**
In a recent study 15 patients suffering from severe back pain were given botox. After several weeks 9 of the patients reported a substantial decrease in pain.

- a) Would you conclude that botox is an effective treatment for causing a reduction in back pain? Explain.
b) How would you design an experiment to provide a better test of the drug?

Example 10-3: Bonus Income
An article in a 2006 issue of *Journal of Behavioral Decision Making* reports on a study involving 47 undergraduate students at Harvard. All of the participants were given $50, but some were told that this was a “tuition rebate” while others were told that this was “bonus income.” Random assignment determined what each student was told. After one week, the students were contacted again and asked how much of the $50 they had spent and how much they had saved. Those in the “rebate” group had spent an average of $22.04, while those in the “bonus” group had spent an average of $9.55.

a) Identify the observational units and variables in this study.

   Observational units:

   Explanatory variable:     Type:

   Response variable:     Type:

b) Is this an observational study or an experiment? Explain.

c) Does this study involve random sampling, random assignment, both, or neither?

d) Is it legitimate to draw a cause-and-effect conclusion in this study? If so, between what and what? Explain.

e) How broadly would you be willing to generalize the results of this study? Explain.
Example 10-4: AZT for HIV
One of the first studies aimed at preventing maternal transmission of AIDS to infants gave the drug AZT to pregnant, HIV-infected women in 1993. Roughly half of the women were randomly assigned to receive the drug AZT, and the others received a placebo. The HIV-infection status came to be known for 363 babies, 180 from the AZT group and 183 from the placebo group. Of the 180 babies whose mothers had received AZT, 13 were HIV-infected, compared to 40 of the 183 babies in the placebo group.

a) Is this an observational study or an experiment?

b) Identify the explanatory and response variables.

c) Why is it important that the subjects not know which treatment group they are in?

- An experiment employs blindness if subjects do not know which treatment group they are in.

d) Organize the data into a 2×2 table of counts, with the explanatory variable groups in columns.

e) Calculate the proportions of HIV+ babies in each group. Also produce a segmented bar graph.

f) Calculate the relative risk of having an HIV+ baby, comparing the placebo group to the AZT group.
g) Does it appear that AZT is helpful? Justify your answer.

h) How would you justify the importance of the placebo group, after the experiment concluded, to the mothers in the control group?

**Example 10-5: Meditation and Blood Pressure**

To study whether meditation can reduce blood pressure, researchers randomly assigned subjects either to a group that practiced meditation for an hour every day or to a control group that was simply told to relax more. The subjects’ blood pressure measurements were taken prior to the beginning of the study and at the end of one month.

a) Is it possible for the subjects in this study to be blind as to which treatment they receive?

b) Why should those taking the blood pressure measurements be blind as to which treatment group the subject is in?

- An experiment is **double-blind** if neither the subjects nor the people who work with them know which treatment each subject is receiving.

**Example 10-6: Memory Study**

You will be asked to study a sequence of letters for 20 seconds and then to write down as many as you can remember, in order. Your score will be the number that you remember correctly before your first error of any kind.
a) Is this an observational study or an experiment? Explain.

b) Identify the explanatory and response variables.

c) How was the assignment of treatments to subjects carried out? How is this relevant to the issue of confounding variables?

d) How did this study control for the concern that some students are better memorizers than others?

e) Did this study make use of blindness? Explain.

f) Put a dot on graph on the board corresponding to your result. Do the graphs suggest that the two “treatment” groups tended to produce different responses? Explain.

g) If further analysis reveals that the differences between the two groups are “statistically significant,” meaning that they are unlikely to occur by random variation if there were no underlying difference between the groups, would you have reason to conclude that one treatment caused lower/higher performance on the task? Explain.