Section I: Observational Studies

You can learn a lot just by watching. That's the idea of an observational study. If you want to know how often people wash their hands after using the bathroom, don't ask them! Observe them. As we saw in the Introduction, what people say and what they actually do can be quite different. But be sure to keep in mind the old adage: "The observer influences the observed." Merely having an observer present in the restroom might affect the percent of people who wash their hands.

In her book, *The Female Brain*, Dr. Louann Brizendine claimed that women talk almost three times as much as men. Some researchers at the University of Arizona were skeptical, so they designed an observational study to examine this claim. About 400 male and female college students participated in the study. The students wore specially designed recording equipment that turned on automatically at pre-set intervals over several days without the students' knowledge. Researchers then counted words used by the male and female participants. Their findings? Both males and females tended to speak an average of about 16,000 words per day. Dr. Brizendine later admitted that her claim had little factual basis.

Let's consider one further example from industry. Suppose you are in charge of quality control at a factory that produces potato chips. Imagine a string of thousands of very similar looking chips moving one behind the other down a conveyor belt, hour after hour, day after day. At some point in the process, salt is added to each chip. How can you be sure that the chips your factory is producing today don't contain too much or too little salt? Do you have to measure the salt content of every potato chip made today? Of course not. It isn't practical to observe every chip. Even if it were, you wouldn't choose to do that, because measuring the amount of salt on a chip actually destroys the chip. If you examined the salt content of every chip produced that day, you'd have no potato chips left to sell! What should you do instead? Select a sample of chips from that day's production and measure the salt content of the chips in the sample.

The potato chip example reminds us of an issue that was discussed briefly in the Introduction. If we want to get information about some characteristic of a population, such as the salt content of the potato chips produced today, we often tend to measure that characteristic on a sample of individuals chosen from the population of interest. We'd like to draw conclusions about the population based on results from the sample. To generalize from sample to population in this way, we need to know that the sample is representative of the population as a whole.

Suppose you measured the salt content of the last 100 potato chips produced at the factory today and found that the chips were generally too salty. Should you conclude that the entire batch of chips produced today is too salty? Not necessarily. Something may have happened during the last hour of production that affected the saltiness of the chips made at the end of the day. The last 100 chips produced may not be a representative sample from the population of today's potato chips.

So how do we get a representative sample? If we choose the first 100 potato chips, or the last 100, or even 100 chips "willy-nilly" off the conveyor belt, we may obtain a sample in which the chips tend to be consistently saltier than or less salty than the entire batch of chips produced that day. The best way to avoid this problem is to let chance select the sample. For example, you might choose one time "at random" in each of the 10 hours of production and measure the salt content of the next 10 potato chips that pass a certain point on the conveyor belt at those times. This incorporates **random selection** into the way the sample is chosen.

Random selection involves using some sort of chance process—such as tossing a coin or rolling a die—to determine which individuals in a population are included in a sample. If the individuals are people, one simple method of random selection is to write people's names on identical slips of paper, put the slips of paper in a hat, mix them thoroughly, and then draw out one slip at a time until we have the number of individuals we want for our sample. An alternative would be to give each individual in the population a distinct number and use the "hat method" with this collection of numbers, instead of people's names. Notice that this variation would work just as well if the individuals in the population were animals or things instead of people.

The hat method works fine if the population isn't too large. If there are too many individuals in the population, however, we would need a very big hat and many small slips of paper. In such cases, it would be easier to "pretend" that we're using the hat method, but to choose the numbers in a more efficient (but equivalent) way.

Technology is the answer. Computers and many calculators have the ability to select numbers "at random" within a specified range, just like drawing the numbers out of a hat. These devices can generate many numbers at random in a short period of time.

Many statistics textbooks contain entire pages filled with rows of "random digits"—numbers from 0 to 9 generated at random using technology. Such tables of random digits were especially useful before the invention of graphing calculators. Here are four rows of random digits that might appear in such a table:

5 2 7 1 1	3 8 8 8 9	9 3 0 7 4	6 0 2 2 7
4 0 0 1 1	8 5 8 4 8	4 8 7 6 7	5 2 5 7 3
9 5 5 9 2	9 4 0 0 7	6 9 9 7 1	9 1 4 8 1
6 0 7 7 9	5 3 7 9 1	1 7 2 9 7	5 9 3 3 5

Now let's consider an example. Kayla wants to conduct an observational study investigating the average number of contacts stored in teenagers' cell phones. She decides to restrict her attention to seniors, most of whom have cell phones. There are 780 seniors in her high school. How might Kayla use random selection to choose a sample of 30 seniors to participate in the cell phone study?

It would be tedious to write 780 names on slips of paper, so Kayla decides to pretend that she's using the hat method. After getting an alphabetized list of the school's seniors from the office, Kayla numbers the students from 1 to 780 in alphabetical order. To choose 30 seniors at random, Kayla can then use either a random digits table or a random number generator.

Random digits table: To use a random digits table, Kayla could look at groups of three digits, which could range from `000` to `999`. If she lets `001` correspond to student 1 on the list, `002` correspond to student 2, and so forth, then `780` would correspond to student 780, the last senior on the list. Numbers `781, 782, …, 000` would not correspond to any of the students on the list. By starting at the left-hand side of a row in the table and reading across three digits at a time, Kayla would continue until she had chosen 30 distinct numbers between `001` and `780`. The corresponding seniors would be the chosen sample.

Using the lines of random digits on the previous page, for example,

5 2 7 **1 1**	**3** 8 8 8 **9**	**9 3** 0 7 4	**6 0 2** 2 7
4 **0 0 1** 1	8 5 **8 4 8**	4 8 7 **6 7**	**5** 2 5 7 **3**
9 5 5 9 2	**9 4 0** 0 7	6 **9 9 7** 1	9 1 **4 8 1**
6 0 7 **7 9**	**5** 3 7 9 **1**	**1 7** 2 9 7	**5 9 3** 3 5

the senior numbered `527` would be chosen first, and the senior numbered `113` would be selected second. Kayla would skip the numbers `888` and `993` because they don't correspond to any seniors, and so on. Continuing likewise, the first 10 students in the sample would be the seniors numbered `527, 113, 074, 602, 274, 001, 185, 487, 675,` and `257`. The eleventh student selected would be the senior numbered `395`. Do you see why?

Random number generator: Kayla could also use her calculator or computer to generate a "random integer" from 1 to 780. She would repeat this until she got 30 distinct numbers from 1 to 780. The seniors on the alphabetized list with the corresponding numbers would be the chosen sample.

In this example, Kayla entered the command `randInt(1,780)` on a TI-84 calculator and pressed ENTER several times to repeat the command. The first ten resulting numbers were `718, 512, 653, 416, 190, 89, 689, 519, 470`, and `44`. So the seniors with these numbers would be included in her sample.

Random Integer Generator

Here are your random numbers:

741	72	355	297	755
559	398	629	47	310
536	304	752	397	483
388	405	149	634	699
739	152	721	516	640
293	589	714	771	566

We used the "random integer generator" at *www.random.org* as an alternative and came up with the numbers here.

If random selection is accomplished by using the hat method or mimicking it with random numbers, the resulting sample is called a **random sample**. To be classified as a random sample, the *n* selected individuals must have been chosen by a method that ensures:

(1) each individual in the population has an equal chance to be included in the sample

(2) each group of *n* individuals in the population is equally likely to be chosen as the sample

In the cell phone study example, Kayla did obtain a random sample. Once she selected the students for her observational study, it might have been quite difficult for Kayla to locate the 30 seniors who were chosen in a school with so many students, however. For practical reasons, Kayla might have used a method of random selection that didn't result in a truly random sample.

If, for example, the 780 seniors were assigned to 30 homerooms of 26 seniors each based on their last names, Kayla might have decided to select one student at random from each homeroom for her cell phone study. Notice that this alternative method of random selection does give each senior in Kayla's school an equal chance to be included in the sample, but it does not give every group of 30 seniors an equal chance to actually be chosen as the sample. In fact, with this method, the chance of getting a sample with two or more students from the same homeroom is zero!

Think back to the potato chip example for a minute. Can you imagine how difficult it would be to take a random sample from all of the potato chips produced in one day? Just picture someone numbering the individual potato chips for starters! It would be much more feasible to select, say, 10 consecutive potato chips from a particular spot on the conveyor belt by choosing a time at random during each hour of production.

Some observational studies do not use random selection to select the individuals who participate. In the hand-washing study from the Introduction, for example, observers simply watched whoever happened to be in public restrooms at the time. Perhaps the kinds of people who use public restrooms at sporting events, in museums or aquariums, and in train stations have different hand-washing habits than the population of adults as a whole.

The researchers from the University of Arizona used volunteer college students from the United States and Mexico in their observational study of talking patterns by gender. Because of the way in which their sample was chosen, their conclusion about male and female talking tendencies wouldn't necessarily apply to older adults or to college students from other countries. In fact, the results might not even extend to all college students, since some—perhaps those who talk a lot—might have refused to participate in the study. Lack of random selection limits our ability to generalize from the sample to a larger population of interest.

In the investigations that follow, you will learn more about designing and analyzing results from observational studies. You will see firsthand how the presence or absence of random selection affects our ability to generalize.

Investigation #2: Get Your Hot Dogs Here!

If baseball is America's game, then hot dogs are America's food. Whether you are at a sporting event, a backyard barbecue, or even a local convenience store, you are bound to see folks wolfing down frankfurters. Why do so many people like to eat hot dogs? For the yummy taste, of course! But what makes hot dogs taste so good? Unfortunately for health-conscious eaters, it's probably the fat and sodium they contain. Not all hot dogs are created equal, however. Some are made from beef, others from poultry, and still others from a combination of meats. With so many varieties available, can hot dog lovers find a healthy option that still tastes great?

Several years ago, Consumers Union, an independent nonprofit organization, tested 54 brands of beef, meat, and poultry hot dogs. For each brand tested, they recorded calories, sodium, cost per ounce, a protein-to-fat rating, and an overall sensory rating that included taste, texture, and appearance. The table below and those on the following two pages summarize some of their findings, which were published in *Consumer Reports*.[1] Note that the hot dogs are categorized by type—meat, beef, and poultry.

Meat Hot Dogs

Brand	Protein-to-Fat	Calories per Frank	Sodium per Frank (mg)	Overall Sensory Rating
Armour Hot Dogs	Poor	146	387	Average
Ball Park	Poor	182	473	Above Avg.
Bryan Juicy Jumbos	Poor	175	507	Average
Eat Slim Veal	Average	107	144	Average
Eckrich Jumbo	Poor	179	405	Average
Eckrich Lean Supreme Jumbo	Average	136	393	Average
Farmer John Wieners	Below Avg.	139	386	Average
Hormel 8 Big	Below Avg.	173	458	Above Avg.
Hygrade's Hot Dogs	Poor	195	511	Average
John Morrell	Poor	153	372	Average
Kahn's Jumbo	Poor	191	506	Above Avg.
Kroger Jumbo Dinner	Poor	190	545	Above Avg.
Oscar Mayer Wieners	Poor	147	360	Above Avg.
Safeway Our Premium	Below Avg.	172	496	Above Avg.
Scotch Buy with Chicken & Beef	Poor	135	405	Below Avg.
Smok-A-Roma Natural Smoke	Poor	138	339	Below Avg.
Wilson	Poor	140	428	Below Avg.

1 "Hot dogs: There's not much good about them except the way they taste," *Consumer Reports*, June 1986.

Beef Hot Dogs

Brand	Protein-to-Fat	Calories per Frank	Sodium per Frank (mg)	Overall Sensory Rating
A & P Skinless Beef	Poor	157	440	Average
Armour Beef Hot Dogs	Poor	149	319	Average
Best's Kosher Beef	Below Avg.	131	317	Average
Best's Kosher Beef Lower Fat	Average	111	300	Average
Eckrich Beef	Poor	149	322	Average
Hebrew National Kosher Beef	Poor	152	330	Average
Hygrade's Beef	Poor	190	645	Average
John Morrell Jumbo Beef	Poor	184	482	Average
Kahn's Jumbo Beef	Poor	175	479	Average
Kroger Jumbo Dinner Beef	Poor	190	587	Average
Mogen David Kosher Skinless Beef	Below Avg.	139	322	Average
Nathan's Famous Skinless Beef	Below Avg.	181	477	Above Avg.
Oscar Mayer Beef	Poor	148	375	Average
Safeway Our Premium Beef	Poor	176	425	Above Avg.
Shofar Kosher Beef	Below Avg.	158	370	Average
Sinai 48 Kosher Beef	Below Avg.	132	253	Below Avg.
Smok-A-Roma Natural Smoke	Below Avg.	141	386	Average
Thorn Apple Valley Brand	Poor	186	495	Above Avg.
Vienna Beef	Below Avg.	135	298	Average
Wilson Beef	Poor	153	401	Average

Poultry Hot Dogs

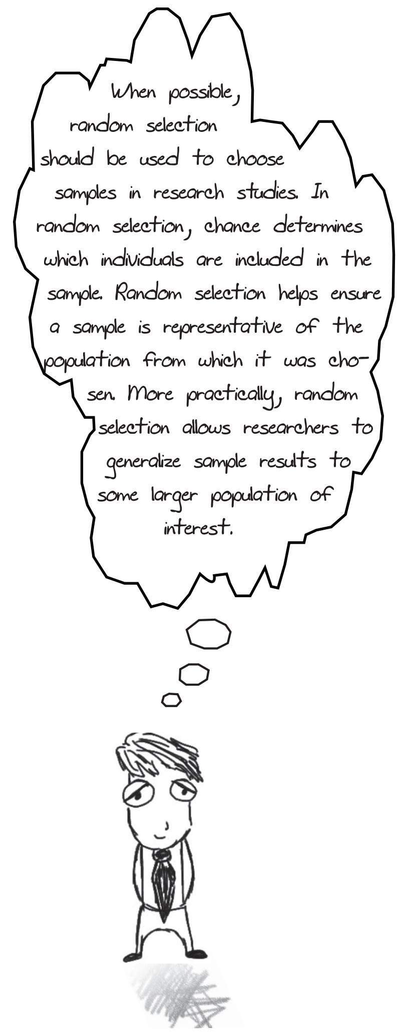
Brand	Protein-to-Fat	Calories per Frank	Sodium per Frank (mg)	Overall Sensory Rating
Foster Farms Jumbo Chicken	Below Avg.	170	528	Average
Gwaltney's Great Dogs Chicken	Below Avg.	152	588	Average
Holly Farms 8 Chicken	Below Avg.	146	522	Average
Hygrade's Grillmaster Chicken	Average	142	513	Average
Kroger Turkey	Excellent	102	542	Average
Longacre Family Chicken	Above Avg.	135	426	Average
Longacre Family Turkey	Above Avg.	94	387	Average
Louis Rich Turkey	Average	106	383	Average
Manor House Chicken (Safeway)	Average	86	358	Average
Manor House Turkey (Safeway)	Excellent	113	513	Average
Mr. Turkey	Average	102	396	Average
Perdue Chicken	Average	143	581	Average
Shenandoah Turkey Lower Fat	Above Avg.	99	357	Average
Shorgood Chicken	Below Avg.	132	375	Average
Tyson Butcher's Best Chicken	Average	144	545	Below Avg.
Weaver Chicken	Below Avg.	129	430	Above Avg.
Weight Watchers Turkey	Excellent	87	359	Average

The *Consumer Reports* article did not provide many details about how the hot dog data were produced. Our best guess is that Consumers Union first obtained one package of each of the 54 brands of hot dogs they intended to test. For each brand, they could then determine the protein-to-fat rating and the calories and sodium per frank from information provided on the package. To prepare the hot dogs for taste testing, Consumers Union cooked each frankfurter in boiling water.

1. Did Consumers Union produce these data using a survey, an experiment, or an observational study? Justify your answer.

2. According to the data table, Oscar Mayer beef hot dogs have 148 calories per frank. Does this mean that *every* Oscar Mayer beef hot dog has exactly 148 calories, or is there some variability in calorie count from frank to frank? Explain.

3. Why didn't Consumers Union cook some hot dogs in the microwave, others on a grill, and the rest in boiling water?



4. For the taste testing, would it have been better to rate one hot dog of each brand, or to get an average sensory rating for several hot dogs of each brand? Why?

5. It is possible that someone from Consumers Union went to one grocery store in a particular city and picked up one easy-to-reach packet of each brand of hot dogs. Would this **convenience sampling** method result in a representative sample of each brand of hot dogs? Why or why not?

6. Suppose Consumers Union had used random selection to choose a package of Armour beef hot dogs from a single grocery store for testing. If they obtained an average sensory rating for all the hot dogs in the selected package, to what population could they generalize their results—all Armour beef hot dogs ever produced, all Armour beef hot dogs that have ever been sent to this store, or all Armour beef hot dogs in this store at the time the sample was chosen? Justify your answer.

In this study, Consumers Union recorded several variables for each brand of hot dog, including type of hot dog, protein-to-fat rating, calories, sodium, and sensory rating. Two of these are **quantitative variables**—calories and sodium. Type of hot dog, protein-to-fat rating, and sensory rating are **categorical variables**. When we analyze data, the types of graphs and numerical summaries we should use are determined by the type of data we are analyzing. We begin by examining two of the categorical variables: type of hot dog and protein-to-fat rating.

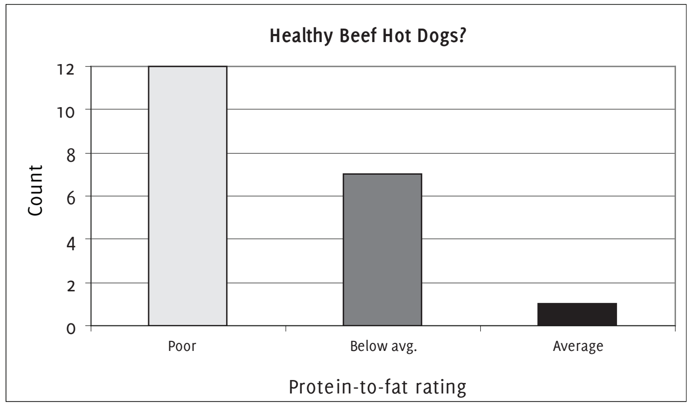
7. Here is a **two-way table** that summarizes the protein-to-fat ratings by type of hot dog.

		Type of Hot Dog		
Protein-to-Fat Rating		Beef	Meat	Poultry
	Poor	12	12	0
	Below Avg.	7	3	5
	Average	1	2	6
	Above Avg.	0	0	3
	Excellent	0	0	3

(a) What percent of hot dogs with a below average protein-to-fat rating were made from poultry?

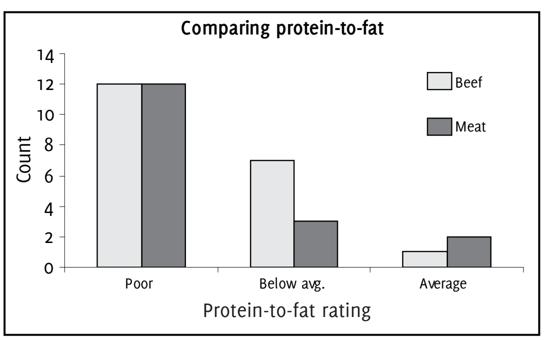
(b) What percent of poultry hot dogs had below average protein-to-fat ratings?

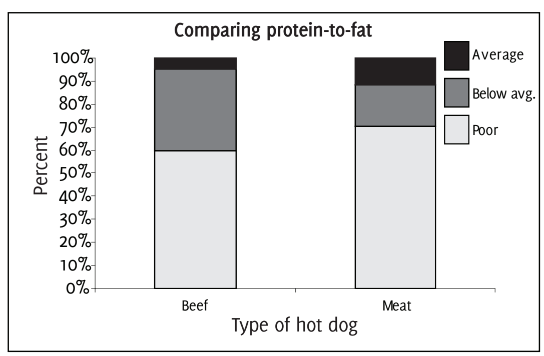
8. Here is an Excel bar graph of the protein-to-fat rating data for the beef hot dogs.



Describe what the graph tells you about protein-to-fat ratings in beef hot dogs.

9. Two Excel bar graphs that could be used for comparing the protein-to-fat ratings for beef and meat hot dogs are displayed below.

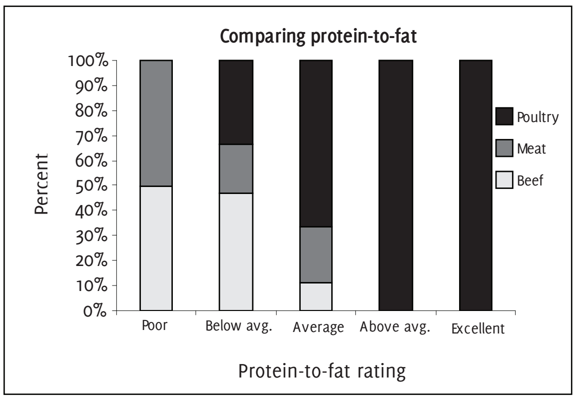


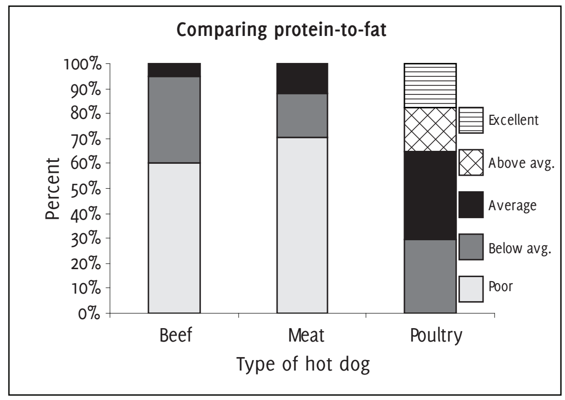


(a) Which graph is more appropriate for making this comparison? Explain.

(b) Write a few sentences comparing protein-to-fat ratings for beef and meat hot dogs.

10. Two different bar graphs that could be used for comparing the protein-to-fat ratings for all three types of hot dogs are displayed below.



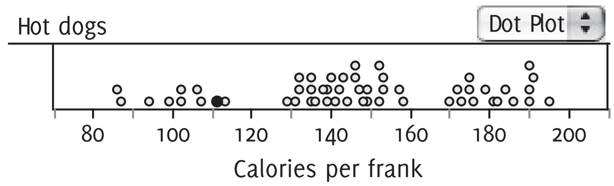


(a) Which graph is more appropriate for making this comparison? Explain.

(b) In terms of protein-to-fat ratings, which type of hot dogs is healthiest? Justify your answer with appropriate graphical and numerical evidence.

Now let's look at the calorie content for different brands of hot dogs.

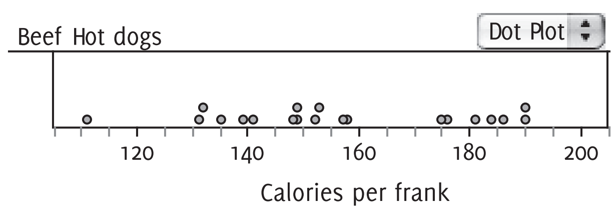
11. A dotplot of the calorie data for all 54 brands of hot dogs is shown below.



(a) Why do you think this distribution has three distinct clusters? Check whether your hunch is accurate.

(b) Identify the brand and type of hot dog for the highlighted point.

12. A dotplot of the calorie content for the 20 brands of beef hot dogs is shown below. Describe the interesting features of this distribution.



13. How does the calorie content of beef and meat hot dogs compare? A partially completed back-to-back stemplot of the calorie data for these two types of hot dogs is shown below.

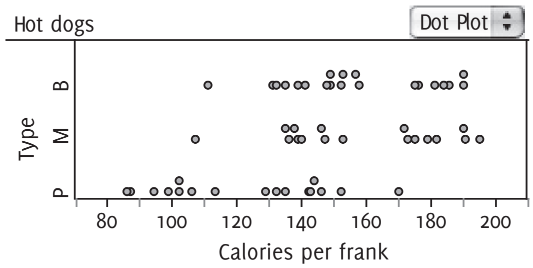
```
Meat          Beef

        |10|
        |11| 1
        |12|
        |13| 1 2 5 9
        |14| 1 8 9 9
        |15| 2 3 7 8
        |16|
        |17| 5 6
        |18| 1 4 6
        |19| 0 0
```

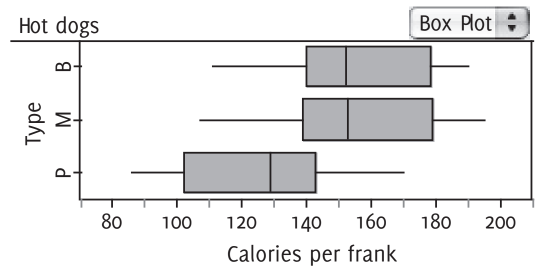
Key: 13| 1 means this brand advertises 131 calories per frank

(a) Add the calorie data for the meat hot dogs to the stemplot. Note that in a back-to-back stemplot, the "leaves" increase in value as you move away from the "stem" in the center of the graph.

(b) Comment on any similarities and differences in the distributions of calories per frank for these two types of hot dogs. Be sure to address center, shape, and spread, as well as any unusual values.

14. To compare calories per frank for all three types of hot dogs, we used computer software to construct graphs and numerical summaries.





Descriptive Statistics: Calories per Frank by Type

Variable	Type	N	Mean	Median	TrMean	StDev
Calories	B	20	156.85	152.50	157.56	22.64
	M	17	158.71	153.00	159.73	25.24
	P	17	122.47	129.00	121.73	25.48
Variable	**Type**	**SE Mean**	**Minimum**	**Maximum**	**Q1**	**Q3**
Calories	B	5.06	111.00	190.00	139.50	179.75
	M	6.12	107.00	195.00	138.50	180.50
	P	6.18	86.00	170.00	100.50	143.50

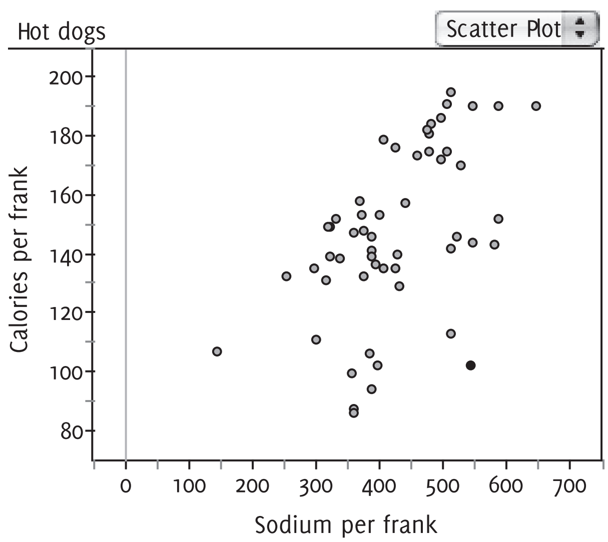
(a) Describe one advantage of using the dotplot instead of the boxplot to display these data.

(b) Describe one advantage of using the boxplot instead of the dotplot to display these data.

(c) How do beef, meat, and poultry hot dogs compare in terms of calorie content? Justify your answer using appropriate graphical and numerical information.

Research Question: Is there a relationship between the calorie content and the amount of sodium per frank in these brands of hot dogs?

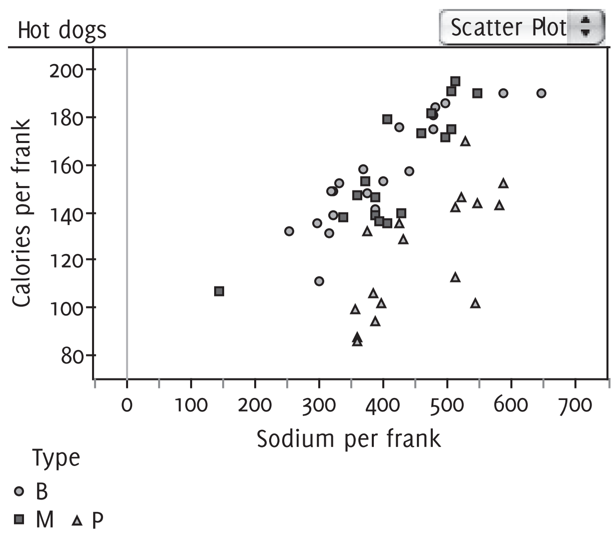
15. The scatterplot below summarizes the sodium and calorie data for the 54 brands of hot dogs in the Consumers Union study.



(a) Describe any interesting features of the scatterplot in the context of this study.

(b) What is unusual about the highlighted point in the scatterplot on the previous page?

Here is another scatterplot of the sodium and calorie data with the type of hot dog identified.



(c) What more can you say about the relationship between sodium and calories per frank when type of hot dog is considered?

16. The next two displays show some numerical summaries of the calorie and sodium data.

Hot dogs

	Calories per frank	Sodium per frank (mg)
	146.611 29.0773	424.833 95.8564

S1 = mean ( )
S2 = stdDev ( )

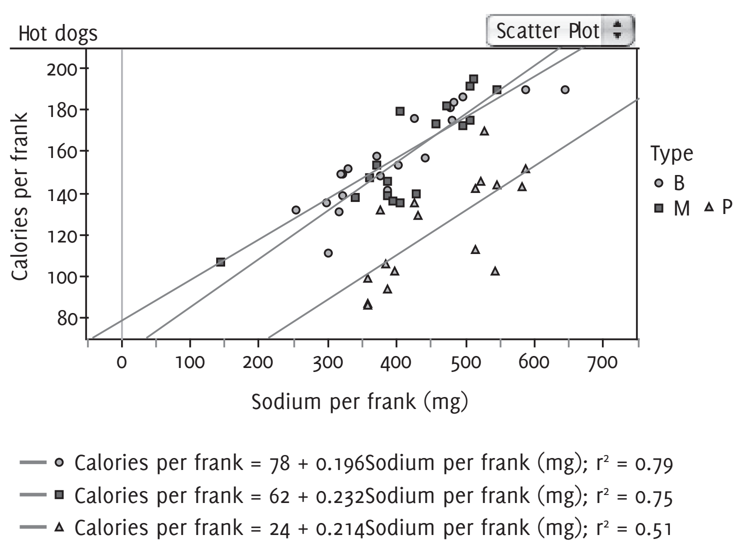
Hot dogs

	Calories per frank
Sodium per frank (mg)	0.516054

S1 = correlation ( )

(a) What additional information about the relationship between sodium and calorie content of hot dogs do these numerical summaries provide?

The graph below includes three summary lines—one describing the relationship for each type of hot dog.



(b) Interpret the slope and the *y*-intercept of the summary line for beef hot dogs.

(c) Suppose Consumers Union had chosen another brand of meat hot dog, beef hot dog, and poultry hot dog, each having 300 milligrams of sodium per frank. What would you predict for the calories per frank in each case? Explain how you made your prediction.

(d) Based on the graph on the previous page, which of the predictions in the previous question do you think would be most accurate? Explain.

17. In the Consumers Union study, beef hot dogs had a mean calorie content of 156.85 calories per frank, compared to 158.71 calories per frank for meat hot dogs and 122.47 calories per frank for poultry hot dogs. Would you feel comfortable generalizing this result about calorie content to the *population* of all brands of beef, meat, and poultry hot dogs? Why or why not?

18. What about the taste? Consumers Union gave an overall sensory rating, which included texture, taste, and appearance. The following table summarizes the ratings by type of hot dog.

		Sensory Rating		
Type of Hot Dog		Above Avg.	Average	Below Avg.
	Beef	3	16	1
	Meat	6	8	3
	Poultry	1	15	1

Which type of hot dog had the best overall sensory ratings? Prepare a brief report that includes graphical and numerical evidence to support your answer.

19. How salty are they? Which have more sodium per frank—beef, meat, or poultry hot dogs? Carry out an analysis that includes graphs and numerical summaries to help answer this question. Write a brief report that summarizes your analysis on a separate piece of paper.

Investigation #3: What's in a Name?

According to the *Seattle Times* (Oct. 5, 2003), there will be a lot of Jacobs and Emilys in the high-school graduating class of 2020—those were the most popular baby names in the United States in 2002 according to Social Security card applications.

It's nice to be popular, and great to be "cool." The authors of the book *Cool Names for Babies* (Satran, Pamela & Rosenkrantz, Linda, Harper Collins Publishers, 2004) say that it is the unusual names that are most cool.

In this activity, you will carry out an observational study to assess the popularity and coolness of your class based on the names of the students in class.

Getting Started

To complete this activity, you will need to use the Social Security Administration's Popular Baby Name web site. It can be found at *www.ssa.gov/OACT/babynames*.

On this site, you will be able to find lists of the 10 most popular baby names for boys and girls in each year starting in 1880. These lists were compiled using a random sample consisting of 1% of all babies born in a particular year who subsequently applied for a social security card. You will also find a list of the top 1,000 names for each decade from the 1900s to the 2000s.

Spend a few minutes familiarizing yourself with the information available on this web site. Then, start answering the questions that follow.

1. Let's start with an easy question! What is your first name?

2. Are you male or female?

3. In what year were you born?

4. Is your name one of the 10 most popular names for the year in which you were born?

5. Is your name one of the 10 most popular names for the most recent year for which data are available?

6. Is your name one of the most popular 1,000 for the decade in which you were born? If so, record your name's rank. If your name is not in the top 1,000, just record that your name is "cool"!

7. After each student in your class has answered questions 1–6, enter the data from the entire class into the following table.

First Name	Gender	Year Born	In Top 10 for Year Born? (Yes or No)	In Top 10 for Most Recent Year? (Yes or No)	Rank for Decade Born (1-1,000 or cool)

8. Is there a most common name for the class? If so, what is the most common name?

9. What is the most common year of birth for the class?

10. In the year that was the most common birth year for the class, what is the most popular name for boys according to the popular baby names web site? For girls? Does anyone in the class have these most popular names?

11. What proportion of the class has "cool" names?

12. Omitting the cool names from the data set, construct a graphical display that shows the distribution of the decade ranks data. How would you describe this distribution? (Comment on shape, center, spread, and any unusual values.)

13. What proportion of the class has names that were in the top 10 names for the year in which they were born?

14. Based on your answers to questions 11 and 13, is your class more popular or more "cool?"

15. What proportion of the class has names that are listed in the top 10 for the most recent year for which data are available?

16. Is the proportion from question 15 lower than, about the same as, or higher than the proportion from question 13? How does this suggest that the popularity of the class' names has changed over time?

17. What makes this study an observational study, rather than an experiment?

18. Was there random selection in the data collection for this study? How does this affect your ability to generalize from the study?

19. How might you modify this study if your goal was to generalize to all students at your school? To all high-school students in your school district? To all high-school students in your state?

Investigation #4: If the Shoe Fits . . .

Welcome to CSI at School. Over the weekend, a student entered the school grounds without permission. Even though it appears the culprit was just looking for a quiet place to study undisturbed by friends, school administrators are anxious to identify the offender and have asked for your help. The only available evidence is a suspicious footprint outside the library door.

In this activity, you will use data on shoe print length, height, and gender to help develop a tentative description of the person who entered the school.

After the incident, school administrators arranged for the data in the table below to be obtained from a random sample of this high school's students. The table shows the shoe print length (in cm), height (in inches), and gender for each individual in the sample.

Shoe Print Length	Height	Gender	Shoe Print Length	Height	Gender
24	71	F	24.5	68.5	F
32	74	M	22.5	59	F
27	65	F	29	74	M
26	64	F	24.5	61	F
25.5	64	F	25	66	F
30	65	M	37	72	M
31	71	M	27	67	F
29.5	67	M	32.5	70	M
29	72	F	27	66	F
25	63	F	27.5	65	F
27.5	72	F	25	62	F
25.5	64	F	31	69	M
27	67	F	32	72	M
31	69	M	27.4	67	F
26	64	F	30	71	M
27	67	F	25	67	F
28	67	F	26.5	65.5	F
26.5	64	F	27.25	67	F
22.5	61	F	30	70	F
			31	66	F

Use the data provided to answer the questions that follow.

1. Construct an appropriate graph for comparing the shoe print lengths for males and females.

2. Describe the similarities and differences in the shoe print length distributions for the males and females in this sample.

3. Explain why this study was an observational study and not an experiment.

4. Why do you think the school's administrators chose to collect data on a random sample of students from the school? What benefit might a random sample offer?

5. If the length of a student's shoe print was 32 cm, would you think the print was made by a male or a female? How sure are you that you are correct? Explain your reasoning.

6. How would you answer question 5 if the suspect's shoe print length was 27 cm? 29 cm?

7. Construct a scatterplot of height versus shoe print length using different colors or different plotting symbols to represent the data for males and females. Does it look like there is a linear relationship between height and shoe print length?

8. Does it look like the same straight line could be used to summarize the relationship between shoe print length and height for both males and females? Explain.

9. Based on the scatterplot, if a student's shoe print length was 30 cm, approximately what height would you predict for the person who made the shoe print? Explain how you arrived at your prediction.

10. The shoe print found outside the library actually had a length of 31 cm. Based on the given data and the analysis of questions 1–9, write a description of the person who you think may have left the print. Explain the reasoning that led to your description and give some indication of how confident you are that your description is correct.

Investigation #5: Buckle Up

Do you wear your seat belt when driving? Do most people? Is seat belt use changing over time? To answer questions such as these (well, at least the last two questions—only you know the answer to the first question, but we sure hope the answer is yes!), the National Center for Statistics and Analysis published data on seat belt use for 48 states. No data were available for New Hampshire or Wyoming.

The data shown in the table at the top of the next page are from a large-scale study conducted annually by the National Highway Traffic Safety Administration.[1] The study involves actual observation of drivers' seat belt use at a random selection of roadway sites in each state.

The table gives the percentage of drivers observed who used seat belts in 2004 and in 2005. The table also shows the change in seat belt use percentage from 2004 to 2005 (computed as 2005 use percentage – 2004 use percentage).

Use the data in the table to answer the following questions.

1. Would comparative dotplots or comparative boxplots be better for comparing the seat belt use rates for 2004 and 2005? Make the graph that you pick. Then write a sentence or two describing the similarities and differences in the seat belt use rate distributions in 2004 and 2005.

2. Construct an appropriate graph that shows the change in seat belt use by state from 2004 to 2005. Comment on any interesting features of the distribution.

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1 "Seat Belt Use in 2006—Use Rates in the States and Territories," Traffic Safety Facts, National Highway Traffic Safety Administration, January 2007.

State	2004 Use	2005 Use	Difference	State	2004 Use	2005 Use	Difference
Alabama	80	82	2	Missouri	76	77	1
Alaska	78	83	5	Montana	81	80	-1
Arizona	95	94	-1	Nebraska	79	79	0
Arkansas	64	68	4	Nevada	87	95	8
California	90	93	3	New Jersey	82	86	4
Colorado	79	79	0	New Mexico	90	90	0
Connecticut	83	82	-1	New York	85	85	0
Delaware	82	84	2	No. Carolina	86	87	1
Florida	76	74	-2	North Dakota	67	76	9
Georgia	87	90	3	Ohio	74	79	5
Hawaii	95	95	0	Oklahoma	80	83	3
Idaho	74	76	2	Oregon	93	93	0
Illinois	83	86	3	Pennsylvania	82	83	1
Indiana	83	81	-2	Rhode Island	76	75	-1
Iowa	86	87	1	So. Carolina	66	70	4
Kansas	68	69	1	South Dakota	69	69	0
Kentucky	66	67	1	Tennessee	72	74	2
Louisiana	75	78	3	Texas	83	90	7
Maine	72	76	4	Utah	86	87	1
Maryland	89	91	2	Vermont	80	85	5
Massachusetts	63	65	2	Virginia	80	80	0
Michigan	91	93	2	Washington	94	95	1
Minnesota	82	84	2	West Virginia	76	85	9
Mississippi	63	61	-2	Wisconsin	72	73	1

3. In what way is the graph in question 2 more informative than the graph in question 1?

4. Did most states increase seat belt use from 2004 to 2005? What aspect of the graph you made in question 2 could be used to justify your answer?

5. Compute the mean and median change in seat belt use.

6. What aspect of the graph you made in question 2 explains the large difference between the mean and the median?

7. Would you recommend using the mean or the median to describe the seat belt use change data? Why?

8. Are there any states that stand out as unusual in this data set? If so, which states and what makes them unusual?

9. How did seat belt use in your state change from 2004 to 2005? Would you describe your state as typical with respect to seat belt use change? Explain. (If your state is one of the two states for which no data are given, choose a neighboring state and answer this question for that state.)

10. What makes this seat belt use study observational, rather than an experiment?

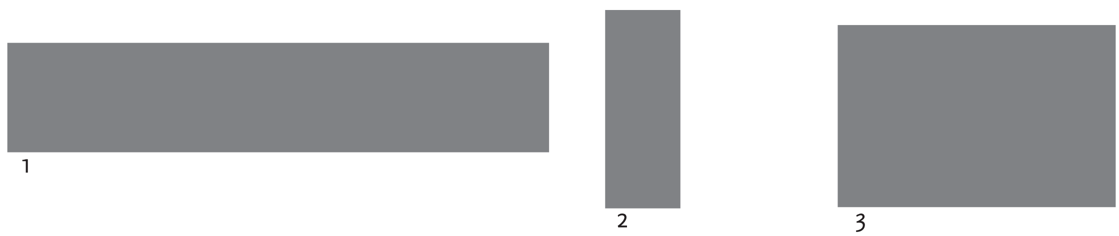
11. Why do you think the study was based on actual observation of drivers, rather than a survey of drivers asking if they use a seat belt when driving?

12. Based on the sampling method used in this study, do you think it would be reasonable to generalize the seat belt use results to drivers at all locations in a given state? Explain.

13. Write a brief summary report describing how seat belt use changed from 2004 to 2005. Include graphs and numerical summaries as appropriate.

Investigation #6: It's Golden (and It's Not Silence)

Which of the three rectangles shown here do you find the most pleasing?



If you picked the third one, you selected the "golden" rectangle. Because they are generally thought to be the most pleasing, golden rectangles are common in art, architecture, and even in the boxes designed for packaging products that are sold in grocery stores.

A rectangle is "golden" if the ratio of its longest side to its shortest side is approximately 1.618.

In this activity, you will design and carry out an observational study to determine if students at your school do, in fact, find golden rectangles more pleasing than other, less-golden ones.

Since the goal is to be able to generalize the study findings to all students at your school, the first thing to think about is how you will select the students who will participate in your study.

1. Describe a way to select study participants that would result in a random sample of students from your school. Don't worry at this point if your plan cannot be easily implemented—instead, focus on what it would take to get a true random sample of students at your school.

2. Do you think it would be possible to actually implement the plan you described in the previous question? Explain.

3. If it would not be possible to carry out the selection plan described in question 1, describe another sampling method that you think would result in a "representative" sample, but not a truly random sample, from your school. Explain why you think a sample selected in the way you propose here could be considered representative of the students at your school.

Now let's think about how you will collect data from the selected students in a way that will enable you to determine if students really do find golden rectangles more pleasing than nongolden rectangles.

4. In the space below, draw a few rectangles that are golden and several nongolden rectangles.

5. In this study, you will be showing the selected students some rectangles and asking which of the rectangles is most pleasing. How many rectangles will you have the selected students choose between? Why did you select this number?

6. Prepare a separate page containing the rectangles to be shown to your study participants.

After your teacher has approved the data collection plan and your page of rectangles, you can proceed to collect the data for your study.

7. Summarize your data in table form and construct an appropriate graphical display of the data.

8. Write a brief report on separate paper that addresses the question "Do students at your school find golden rectangles to be the most pleasing?" Use tables and graphs to support your conclusions.