showed up in the use of alcohol and marijuana, conviction of crimes, and teenage pregnancy.

2. The journal *Circulation* reported that among 1900 people who had heart attacks, those who drank an average of 19 cups of tea a week were 44% more likely than non-drinkers to survive at least 3 years after the attack.

3. Researchers at the Purina Pet Institute studied Labrador retrievers for evidence of a relationship between diet and longevity. At 8 weeks of age, 2 puppies of the same sex and weight were randomly assigned to one of two groups—a total of 48 dogs in all. One group was allowed to eat all they wanted, while the other group was fed a diet about 25% lower in calories. The median lifespan of dogs fed the restricted diet was 22 months longer than that of other dogs. (Science News 161, no. 19)
4. The radioactive gas radon, found in some homes, poses a health risk to residents. To assess the level of contamination in their area, a county health department wants to test a few homes. If the risk seems high, they will publicize the results to emphasize the need for home testing. Officials plan to use the local property tax list to randomly choose 25 homes from various areas of the county.

5. Almost 90,000 women participated in a 16-year study of the role of the vitamin folate in preventing colon cancer. Some of the women had family histories of colon cancer in close relatives. In this at-risk group, the incidence of colon cancer was cut in half among those who maintained a high folate intake. No such difference was observed in those with no family-based risk. (Science News, Feb. 9, 2002)

6. In the journal Science, a research team reported that plants in southern England are flowering earlier in the spring. Records of the first flowering dates for 385 species over a period of 47 years indicate that flowering has advanced an average of 15 days per decade, an indication of climate warming, according to the authors.

7. Fireworks manufacturers face a dilemma. They must be sure that the rockets work properly, but testing a rocket essentially destroys it. On the other hand, not testing the product leaves open the danger that they sell a bunch of duds, leading to unhappy customers and loss of future sales. The solution, of course, is to test a few of the rockets produced each day, assuming that if those tested work properly, the others are ready for sale.

8. Can makeup damage fetal development? Many cosmetics contain a class of chemicals called phthalates. Studies that exposed some laboratory animals to these chemicals found a heightened incidence of damage to male reproductive systems. Since traces of phthalates are found in the urine of women who use beauty products, there is growing concern that they may present a risk to male fetuses. (Science News, July 20, 2002)


10. Some doctors have expressed concern that men who have vasectomies seemed more likely to develop prostate cancer. Medical researchers used a national cancer registry to identify 923 men who had had prostate cancer and 1224 men of similar ages who had not. Roughly one quarter of the men in each group had undergone a vasectomy, many more than 25 years before the study. The study’s authors concluded that there is strong evidence that having the operation presents no long-term risk for developing prostate cancer. (Science News, July 20, 2002)

11. Researchers investigating appetite control as a means of losing weight found that female rats ate less and lost weight after injections of the hormone leptin, while male rats responded better to insulin. (Science News, July 20, 2002)

12. An artisan wants to create pottery that has the appearance of age. He prepares several samples of clay with four different glazes and test fires them in a kiln at three different temperature settings.

13. Tests of gene therapy on laboratory rats have raised hopes of stopping the degeneration of tissue that characterizes chronic heart failure. Researchers at the University of California, San Diego, used hamsters with cardiac disease, randomly assigning 30 to receive the gene therapy and leaving the other 28 untreated. Five weeks after treatment the gene therapy group’s heart muscles stabilized, while those of the untreated hamsters continued to weaken. (Science News, July 27, 2002)

14. Researchers at the University of Bristol (England) investigated reasons why different species of birds begin to sing at different times in the morning. They captured and examined birds of 57 species at seven different sites. They measured the diameter of the birds’ eyes and also recorded the time of day at which each species began to sing. These researchers reported a strong relationship between eye diameter and time of singing, saying that birds with bigger eyes tended to sing earlier. (Science News, 161, no. 16 [2002])

15. An orange-juice processing plant will accept a shipment of fruit only after several hundred oranges selected from various locations within the truck are carefully inspected. If too many show signs of unsuitability for juice (bruised, rotten, unripe, etc.), the whole truckload is rejected.

16. A soft-drink manufacturer must be sure the bottle caps on the soda are fully sealed and will not come off easily. Inspectors pull a few bottles off the production line at regular intervals and test the caps. If they detect any problems, they will stop the bottling process to adjust or repair the machine that caps the bottles.

17. Physically fit people seem less likely to die of cancer. A report in the May 2002 issue of Medicine and Science in Sports and Exercise followed 25,892 men aged 30 to 87 for 10 years. The most physically fit men had a 55% lower risk of death from cancer than the least fit group.

18. Does the use of computer software in Introductory Statistics classes lead to better understanding of the concepts? A professor teaching two sections of Statistics decides to investigate. She teaches both sections using the same lectures and assignments, but gives one class statistics software to help them with their homework. The classes take the same final exam, and graders do not know which students used computers during the semester. The professor is also concerned that students who have had calculus may perform differently from those who have not, so she plans to compare software vs. no-software scores separately for these two groups of students.

19. Point spread. When taking bets on sporting events, bookmakers often include a “point spread” that awards the weaker team extra points. In theory this makes the outcome of the bet a toss-up. Suppose a gambler places a $10 bet and picks the winners of five games. If he’s right about fewer than three of the games, he loses. If he gets three, four, or all five correct, he’s paid $10, $20, and $50, respectively. Estimate the amount such a bettor might expect to lose over many weeks of gambling.
20. **The lottery.** Many people spend a lot of money trying to win huge jackpots in state lotteries. Let’s play a simplified version using only the numbers from 1 to 20. You bet on three numbers. The state picks five winning numbers. If your three are all among the winners, you are rich!
   a) Simulate repeated plays. How long did it take you to win?
   b) In real lotteries, there are many more choices (often 54) and you must match all five winning numbers. Explain how these changes affect your chances of hitting the jackpot.

21. **Everyday randomness.** Aside from casinos, lotteries, and games, there are other situations you encounter in which something is described as “random” in some way. Give three different examples. Describe how randomness is (or is not) achieved in each.

22. **Cell phone risks.** Researchers at the Washington University School of Medicine randomly placed 480 rats into one of three chambers containing radio antennas. One group was exposed to digital cell phone radio waves, the second to analog cell phone waves, and the third group to no radio waves. Two years later the rats were examined for signs of brain tumors. In June 2002 the scientists said that differences among the three groups were not statistically significant.
   a) Is this a study or an experiment? Explain.
   b) Explain in this context what “not statistically significant” means.
   c) Comment on the fact that this research was funded by Motorola, a manufacturer of cell phones.

23. **Tips.** In restaurants, servers rely on tips as a major source of income. Does serving candy after the meal produce larger tips? To find out, two waiters determined randomly whether or not to give candy to 92 dining parties. They recorded the sizes of the tips and reported that guests getting candy tipped an average of 17.8% of the bill, compared with an average tip of only 15.1% from those who got no candy. (“Sweetening the Till: The Use of Candy to Increase Restaurant Tipping,” *Journal of Applied Social Psychology* 32, no. 2 [2002]: 300–309)
   a) Was this an experiment or an observational study? Explain.
   b) Is it reasonable to conclude that the candy caused guests to tip more? Explain.
   c) The researchers said the difference was statistically significant. Explain in this context what that means.

24. **Tips, take 2.** In another experiment to see if getting candy after a meal would induce customers to leave a bigger tip, a waitress randomly decided what to do with 80 dining parties. They recorded the sizes of the tips and reported that guests getting candy tipped an average of 17.8% of the bill, compared with an average tip of only 15.1% from those who got no candy. (“Sweetening the Till: The Use of Candy to Increase Restaurant Tipping,” *Journal of Applied Social Psychology* 32, no. 2 [2002]: 300–309)
   a) Diagram this experiment.
   b) How many factors are there? How many levels?
   c) How many treatments are there?
   d) What is the response variable?
   e) Did this experiment involve blinding? Double blinding?
   f) In what way might the waitress, perhaps unintentionally, have biased the results?

25. **Cloning.** In September 1998, *USA Weekend* magazine asked, “Should humans be cloned?” Readers were invited to vote “Yes” or “No” by calling one of two different 900 numbers. Based on 36,023 responses, the magazine reported that “9 out of 10 readers oppose cloning.”
   a) Explain why you think the conclusion is not justified. Describe the types of bias that may be present.
   b) Reword the question in a way that you think might create a more positive response.

26. **Laundry.** An experiment to test a new laundry detergent, SparkleKleen, is being conducted by a consumer advocacy group. They would like to compare its performance with that of a laboratory standard detergent they have used in previous experiments. They can stain 16 swatches of cloth with 2 tsp of a common staining compound and then use a well-calibrated optical scanner to detect the amount of the stain left after washing. To save time in the experiment, several suggestions have been made. Comment on the possible merits and drawbacks of each one.
   a) Since data for the laboratory standard detergent are already available from previous experiments, for this experiment wash all 16 swatches with SparkleKleen, and compare the results with the previous data.
   b) Use both detergents with eight separate runs each, but to save time, use only a 10-second wash time with very hot water.
   c) To ease bookkeeping, first run all of the standard detergent washes on eight swatches, then run all of the SparkleKleen washes on the other eight swatches.
   d) Rather than run the experiment, use data from the company that produced SparkleKleen, and compare them with past data from the standard detergent.

27. **When to stop?** You play a game that involves rolling a die. You can roll as many times as you want, and your score is the total for all the rolls. But ... if you roll a 6 your score is 0 and your turn is over. What might be a good strategy for a game like this?
   a) One of your opponents decides to roll 4 times, then stop (hoping not to get the dreaded 6 before then). Use a simulation to estimate his average score.
   b) Another opponent decides to roll until she gets at least 12 points, then stop. Use a simulation to estimate her average score.
   c) Propose another strategy that you would use to play this game. Using your strategy, simulate several turns. Do you think you would beat the two opponents?

28. **Rivets.** A company that manufactures rivets believes the shear strength of the rivets they manufacture follows a Normal model with a mean breaking strength of 950 pounds and a standard deviation of 40 pounds.
PART III  Gathering Data

29. Homecoming. A college Statistics class conducted a survey concerning community attitudes about the college’s large homecoming celebration. That survey drew its sample in the following manner: Telephone numbers were generated at random by selecting one of the local telephone exchanges (first three digits) at random and then generating a random four-digit number to follow the exchange. If a person answered the phone and the call was to a residence, then that person was taken to be the subject for interview. (Undergraduate students and those under voting age were excluded, as was anyone who could not speak English.) Calls were placed until a sample of 200 eligible respondents had been reached.

a) Did every telephone number that could occur in that community have an equal chance of being generated?
b) Did this method of generating telephone numbers result in a simple random sample (SRS) of local residences? Explain.
c) Did this method generate an SRS of local voters? Explain.
d) Is this method unbiased in generating samples of households? Explain.

30. Youthful appearance. Readers’ Digest reported results of several surveys that asked graduate students to examine photographs of men and women and try to guess their ages. Researchers compared these guesses with the number of times the people in the pictures reported having sexual intercourse. It turned out that those who had been more sexually active were judged as looking younger, and that the difference was described as “statistically significant.” Psychologist David Weeks, who compiled the research, speculated that lovemaking boosts hormones that “reduce fatty tissue and increase lean muscle, giving a more youthful appearance.”

a) What does “statistically significant” mean in this context?
b) Explain in statistical terms why you might be skeptical about Dr. Weeks’s conclusion. Propose an alternative explanation for these results.

31. Smoking and Alzheimer’s. Medical studies indicate that smokers are less likely to develop Alzheimer’s disease than people who never smoked.

a) Does this prove that smoking may offer some protection against Alzheimer’s? Explain.
b) Offer an alternative explanation for this association.
c) How would you conduct a study to investigate this?

32. Antacids. A researcher wants to compare the performance of three types of antacid in volunteers suffering from acid reflux disease. Because men and women may react differently to this medication, the subjects are split into two groups, by sex. Subjects in each group are randomly assigned to take one of the antacids or to take a sugar pill made to look the same. The subjects will rate their level of discomfort 30 minutes after eating.

a) What kind of design is this?
b) The experiment uses volunteers rather than a random sample of all people suffering from acid reflux disease. Does this make the results invalid? Explain.
c) How may the use of the placebo confound this experiment? Explain.

33. Sex and violence. Does the content of a television program affect viewers’ memory of the products advertised in commercials? Design an experiment to compare the ability of viewers to recall brand names of items featured in commercials during programs with violent content, sexual content, or neutral content.

34. Pubs. In England, a Leeds University researcher said that the local watering hole’s welcoming atmosphere helps men get rid of the stresses of modern life and is vital for their psychological well-being. Author of the report, Dr. Colin Gill, said rather than complain, women should encourage men to “pop out for a swift half.” “Pub-time allows men to bond with friends and colleagues,” he said. “Men need break-out time as much as women and are mentally healthier for it.” Gill added that men might feel unfulfilled or empty if they had not been to the pub for a week. The report, commissioned by alcohol-free beer brand Kaliber, surveyed 900 men on their reasons for going to the pub. More than 40% said they went for the conversation, relaxation and a friendly atmosphere being the other most common reasons. Only 1 in 10 listed alcohol as the overriding reason.

Let’s examine this news story from a statistical perspective.

a) What are the W’s: Who, What, When, Where, Why?
b) What population does the researcher think the study applies to?
c) What is the most important thing about the selection process that the article does not tell us?
d) How do you think the 900 respondents were selected? (Name a method of drawing a sample that is likely to have been used.)
e) Do you think the report that only 10% of respondents listed alcohol as an important reason for going to the pub might be a biased result? Why?

35. Age and party. The Gallup Poll conducted a representative telephone survey during the first quarter of 1999. Among its reported results was the following table concerning the preferred political party affiliation of respondents and their ages:

<table>
<thead>
<tr>
<th>Age</th>
<th>Republican</th>
<th>Democratic</th>
<th>Independent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–29</td>
<td>241</td>
<td>351</td>
<td>409</td>
<td>1001</td>
</tr>
<tr>
<td>30–49</td>
<td>299</td>
<td>330</td>
<td>370</td>
<td>999</td>
</tr>
<tr>
<td>50–64</td>
<td>282</td>
<td>341</td>
<td>375</td>
<td>998</td>
</tr>
<tr>
<td>65+</td>
<td>279</td>
<td>382</td>
<td>343</td>
<td>1004</td>
</tr>
<tr>
<td>Total</td>
<td>1101</td>
<td>1404</td>
<td>1497</td>
<td>4002</td>
</tr>
</tbody>
</table>

Let’s examine the news story from a statistical perspective:

a) What is the most important thing about this table?
b) How may the use of the placebo confound this experiment? Explain.
36. **Bias?** Political analyst Michael Barone has written that “conservatives are more likely than others to refuse to respond to polls, particularly those polls taken by media outlets that conservatives consider biased” (*The Weekly Standard*, March 10, 1997). The Pew Research Foundation tested this assertion by asking the same questions in a national survey run by standard methods and in a more rigorous survey that was a true SRS with careful follow-up to encourage participation. The response rate in the “standard survey” was 42%. The response rate in the “rigorous survey” was 71%.

a) What kind of bias does Barone claim may exist in polls?
b) What is the population for these surveys?
c) Do you think this is a good estimate of the percentage of voters in the United States who are registered Democrats? Why or why not?
d) In creating this sample design, what question do you think the pollsters were trying to answer?

d) The Pew researchers report the following table:

<table>
<thead>
<tr>
<th>Political Position</th>
<th>Standard Survey</th>
<th>Rigorous Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>37%</td>
<td>35%</td>
</tr>
<tr>
<td>Moderate</td>
<td>40%</td>
<td>41%</td>
</tr>
<tr>
<td>Liberal</td>
<td>19%</td>
<td>20%</td>
</tr>
</tbody>
</table>

What makes you think these results are incomplete?
d) The Pew researchers report that differences between opinions expressed on the two surveys were not statistically significant. Explain what “not statistically significant” means in this context.

37. **Save the grapes.** Vineyard owners have problems with birds that like to eat the ripening grapes. Some vineyards use scarecrows to try to keep birds away. Others use netting that covers the plants. Owners really would like to know if either method works and, if so, which one is better. One owner has offered to let you use his vineyard this year for an experiment. Propose a design. Carefully indicate how you would set up the experiment, specifying the factor(s) and response variable.

38. **Bats.** It’s generally believed that baseball players can hit the ball farther with aluminum bats than with the traditional wooden ones. Is that true? And, if so, how much farther? Players on your local high school baseball team have agreed to help you find out. Design an appropriate experiment.

39. **Knees.** Research reported in the spring of 2002 cast doubt on the effectiveness of arthroscopic knee surgery for patients with arthritis. Patients suffering from arthritis pain who volunteered to participate in the study were randomly divided into groups. One group received arthroscopic knee surgery. The other group underwent “placebo surgery” during which incisions were made in their knees, but no surgery was actually performed. Follow-up evaluations over a period of 2 years found that differences in the amount of pain relief experienced by the two groups were not statistically significant. (*NEJM* 347:81–88 July 11, 2002)

a) Why did the researchers feel it was necessary to have some of the patients undergo “placebo surgery”? Why that does not invalidate the findings of the experiment.

b) Because patients had to consent to participate in this experiment, the subjects were essentially self-selected—a kind of voluntary response group. Explain why that does not invalidate the findings of the experiment.

c) What does “statistically significant” mean in this context?

40. **NBA draft lottery.** Professional basketball teams hold a “draft” each year in which they get to pick the best available college and high school players. In an effort to promote competition, teams with the worst records get to pick first, theoretically allowing them to add better players. To combat the fear that teams with no chance to make the playoffs might try to get better draft picks by intentionally losing late-season games, the NBA’s Board of Governors adopted a weighted lottery system in 1990. Under this system, the 11 teams that did not make the playoffs were eligible for the lottery. The NBA prepared 66 cards, each naming one of the teams. The team with the worst win-loss record was named on 11 of the cards, the second-worst team on 10 cards, and so on, with the team having the best record among the nonplayoff clubs getting only one chance at having the first pick. The cards were mixed, then drawn randomly to determine the order in which the teams could draft players. (Since 1995, 13 teams have been involved in the lottery, using a complicated system with 14 numbered Ping-Pong balls drawn in groups of four.) Suppose there are two exceptional players available in this year’s draft and your favorite team had the third-worst record. Use a simulation to find out how likely it is that your team gets to pick first or second. Describe your simulation carefully.

41. **Security.** There are 20 first-class passengers and 120 coach passengers scheduled on a flight. In addition to the usual security screening, 10% of the passengers will be subjected to a more complete search.

a) Describe a sampling strategy to randomly select those to be searched.
b) Here is the first-class passenger list and a set of random digits. Select two passengers to be searched, carefully demonstrating your process.

65436 71127 04879 41516 20451 02227 94769 23593

<table>
<thead>
<tr>
<th>Bergman</th>
<th>Cox</th>
<th>Fontana</th>
<th>Perl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowman</td>
<td>DeLara</td>
<td>Forester</td>
<td>Rabkin</td>
</tr>
<tr>
<td>Burkhauser</td>
<td>DeLl-Bovi</td>
<td>Frongillo</td>
<td>Roufael</td>
</tr>
<tr>
<td>Castillo</td>
<td>Dugan</td>
<td>Furnas</td>
<td>Swafford</td>
</tr>
<tr>
<td>Clancy</td>
<td>Febo</td>
<td>LePage</td>
<td>Testut</td>
</tr>
</tbody>
</table>

c) Explain how you would use a random number table to select the coach passengers to be searched.
42. **Profiling?** Among the 20 first-class passengers on the flight described in Exercise 41, there were four businessmen from the Middle East. Two of them were the two passengers selected to be searched. They complained of profiling, but the airline claims that the selection was random. What do you think? Support your conclusion with a simulation.

43. **Par 4.** In theory, a golfer playing a par-4 hole tees off, hitting the ball in the fairway, then hits an approach shot onto the green. The first putt (usually long) probably won’t go in, but the second putt (usually much shorter) should. Sounds simple enough, but how many strokes might it really take? Use a simulation to estimate a pretty good golfer’s score based on these assumptions:
   - The tee shot hits the fairway 70% of the time.
   - A first approach shot lands on the green 80% of the time from the fairway, but only 40% of the time otherwise.
   - Subsequent approach shots land on the green 90% of the time.
   - The first putt goes in 20% of the time, and subsequent putts go in 90% of the time.

44. **The back nine.** Use simulations to estimate more golf scores, similar to the procedure in Exercise 43.
   a) On a par 3, the golfer hopes the tee shot lands on the green. Assume that the tee shot behaves like the first approach shot described in Exercise 43.
   b) On a par 5, the second shot will reach the green 10% of the time and hit the fairway 60% of the time. If it does not hit the green, the golfer must play an approach shot as described in Exercise 43.
   c) Create a list of assumptions that describe your golfing ability, and then simulate your score on a few holes. Explain your simulation clearly.