Solutions

Chapter 1

Introduction

Answers to Check Your Understanding

page 4: **1.** The cars in the student parking lot. **2.** He measured the car's model (categorical), year (quantitative), color (categorical), number of cylinders (quantitative), gas mileage (quantitative), weight (quantitative), and whether it has a navigation system (categorical).

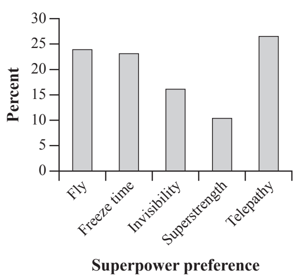
Answers to Odd-Numbered Introduction Exercises

1.1 Type of wood, type of water repellent, and paint color are categorical. Paint thickness and weathering time are quantitative.
1.3 (**a**) AP® Statistics students who completed a questionnaire on the first day of class. (**b**) Categorical: gender, handedness, and favorite type of music. Quantitative: height, homework time, and the total value of coins in a student's pocket. (**c**) The individual is a female who is right-handed. She is 58 inches tall, spends 60 minutes on homework, prefers Alternative music, and has 76 cents in her pocket.
1.5 Student answers will vary. For example, quantitative variables could be graduation rate and student-faculty ratio, and categorical variables could be region of the country and type of institution (2-year college, 4-year college, university).
1.7 b

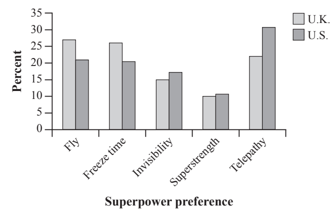
Section 1.1

Answers to Check Your Understanding

page 14: **1.** Fly: 99/415 = 23.9%, Freeze time: 96/415 = 23.1%, Invisibility: 67/415 = 16.1%, Superstrength: 43/415 = 10.4%, Telepathy: 110/415 = 26.5%. **2.** A bar graph is shown below. It appears that telepathy, ability to fly, and ability to freeze time were the most popular choices, with about 25% of students choosing each one. Invisibility was the 4th most popular and superstrength was the least popular.

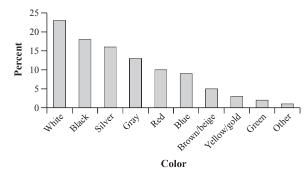


page 18: **1.** For the U.K. students: 54/200 = 27% said fly, 52/200 = 26% said freeze time, 30/200 = 15% said invisibility, 20/200 = 10% said superstrength, and 44/200 = 22% said telepathy. For the U.S. students: 45/215 = 20.9% said fly, 44/215 = 20.5% said freeze time, 37/215 = 17.2% said invisibility, 23/215 = 10.7% said superstrength, and 66/215 = 30.7% said telepathy. **2.** A bar graph is shown in the next column. 3. There is an association between country of origin and superpower preference. Students in the U.K. are more likely to choose flying and freezing time, while students in the U.S. are more likely to choose invisibility or telepathy. Superstrength is about equally unpopular in both countries.

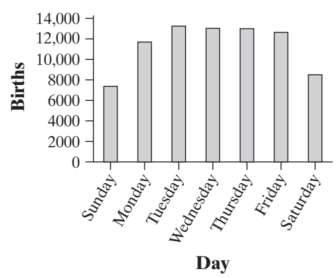


Answers to Odd-Numbered Section 1.1 Exercises

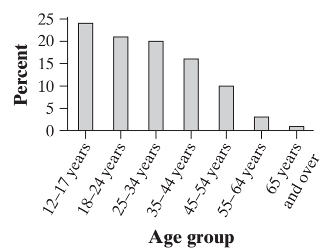
1.9 (**a**) 1% (**b**) A bar graph is given below. (**c**) Yes, because the numbers in the table refer to parts of a single whole.



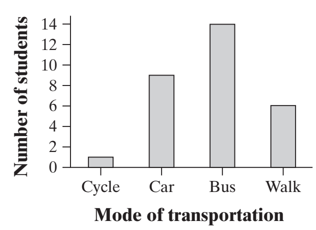
1.11 (**a**) A bar graph is given below. A pie chart would also be appropriate because the numbers in the table refer to parts of a single whole. (**b**) Perhaps induced or C-section births are scheduled for weekdays so doctors don't have to work as much on the weekend.



1.13 About 63% are Mexican and 9% are Puerto Rican.
1.15 (**a**) The given percents represent fractions of different age groups, rather than parts of a single whole. (**b**) A bar graph is given below.

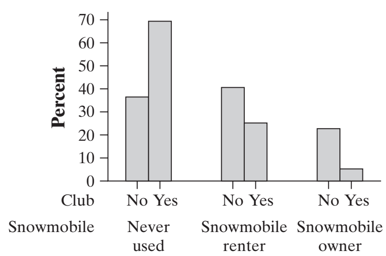


1.17 (**a**) The areas of the pictures should be proportional to the numbers of students they represent. (**b**) A bar graph is given below.



1.19 (a) 133 people; 36 buyers of coffee filters made of recycled paper. (b) 36.8% said "higher," 24.1% said "the same," and 39.1% said "lower." Overall, 60.9% of the members of the sample think the quality is the same or higher.
1.21 For buyers, 55.6% said higher, 19.4% said the same, and 25% said lower. For the nonbuyers, 29.9% said higher, 25.8% said the same, and 44.3% said lower. We see that buyers are much more likely to consider recycled filters higher in quality and much less likely to consider them lower in quality than nonbuyers.
1.23 Americans are much more likely to choose white/pearl and red, while Europeans are much more likely to choose silver, black, or gray. Preferences for blue, beige/brown, green, and yellow/gold are about the same for both groups.
1.25 A table and a side-by-side bar graph comparing the distributions of snowmobile use for environmental club members and nonmembers are shown below. There appears to be an association between environmental club membership and snowmobile use. The visitors who are members of an environmental club are much more likely to have never used a snowmobile and less likely to have rented or owned a snowmobile than visitors who are not in an environmental club.

	Not a member	Member
Never used	445/1221 = 36.4%	212/305 = 69.5%
Snowmobile renter	497/1221 = 40.7%	77/305 = 25.2%
Snowmobile owner	279/1221 = 22.9%	16/305 = 5.2%



1.27 d
1.29 d
1.31 b
1.33 d

1.35 Answers will vary. Two possible tables are given below.

10	40
50	0

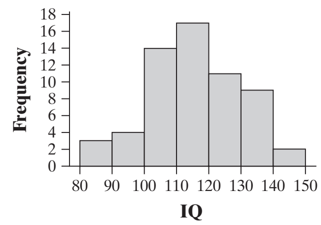
30	20
30	20

Section 1.2

Answers to Check Your Understanding

page 29: **1.** This distribution is skewed to the right and unimodal. **2.** The midpoint of the 28 values is between 1 and 2. **3.** The number of siblings varies from 0 to 6. **4.** There are two potential outliers at 5 and 6 siblings.

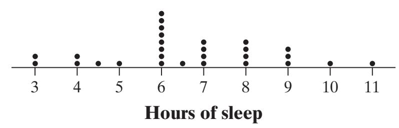
page 32: **1.** Both males and females have distributions that are skewed to the right, though the distribution for the males is more heavily skewed. The midpoint for the males (9 pairs) is less than the midpoint for the females (26 pairs). The number of shoes owned by females varies more (from 13 to 57) than for males (from 4 to 38). The male distribution has three likely outliers at 22, 35, and 38. The females do not have any likely outliers. **2.** b **3.** e **4.** c
page 38: **1.** One possible histogram is shown below. **2.** The distribution is roughly symmetric and bell-shaped. The typical IQ appears to be between 110 and 120 and the IQs vary from 80 to 150. There do not appear to be any outliers.



page 39: **1.** This is a bar graph because field of study is a categorical variable. **2.** No, because the variable is categorical and the categories could be listed in any order on the horizontal axis.

Answers to Odd-Numbered Section 1.2 Exercises

1.37 (a) The graph is shown below. (b) The distribution is roughly symmetric with a midpoint of 6 hours. The hours of sleep vary from 3 to 11. There do not appear to be any outliers.



1.39 (a) This dot represents a game where the opposing team won by 1 goal. (b) All but 4 of the 25 values are positive, which indicates that the U.S. women's soccer team had a very good season. They won 21/25 = 84% of their games.
1.41 As coins get older, they are taken out of circulation and new coins are introduced, meaning that most coins will be from recent years with a few from previous years.
1.43 Both distributions are roughly symmetric and have about the same amount of variability. The center of the internal distribution is greater than the center of the external distribution, indicating that external rewards do not promote creativity. Neither distribution appears to have outliers.
1.45 (a) Otherwise, most of the data would appear on just a few stems, making it hard to identify the shape of the distribution. (b) Key: 12 | 1 means that 12.1% of that state's residents are aged 25 to 34. (c) The distribution of percent of residents aged 25−34 is roughly symmetric with a possible outlier at 16.0%. The center is around 13%. Other than the outlier at 16.0%, the values vary from 11.4% to 15.1%.
1.47 (a) The stemplots are given in the next column. The stemplot with split stems makes it easier to see the shape of the distribution. (b) The distribution is slightly skewed to the right with a center near 780 mm, and values that vary from around 600 mm to 960 mm. There do not appear to be any outliers. (c) In El Niño years, there is typically less rain than in other years (18 of 23 years).

Without splitting stems

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

Key: 6 | 3 = 630 mm of rain

With splitting stems

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

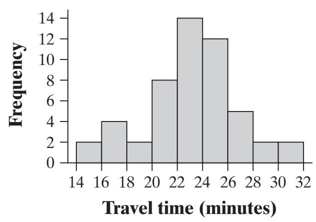
1.49 **(a)** Most people will round their answers to the nearest 10 minutes (or 30 or 60). The students who claimed 300 and 360 minutes of studying on a typical weeknight may have been exaggerating. **(b)** The stemplots suggest that women (claim to) study more than men. The center for women (about 175 minutes) is greater than the center for men (about 120 minutes).

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

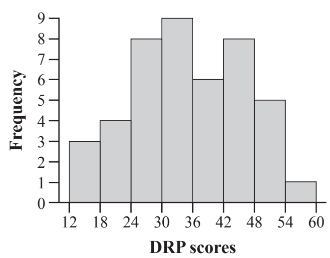
Key: 2|3 = 230 minutes

1.51 **(a)** The distribution is slightly skewed to the left and unimodal. **(b)** The center is between 0% and 2.5%. **(c)** The highest return was between 10% and 12.5%. Ignoring the low outliers, the lowest return was between −12.5% and −10%. **(d)** About 37% of these months (102 out of 273) had negative returns.

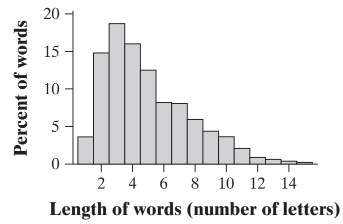
1.53 **(a)** The histogram is given below. **(b)** The distribution of travel times is roughly symmetric. The center is near 23 minutes and the values vary from 15.5 to 30.9 minutes. There do not appear to be any outliers.



1.55 The histogram is given below. The distribution of DRP scores is roughly symmetric with the center around 35. The DRP scores vary from 14 to 54. There do not appear to be any outliers.

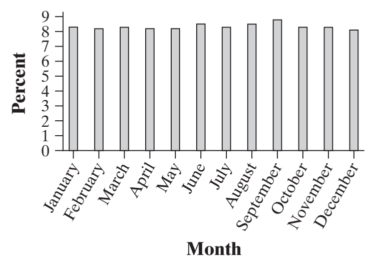


1.57 **(a)** The histogram is given below. The distribution of word lengths is skewed to the right and single-peaked. The center is around 4 letters, with words that vary from 1 to 15 letters. There do not appear to be any outliers. **(b)** There are more short words in Shakespeare's plays and more very long words in *Popular Science* articles.

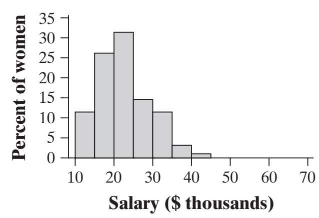


1.59 The scale on the horizontal axis is very different from one graph to the other.

1.61 A bar graph should be used because birth month is a categorical variable. A possible bar graph is given below.



1.63 **(a)** The percents for women sum to 100.1% due to rounding errors. **(b)** Relative frequency histograms are shown below because there are considerably more men than women. **(c)** Both histograms are skewed to the right. The center of the women's distribution of salaries is less than the men's. The distributions of salaries are about equally variable, and the table shows that there are some outliers in each distribution who make between \$65,000 and \$70,000.



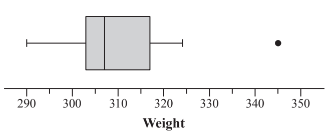
1.65 The distribution of age is skewed to the right for both males and females, meaning that younger people outnumber older people. Among the younger Vietnamese, there are more males than females. After age 35, however, females seem to outnumber the males, making the center of the female distribution a little greater than the male distribution. Both distributions have about the same amount of variability and no outliers.

1.67 (a) Amount of studying. We would expect some students to study very little, but most students to study a moderate amount. Any outliers would likely be high outliers, leading to a right-skewed distribution. (b) Right- versus left-handed. About 90% of the population is right-handed (represented by the bar at 0). (c) Gender. We would expect a more similar percentage of males and females than for the right-handed and left-handed students. (d) Heights. We expect many heights near the average and a few very short or very tall people.
1.69 a
1.71 c
1.73 d
1.75 (a) Major League Baseball players who were on the roster on opening day of the 2012 season. (b) 6. Two variables are categorical (team, position) and the other 4 are quantitative (age, height, weight, and salary).
1.77 (a) 71/858 = 8.3% were elite soccer players and 43/858 = 5.0% of the people had arthritis. (b) 10/71 = 14.1% of elite soccer players had arthritis and 10/43 = 23.3% of those with arthritis were elite soccer players.

Section 1.3

Answers to Check Your Understanding

page 53: **1.** Because the distribution is skewed to the right, we would expect the mean to be larger than the median. **2.** Yes. The mean is 31.25 minutes, which is greater than the median of 22.5 minutes. **3.** Because the distribution is skewed, the median would be a better measure of the center of the distribution.
page 59: **1.** The data in order are: 290, 301, 305, 307, 307, 310, 324, 345. The 5-number summary is 290, 303, 307, 317, 345. **2.** The *IQR* is 14 pounds. The range of the middle half of the data is 14 pounds. **3.** Any outliers occur below 303 − 1.5(14) = 282 or above 317 + 1.5(14) = 338, so 345 pounds is an outlier. **4.** The boxplot is given below.



page 63: **1.** The mean is 75. **2.** The table is given below.

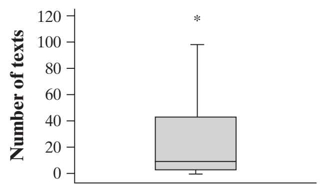
Observation	Deviation	Squared deviation
67	67 − 75 = −8	$(-8)^2 = 64$
72	72 − 75 = −3	$(-3)^2 = 9$
76	76 − 75 = 1	$1^2 = 1$
76	76 − 75 = 1	$1^2 = 1$
84	84 − 75 = 9	$9^2 = 81$
Total	**0**	**156**

3. The variance is $s_x^2 = \dfrac{156}{5-1} = 39$ inches squared and the standard deviation is $s_x = \sqrt{39} = 6.24$ inches.
4. The players' heights typically vary by about 6.24 inches from the mean height of 75 inches.

Answers to Odd-Numbered Section 1.3 Exercises

1.79 $\bar{x} = 85$
1.81 (a) median = 85 (b) $\bar{x} = 79.33$ and median = 84. The median did not change much but the mean did, showing that the median is more resistant to outliers than the mean.
1.83 The mean is \$60,954 and the median is \$48,097. The distribution of salaries is likely to be quite right skewed because of a few people who have a very large income, making the mean larger than the median.
1.85 The team's annual payroll is 1.2(25) = 30 or \$30 million. No, because the median only describes the middle value in the distribution. It doesn't provide specific information about any of the other values.
1.87 (a) Estimating the frequencies of the bars (from left to right) as 10, 40, 42, 58, 105, 60, 58, 38, 27, 18, 20, 10, 5, 5, 1, and 3, the mean is $\bar{x} = \dfrac{3504}{500} = 7.01$. The median is the average of the 250th and 251st values, which is 6. (b) Because the median is less than the mean, we would use the median to argue that shorter domain names are more popular.

1.89 (a) *IQR* = 91 − 78 = 13. The middle 50% of the data have a range of 13 points. (b) Any outliers are below 78 − 1.5(13) = 58.5 or above 91 + 1.5(13) = 110.5. There are no outliers.
1.91 (a) Outliers are anything below 3 − 1.5(40) = −57 or above 43 + 1.5(40) = 103, so 118 is an outlier. The boxplot is shown below. (b) The article claims that teens send 1742 texts a month, which is about 58 texts a day. Nearly all of the members of the class (21 of 25) sent fewer than 58 texts per day, which seems to contradict the claim in the article.

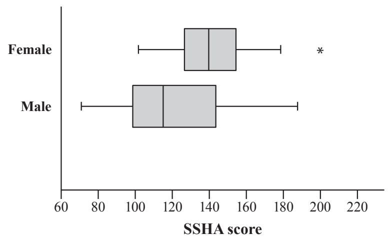


1.93 (a) Positive numbers indicate students who had more text messages than calls. Because the 1st quartile is about 0, roughly 75% of the students had more texts than calls, which supports the article's conclusion. (b) No. Students in statistics classes tend to be upperclassmen and their responses might differ from those of underclassmen.
1.95 (a) About 3% and −3.5%. (b) About 0.1%. (c) The stock fund is much more variable. It has higher positive returns, but also higher negative returns.

1.97 (a) $s_x = \sqrt{\dfrac{2.06}{6-1}} = 0.6419$ mg/dl. (b) The phosphate level typically varies from the mean by about 0.6419 mg/dl.

1.99 (a) Skewed to the right, because the mean is much larger than the median and Q_3 is much further from the median than Q_1. (b) The amount of money spent typically varies from the mean by \$21.70. (c) Any points below 19.06 − 1.5(26.66) = −20.93 or above 45.72 + 1.5(26.66) = 85.71 are outliers. Because the maximum of 93.34 is greater than 85.71, there is at least one outlier.
1.101 Yes. For example, in data set 1, 2, 3, 4, 5, 6, 7, 8 the *IQR* is 4. If 8 is changed to 88, the *IQR* will still be 4.
1.103 (a) One possible answer is 1, 1, 1, 1. (b) 0, 0, 10, 10. (c) For part (a), any set of four identical numbers will have $s_x = 0$. For part (b), however, there is only one possible answer. We want the values to be as far from the mean as possible, so our best choice is two values at each extreme.

1.105 *State*: Do the data indicate that men and women differ in their study habits and attitudes toward learning? *Plan*: We will draw side-by-side boxplots of the data about men and women; compute summary statistics; and compare the shape, center, and spread of both distributions. *Do*: The boxplots are given below, as is a table of summary statistics.



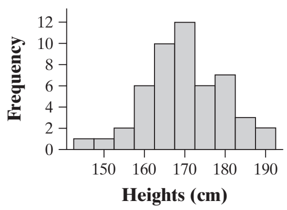
Variable	N	Mean	StDev	Minimum	Q_1	Median	Q_3	Maximum
Women	18	141.06	26.44	101.00	126.00	138.50	154.00	200.00
Men	20	121.25	32.85	70.00	98.00	114.50	143.00	187.00

Both distributions are slightly skewed to the right. Both the mean and median are higher for women than for men. The scores for men are more variable than the scores for women. There are no outliers in the male distribution and a single outlier at 200 in the female distribution. *Conclude*: Men and women differ in their study habits and attitudes toward learning. The typical score for females is about 24 greater than the typical score for males. Female scores are also more consistent than male scores.

1.107 d

1.109 e

1.111 A histogram is given below. This distribution is roughly symmetric with a center around 170 cm and values that vary from 145.5 cm to 191 cm. There do not appear to be any outliers.

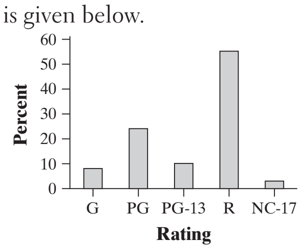


1.113 Women appear to be more likely to engage in behaviors that are indicative of good "habits of mind." They are especially more likely to revise papers to improve their writing. The difference is a little smaller for seeking feedback on their work, although the percentage is still higher for females.

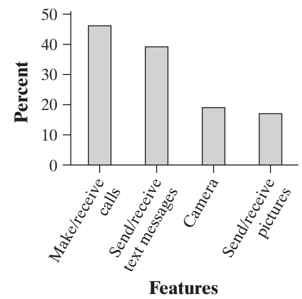
Answers to Chapter 1 Review Exercises

R1.1 (**a**) Movies. (**b**) Quantitative: Year, time, box office sales. Categorical: Rating, genre. *Note*: Year might be considered categorical if we want to know how many of these movies were made each year rather than the average year. (**c**) This movie is *Avatar*, released in 2009. It was rated PG-13, runs 162 minutes, is an action film, and had box office sales of $2,781,505,847.

R1.2 A bar chart is given below.



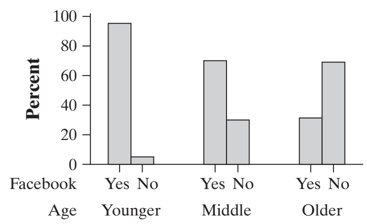
R1.3 (**a**) The "bars" are different widths. For example, the bar for "send/receive text messages" should be roughly twice the size of the bar for "camera" when it is actually about 4 times as large. (**b**) No, because they do not describe parts of a whole. Students were free to answer in more than one category. (**c**) A bar graph is given below.



R1.4 (**a**) 148/219 = 67.6%. Marginal distribution, because it is part of the distribution of one variable for all categories of the other variable. (**b**) 78/82 = 95.1% of the younger students were Facebook users. 78/148 = 52.7% of the Facebook users were younger.

R1.5 There does appear to be an association between age and Facebook status. From both the table and the graph given below, we can see that as age increases, the percent of Facebook users decreases. For younger students, about 95% are members. That drops to 70% for middle students and drops even further to 31.3% for older students.

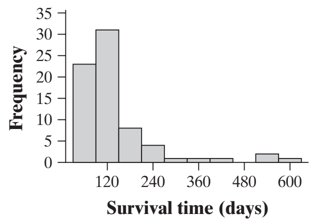
	Facebook user?	
Age	**Yes**	**No**
Younger (18–22)	95.1%	4.9%
Middle (23–27)	70.0%	30.0%
Older (28 and up)	31.3%	68.7%



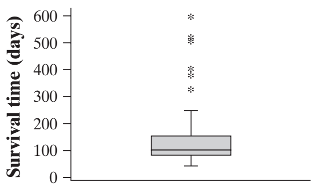
R1.6 (**a**) A stemplot is given below. (**b**) The distribution is roughly symmetric with one possible outlier at 4.88. The center of the distribution is between 5.4 and 5.5. The densities vary from 4.88 to 5.85. (**c**) Because the distribution is roughly symmetric, we can use the mean to estimate the Earth's density to be about 5.45 times the density of water.

```
48 | 8
49 |
50 | 7
51 | 0
52 | 6799
53 | 04469      Key: 48 | 8 = 4.88
54 | 2467
55 | 03578
56 | 12358
57 | 59
58 | 5
```

R1.7 (a) A histogram is given below. The survival times are right-skewed, as expected. The median survival time is 102.5 days and the range of survival times is 598 − 43 = 555 days. There are several high outliers with survival times above 500.



(b) The boxplot is given below.



(c) Use the median and *IQR* to summarize the distribution because the outliers will have a big effect on the mean and standard deviation.

R1.8 (a) About 20% of low-income and 33% of high-income households. (b) The shapes of both distributions are skewed to the right; however, the skewness is much stronger in the distribution for low-income households. On average, household size is larger for high-income households. One-person households might have less income because they would include many young single people who have no job or retired single people with a fixed income.

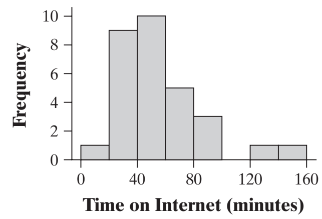
R1.9 (a) The amount of mercury per can of tuna will typically vary from the mean by about 0.3 ppm. (b) Any point below 0.071 − 1.5(0.309) = −0.393 or above 0.38 + 1.5(0.309) = 0.8435 would be considered an outlier. There are no low outliers, but there are several high outliers. (c) The distribution of the amount of mercury in cans of tuna is highly skewed to the right. The median is 0.18 ppm and the *IQR* is 0.309 ppm.

R1.10 The distribution for light tuna is skewed to the right with several high outliers, while the distribution for albacore tuna is more symmetric with just a couple of high outliers. Because it has a greater center, the albacore tuna generally has more mercury. However, the light tuna has a much bigger spread of values, with some cans having as much as twice the amount of mercury as the largest amount in the albacore tuna.

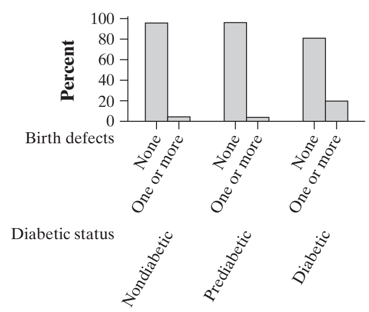
Answers to Chapter 1 AP® Statistics Practice Test

T1.1 d
T1.2 e
T1.3 b
T1.4 b
T1.5 c
T1.6 c
T1.7 b
T1.8 c
T1.9 e
T1.10 b
T1.11 d

T1.12 (a) A histogram is given below. (b) Any point below 30 – 1.5(47) = −40.5 or above 77 + 1.5(47) = 147.5 is an outlier. So 151 minutes is an outlier. (c) Median and *IQR*, because the distribution is skewed and has a high outlier.



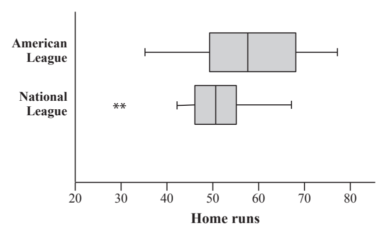
T1.13 (a) Row totals are 1154, 53, and 1207. Column totals are 785, 375, 47, and 1207. (b) Nondiabetic: 96.1% none and 3.9% one or more. Prediabetic: 96.5% none and 3.5% one or more. Diabetic: 80.9% none and 19.1% one or more. (c) The graph is given below.



(d) Yes. Nondiabetics and prediabetics appear to have babies with birth defects at about the same rate. However, those with diabetes have a much higher rate of babies with birth defects.

T1.14 (a) Between 550 and 559 hours. (b) Because it has a higher minimum lifetime or because its lifetimes are more consistent (less variable). (c) Because it has a higher median lifetime.

T1.15 Side-by-side boxplots and descriptive statistics for both leagues are given below. Both distributions are roughly symmetric, although there are two low outliers in the NL. The data suggest that the number of home runs is somewhat less in the NL. All 5 numbers in the 5-number summary are less for the NL teams than for the AL teams. However, there is more variability among the AL teams.



Variable	*N*	Mean	StDev	Minimum	Q_1	Median	Q_3	Maximum
American League	14	56.93	12.69	35.00	49.00	57.50	68.00	77.00
National League	14	50.14	11.13	29.00	46.00	50.50	55.00	67.00

Chapter 2

Section 2.1

Answers to Check Your Understanding

page 89: **1.** c **2.** Her daughter weighs more than 87% of girls her age and she is taller than 67% of girls her age. **3.** About 65% of calls lasted less than 30 minutes, which means that about 35% of calls lasted 30 minutes or longer. **4.** $Q_1 = 13$ minutes, $Q_3 = 32$ minutes, and $IQR = 19$ minutes.

page 91: **1.** $z = -0.466$. Lynette's height is 0.466 standard deviations below the mean height of the class. **2.** $z = 1.63$. Brent's height is 1.63 standard deviations above the mean height of the class. **3.** $-0.85 = \dfrac{74 - 76}{\sigma}$, so $\sigma = 2.35$ inches.

page 97: **1.** Shape will not change. However, it will multiply the center (mean, median) and spread (range, *IQR*, standard deviation) by 2.54. **2.** Shape and spread will not change. It will, however, add 6 inches to the center (mean, median). **3.** Shape will not change. However, it will change the mean to 0 and the standard deviation to 1.

Answers to Odd-Numbered Section 2.1 Exercises

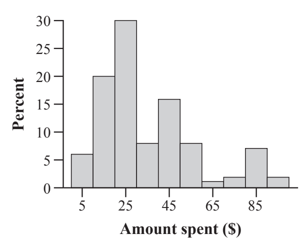
2.1 **(a)** She is at the 25th percentile, meaning that 25% of the girls had fewer pairs of shoes than she did. **(b)** He is at the 85th percentile, meaning that 85% of the boys had fewer pairs of shoes than he did. **(c)** The boy is more unusual because only 15% of the boys have as many or more than he has. The girl has a value that is closer to the center of the distribution.

2.3 A percentile only describes the relative location of a value in a distribution. Scoring at the 60th percentile means that Josh's score is better than 60% of the students taking this test. His correct percentage could be greater than 60% or less than 60%, depending on the difficulty of the test.

2.5 The girl weighs more than 48% of girls her age, but is taller than 78% of the girls her age.

2.7 **(a)** The student sent about 205 text messages in the 2-day period and sent more texts than about 78% of the students in the sample. **(b)** Locate 50% on the *y*-axis, read over to the points, and then go down to the *x*-axis. The median is approximately 115 text messages.

2.9 **(a)** $IQR \approx \$46 - \$19 = \$27$ **(b)** About the 26th percentile. **(c)** The histogram is below.



2.11 Eleanor. Her standardized score ($z = 1.8$) is higher than Gerald's ($z = 1.5$).

2.13 **(a)** Your bone density is far below average—about 1.5 times farther below average than a typical below-average density. **(b)** Solving $-1.45 = \dfrac{948 - 956}{\sigma}$ gives $\sigma = 5.52$ g/cm^2.

2.15 **(a)** He is at the 76th percentile, meaning his salary is higher than 76% of his teammates. **(b)** $z = 0.79$. Lidge's salary was 0.79 standard deviations above the mean salary.

2.17 Multiply each score by 4 and add 27.

2.19 **(a)** mean = 87.188 inches and median = 87.5 inches. **(b)** The standard deviation (3.20 inches) and *IQR* (3.25 inches) do not change because adding a constant to each value in a distribution does not change the spread.

2.21 **(a)** mean = 5.77 feet and median = 5.79 feet. **(b)** Standard deviation = 0.267 feet and *IQR* = 0.271 feet.

2.23 Mean $= \frac{9}{5}(25) + 32 = 77°$F and standard deviation $= \frac{9}{5}(2) = 3.6°$F.

2.25 c

2.27 c

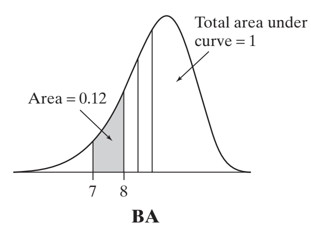
2.29 c

2.31 The distribution is skewed to the right with a center around 20 minutes and the range close to 90 minutes. The two largest values appear to be outliers.

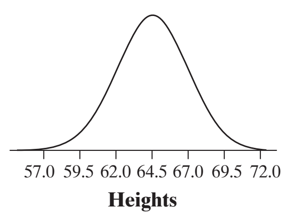
Section 2.2

Answers to Check Your Understanding

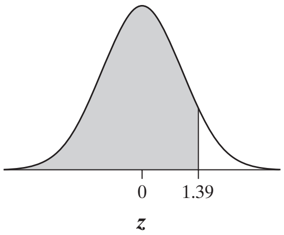
page 107: **1.** It is legitimate because it is positive everywhere and it has total area under the curve = 1. **2.** 12% **3.** Point A in the graph below is the approximate median. About half of the area is to the left of A and half of the area is to the right of A. **4.** Point B in the graph below is the approximate mean (balance point). The mean is less than the median in this case because the distribution is skewed to the left.

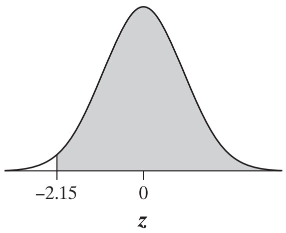


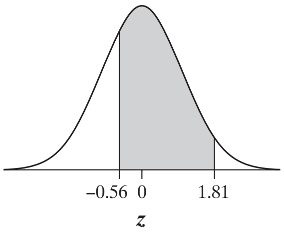
page 112: **1.** The graph is given below. **2.** Approximately $\dfrac{100\% - 68\%}{2} = 16\%$. **3.** Approximately $\dfrac{100\% - 68\%}{2} = 16\%$ have heights below 62 inches and approximately $\dfrac{100\% - 99.7\%}{2} = 0.15\%$ of young women have heights above 72 inches, so the remaining 83.85% have heights between 62 and 72 inches.

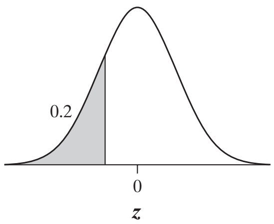


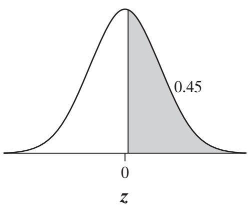
page 116: (All graphs are shown on the following page.) **1.** The proportion is 0.9177. **2.** The proportion is 0.9842. **3.** The proportion is $0.9649 - 0.2877 = 0.6772$. **4.** The *z*-score for the 20th percentile is $z = -0.84$. **5.** 45% of the observations are greater than $z = 0.13$.



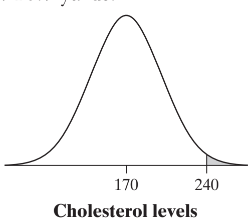


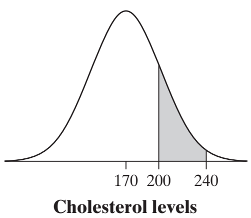


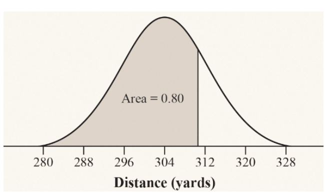




page 121: **1.** For 14-year-old boys, the amount of cholesterol follows a $N(170, 30)$ distribution and we want to find the percent of boys with cholesterol of more than 240 (see graph below). $z = \dfrac{240 - 170}{30} = 2.33$. From Table A, the proportion of z-scores above 2.33 is $1 - 0.9901 = 0.0099$. *Using technology:* `normalcdf(lower:240,upper:1000,μ:170,σ:30)` $= 0.0098$. About 1% of 14-year-old boys have cholesterol above 240 mg/dl. **2.** For 14-year-old boys, the amount of cholesterol follows a $N(170, 30)$ distribution and we want to find the percent of boys with cholesterol between 200 and 240 (see graph below). $z = \dfrac{200 - 170}{30} = 1$ and $z = \dfrac{240 - 170}{30} = 2.33$. From Table A, the proportion of z-scores between 1 and 2.33 is $0.9901 - 0.8413 = 0.1488$. *Using technology*: `normalcdf(lower:200,upper:240,μ:170,σ:30)` $= 0.1488$. About 15% of 14-year-old boys have cholesterol between 200 and 240 mg/dl. **3.** For Tiger Woods, the distance his drives travel follows an $N(304, 8)$ distribution and the 80th percentile is the boundary value x with 80% of the distribution to its left (see graph below). A z-score of 0.84 gives the area closest to 0.80 (0.7995). Solving $0.84 = \dfrac{x - 304}{8}$ gives $x = 310.7$. *Using technology:* `invNorm(area:0.8,μ:304,σ:8)` $= 310.7$. The 80th percentile of Tiger Woods's drive lengths is about 310.7 yards.

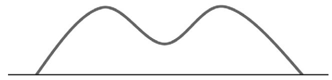






Answers to Odd-Numbered Section 2.2 Exercises

2.33 Sketches will vary, but here is one example:

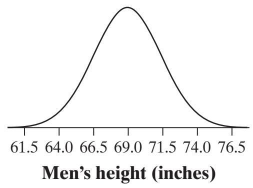


2.35 (**a**) It is on or above the horizontal axis everywhere, and the area beneath the curve is $\frac{1}{3} \times 3 = 1$. (**b**) $\frac{1}{3} \times 1 = \frac{1}{3}$. (**c**) Because $1.1 - 0.8 = 0.3$, the proportion is $\frac{1}{3} \times 0.3 = 0.1$.

2.37 Both are 1.5.

2.39 (**a**) Mean is C, median is B. (**b**) Mean is B, median is B.

2.41 The graph is shown below.



2.43 (**a**) Between $69 - 2(2.5) = 64$ and $69 + 2(2.5) = 74$ inches. (**b**) About $\dfrac{100\% - 95\%}{2} = 2.5\%$. (**c**) About $\dfrac{100\% - 68\%}{2} = 16\%$ of men are shorter than 66.5 inches and $\dfrac{100\% - 95\%}{2} = 2.5\%$ are shorter than 64 inches, so approximately $16\% - 2.5\% = 13.5\%$ of men have heights between 64 inches and 66.5 inches. (**d**) Because $\dfrac{100\% - 68\%}{2} = 16\%$ of the area is to the right of 71.5, 71.5 is at the 84th percentile.

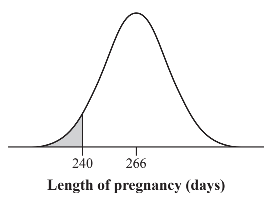
2.45 Taller curve: standard deviation ≈ 0.2. Shorter curve: standard deviation ≈ 0.5.

2.47 (**a**) 0.9978. (**b**) $1 - 0.9978 = 0.0022$ (**c**) $1 - 0.0485 = 0.9515$ (**d**) $0.9978 - 0.0485 = 0.9493$

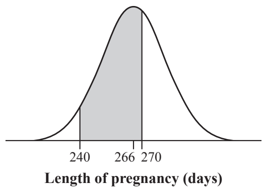
2.49 (**a**) $0.9505 - 0.0918 = 0.8587$ (**b**) $0.9633 - 0.6915 = 0.2718$

2.51 (**a**) $z = -1.28$ (**b**) $z = 0.41$

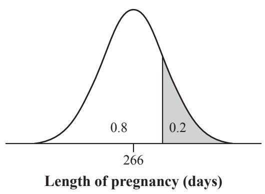
2.53 (**a**) The length of pregnancies follows a $N(266, 16)$ distribution and we want the proportion of pregnancies that last less than 240 days (see graph below). $z = \dfrac{240 - 266}{16} = -1.63$. From Table A, the proportion of z-scores less than -1.63 is 0.0516. *Using technology:* `normalcdf(lower:-1000,upper:240,μ:266,σ:16)` $= 0.0521$. About 5% of pregnancies last less than 240 days, so 240 days is at the 5th percentile of pregnancy lengths.



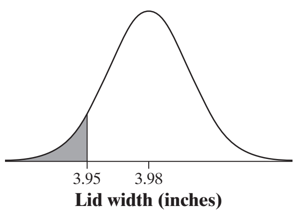
(**b**) The length of pregnancies follows a $N(266, 16)$ distribution and we want the proportion of pregnancies that last between 240 and 270 days (see the following graph). $z = \dfrac{240 - 266}{16} = -1.63$ and $z = \dfrac{270 - 266}{16} = 0.25$. From Table A, the proportion of z-scores between -1.63 and 0.25 is $0.5987 - 0.0516 = 0.5471$. *Using technology:* `normalcdf(lower:240,upper:270,` `µ:266,σ:16)` = 0.5466. About 55% of pregnancies last between 240 and 270 days.



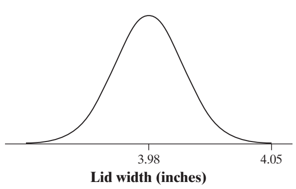
(c) The length of pregnancies follows a $N(266, 16)$ distribution and we are looking for the boundary value x that has an area of 0.20 to the right and 0.80 to the left (see graph below). A z-score of 0.84 gives the area closest to 0.80 (0.7995). Solving $0.84 = \dfrac{x - 266}{16}$ gives $x = 279.44$. *Using technology:* `invNorm(area:0.8,µ:266,σ:16)` = 279.47. The longest 20% of pregnancies last longer than 279.47 days.



2.55 **(a)** For large lids, the diameter follows a $N(3.98, 0.02)$ distribution and we want to find the percent of lids that have diameters less than 3.95 (see graph below). $z = \dfrac{3.95 - 3.98}{0.02} = -1.5$. From Table A, the proportion of z-scores below -1.5 is 0.0668. *Using technology:* `normalcdf(lower:-1000,upper:3.95,µ:3.98,σ:0.02)` = 0.0668. About 7% of the large lids are too small to fit.

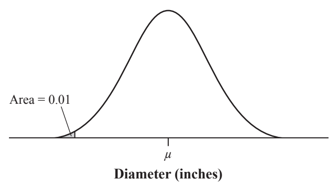


(b) For large lids, the diameter follows a $N(3.98, 0.02)$ distribution and we want to find the percent of lids that have diameters greater than 4.05 (see graph below). $z = \dfrac{4.05 - 3.98}{0.02} = 3.5$. From Table A, the proportion of z-scores above 3.50 is approximately 0. *Using technology:* `normalcdf(lower:4.05,upper:1000,µ:3.98,σ:0.02)` = 0.0002. Approximately 0% of the large lids are too big to fit.

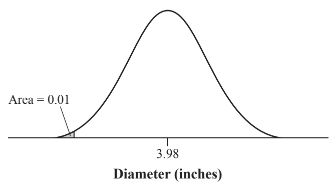


(c) Make a larger proportion of lids too small. If lids are too small, customers will just try another lid. But if lids are too large, the customer may not notice and then spill the drink.

2.57 **(a)** For large lids, the diameter follows a $N(\mu, 0.02)$ distribution and we want to find the value of μ that will result in only 1% of lids that are too small to fit (see graph below). A z-score of -2.33 gives the value closest to 0.01 (0.0099). Solving $-2.33 = \dfrac{3.95 - \mu}{0.02}$ gives $\mu = 4.00$. *Using technology:* `invNorm(area:0.01,µ:0,σ:1)` gives $z = -2.326$. Solving $-2.326 = \dfrac{3.95 - \mu}{0.02}$ gives $\mu = 4.00$. The manufacturer should set the mean diameter to approximately $\mu = 4.00$ to ensure that only 1% of lids are too small. **(b)** For large lids, the diameter follows a $N(3.98, \sigma)$ distribution and we want to find the value of σ that will result in only 1% of lids that are too small to fit (see graph below). A z-score of -2.33 gives the value closest to 0.01 (0.0099). Solving $-2.33 = \dfrac{3.95 - 3.98}{\sigma}$ gives $\sigma = 0.013$. *Using technology:* `invNorm(area:0.01,µ:0,σ:1)` gives $z = -2.326$. Solving $-2.326 = \dfrac{3.95 - 3.98}{\sigma}$ gives $\sigma = 0.013$. A standard deviation of at most 0.013 will result in only 1% of lids that are too small to fit.



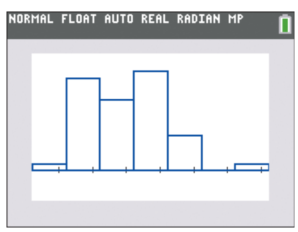
(c) Reduce the standard deviation. This will reduce the number of lids that are too small and the number of lids that are too big. If we make the mean a little larger as in part (a), we will reduce the number of lids that are too small, but we will increase the number of lids that are too big.



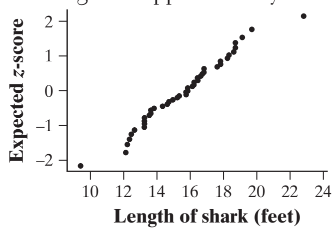
2.59 **(a)** $z = -1.28$ and $z = 1.28$ **(b)** Solving $-1.28 = \dfrac{x - 64.5}{2.5}$ gives $x = 61.3$ inches and solving $1.28 = \dfrac{x - 64.5}{2.5}$ gives $x = 67.7$ inches.

2.61 Solving $1.04 = \dfrac{60 - \mu}{\sigma}$ and $1.88 = \dfrac{75 - \mu}{\sigma}$ gives $\mu = 41.43$ minutes and $\sigma = 17.86$ minutes.

2.63 **(a)** A histogram is given below. The distribution of shark lengths is roughly symmetric and somewhat bell-shaped, with a mean of 15.586 feet and a standard deviation of 2.55 feet. **(b)** 30/44 = 68.2%, 42/44 = 95.5%, and 44/44 = 100%. These are very close to the 68−95−99.7 rule.



(c) A Normal probability plot is given below. Except for one small shark and one large shark, the plot is fairly linear, indicating that the distribution of shark lengths is approximately Normal.



(d) All indicate that shark lengths are approximately Normal.

2.65 The distribution is close to Normal because the plot is nearly linear. There is a small "wiggle" between 120 and 130, with several values a little larger than would be expected in a Normal distribution. Also, the smallest value and the two largest values are a little farther from the mean than would be expected in a Normal distribution.

2.67 No. If it was Normal, then the minimum value should be around 2 or 3 standard deviations below the mean. However, the actual minimum has a z-score of just $z = -1.09$. Also, if the distribution was Normal, the minimum and maximum should be about the same distance from the mean. However, the maximum is much farther from the mean (20,209) than the minimum (8741).

2.69 b

2.71 b

2.73 a

2.75 For both kinds of cars, we see that the highway mileage is greater than the city mileage. The two-seater cars have a more variable distribution, both on the highway and in the city. Also the mileage values are slightly lower for the two-seater cars than for the minicompact cars, both on the highway and in the city, with a greater difference on the highway. All four distributions are roughly symmetric.

Answers to Chapter 2 Review Exercises

R2.1 (a) $z = 1.20$. Paul's height is 1.20 standard deviations above the average male height for his age. (b) 85% of boys Paul's age are shorter than Paul.

R2.2 (a) 58th percentile (b) $IQR = 11 - 2.5 = 8.5$ hours per week.

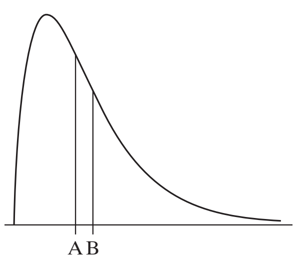
R2.3 (a) The shape of the distribution would not change.

Mean $= \dfrac{43.7}{3.28} = 13.32$ meters, median $= \dfrac{42}{3.28} = 12.80$ meters,

standard deviation $= \dfrac{12.5}{3.28} = 3.81$ meters,

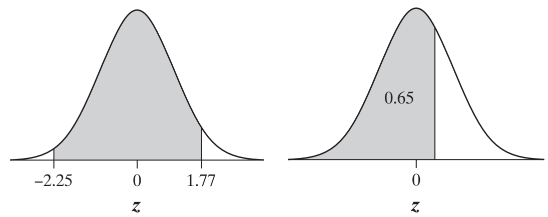
$IQR = \dfrac{12.5}{3.28} = 3.81$ meters. (b) Mean $= 43.7 - 42.6 = 1.1$ feet; standard deviation $= 12.5$ feet, because subtracting a constant from each observation does not change the spread.

R2.4 (a) The median (line A in the graph below) should be slightly to the right of the main peak, with half of the area to the left and half to the right. (b) The mean (line B in the graph below) should be slightly to the right of the line for the median at the balancing point.

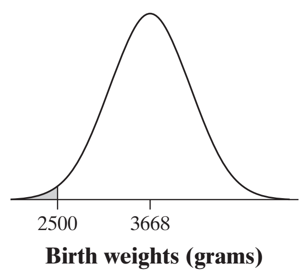


R2.5 (a) Between $336 - 3(3) = 327$ days and $336 + 3(3) = 345$ days. (b) About $\dfrac{100\% - 68\%}{2} = 16\%$.

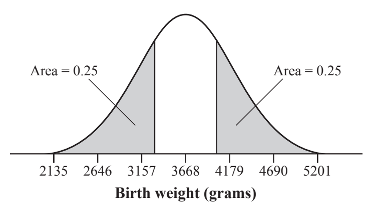
R2.6 (a) $0.9616 - 0.0122 = 0.9494$ (b) If 35% of all values are greater than a particular z-value, then 65% are lower. A z-score of 0.39 gives the value closest to 0.65 (0.6517). *Using technology:* `invNorm(area:0.65,μ:0,σ:1)` gives $z = 0.385$.



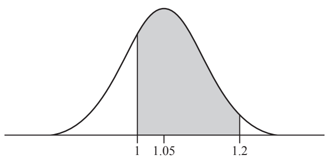
R2.7 (a) Birth weights follow a $N(3668, 511)$ distribution and we want to find the percent of babies with weights less than 2500 grams (see graph below). $z = \dfrac{2500 - 3668}{511} = -2.29$. From Table A, the proportion of z-scores below -2.29 is 0.0110. *Using technology:* `normalcdf(lower:-1000,upper:2500,μ:3668,σ:511)` = 0.0111. About 1% of babies will be identified as low birth weight.



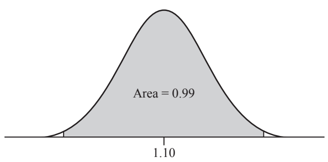
(b) Birth weights follow a $N(3668, 511)$ distribution. The 1st quartile is the boundary value with 25% of the area to its left. The 3rd quartile is the boundary value with 75% of the area to its left (see graph below). A z-score of -0.67 gives the value closest to 0.25 (0.2514). Solving $-0.67 = \dfrac{x - 3668}{511}$ gives $Q_1 = 3325.63$. A z-score of 0.67 gives the value closest to 0.75 (0.7486). Solving $0.67 = \dfrac{x - 3668}{511}$ gives $Q_3 = 4010.37$. *Using technology:* `invNorm(area:0.25,μ:3668,σ:511)` gives $Q_1 = 3323.34$ and `invNorm(area:0.75,μ:3668,σ:511)` gives $Q_3 = 4012.66$. The quartiles are $Q_1 = 3323.34$ grams and $Q_3 = 4012.66$ grams.



R2.8 (a) The amount of ketchup dispensed follows a $N(1.05, 0.08)$ distribution and we want to find the percent of times that the amount of ketchup dispensed will be between 1 and 1.2 ounces (see graph below). $z = \dfrac{1.2 - 1.05}{0.08} = 1.88$ and $z = \dfrac{1 - 1.05}{0.08} = -0.63$. From Table A, the proportion of z-scores between -0.63 and 1.88 is $0.9699 - 0.2643 = 0.7056$. *Using technology:* `normalcdf(lower:1,upper:1.2,μ:1.05,σ:0.08)` = 0.7036. About 70% of the time the dispenser will put between 1 and 1.2 ounces of ketchup on a burger.

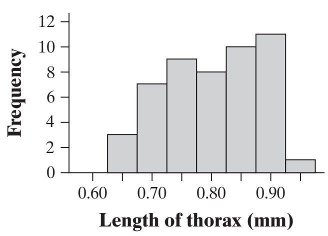


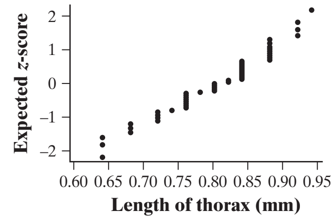
(b) The amount of ketchup dispensed follows a $N(1.1, \sigma)$ distribution and we want to find the value of σ that will result in at least 99% of burgers getting between 1 and 1.2 ounces of ketchup (see graph below). Because the mean of 1.1 is in the middle of the interval from 1 to 1.2, we are looking for the middle 99% of the distribution. This leaves 0.5% in each tail. A z-score of -2.58 gives the value closest to 0.005 (0.0049). Solving $-2.58 = \dfrac{1 - 1.1}{\sigma}$ gives $\sigma = 0.039$. *Using technology:* `invNorm(area:0.005,μ:0,σ:1)` gives $z = -2.576$. Solving $-2.576 = \dfrac{1 - 1.1}{\sigma}$ gives $\sigma = 0.039$. A standard deviation of at most 0.039 ounces will result in at least 99% of burgers getting between 1 and 1.2 ounces of ketchup.



R2.9 If the distribution is Normal, the 10th and 90th percentiles must be equal distances above and below the mean. Thus, the mean is $\dfrac{25 + 475}{2} = 250$ points. The 10th percentile in a standard Normal distribution is $z = -1.28$. Solving $-1.28 = \dfrac{25 - 250}{\sigma}$, we get $\sigma = 175.8$. *Using technology*: `invNorm(area:0.10,μ:0,σ:1)` gives $z = -1.282$, so $-1.282 = \dfrac{25 - 250}{\sigma}$ and $\sigma = 175.5$.

R2.10 A histogram and Normal probability plot are given below. The histogram is roughly symmetric but not very bell-shaped. The Normal probability plot, however, is roughly linear. For these data, $\bar{x} = 0.8004$ and $s_x = 0.0782$. Although the percentage within 1 standard deviation of the mean (55.1%) is less than expected (68%), the percentage within 2 (93.9%) and 3 standard deviations (100%) match the 68–95–99.7 rule quite well. It is reasonable to say that these data are approximately Normally distributed.



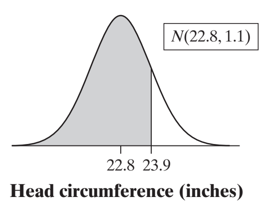


R2.11 The steep, nearly vertical portion at the bottom and the clear bend to the right indicate that the distribution of the data is right-skewed with several outliers and not approximately Normally distributed.

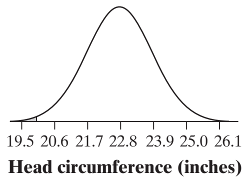
Answers to Chapter 2 AP® Statistics Practice Test

T2.1 e
T2.2 d
T2.3 b
T2.4 b
T2.5 a
T2.6 e
T2.7 c
T2.8 e
T2.9 e
T2.10 c
T2.11 **(a)** Jane's performance was better. Because her performance (40) exceeded the standard for the Presidential award (39), she performed above the 85th percentile. Matt's performance (40) met the standard for the National award (40), meaning he performed at the 50th percentile. **(b)** Because Jane's score has a higher percentile than Matt's score, she is farther to the right in her distribution than Matt is in his. Therefore, Jane's standardized score will likely be greater than Matt's.

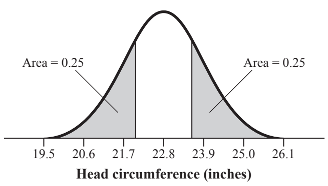
T2.12 **(a)** For male soldiers, head circumference follows a $N(22.8, 1.1)$ distribution and we want to find the percent of soldiers with head circumference less than 23.9 inches (see graph below). $z = \dfrac{23.9 - 22.8}{1.1} = 1$. From Table A, the proportion of z-scores below 1 is 0.8413. *Using technology:* `normalcdf(lower:−1000,upper:23.9,μ:22.8,σ:1.1)` = 0.8413. About 84% of soldiers have head circumferences less than 23.9 inches. Thus, 23.9 inches is at the 84th percentile.



(b) For male soldiers, head circumference follows a $N(22.8, 1.1)$ distribution and we want to find the percent of soldiers with head circumferences less than 20 inches or greater than 26 inches (see graph below). $z = \dfrac{20 - 22.8}{1.1} = -2.55$ and $z = \dfrac{26 - 22.8}{1.1} = 2.91$. From Table A, the proportion of z-scores below $z = -2.55$ is 0.0054 and the proportion of z-scores above 2.91 is $1 - 0.9982 = 0.0018$, for a total of $0.0054 + 0.0018 = 0.0072$. *Using technology:* 1 − `normalcdf(lower:20,upper:26,μ:22.8,σ:1.1)` $= 1 - 0.9927 = 0.0073$. A little less than 1% of soldiers have head circumferences less than 20 inches or greater than 26 inches and require custom helmets.



(**c**) For male soldiers, head circumference follows a $N(22.8, 1.1)$ distribution. The 1st quartile is the boundary value with 25% of the area to its left. The 3rd quartile is the boundary value with 75% of the area to its left (see graph below). A z-score of -0.67 gives the value closest to 0.25 (0.2514). Solving $-0.67 = \dfrac{x - 22.8}{1.1}$ gives $Q_1 = 22.063$. A z-score of 0.67 gives the value closest to 0.75 (0.7486). Solving $0.67 = \dfrac{x - 22.8}{1.1}$ gives $Q_3 = 23.537$. *Using technology*: `invNorm(area:0.25,μ:22.8,σ:1.1)` gives $Q_1 = 22.058$ and `invNorm(area:0.75,μ:22.8,σ:1.1)` gives $Q_3 = 23.542$. Thus, $IQR = 23.542 - 22.058 = 1.484$ inches.



T2.13 No. First, there is a large difference between the mean and the median. In a Normal distribution, the mean and median are the same, but in this distribution the mean is 48.25 and the median is 37.80. Second, the distance between the minimum and the median is 35.80 but the distance between the median and the maximum is 167.10. In a Normal distribution, these distances should be about the same. Both of these facts suggest that the distribution is skewed to the right.

Chapter 3

Section 3.1

Answers to Check Your Understanding

page 144: **1.** Explanatory: number of cans of beer. Response: blood alcohol level. **2.** Explanatory: amount of debt and income. Response: stress caused by college debt.

page 149: **1.** Positive. The longer the duration of the eruption, the longer we should expect to wait between eruptions because long eruptions use more energy and it will take longer to build up the energy needed to erupt again. **2.** Roughly linear with two clusters. The clusters indicate that, in general, there are two types of eruptions—shorter eruptions that last around 2 minutes and longer eruptions that last around 4.5 minutes. **3.** Fairly strong. The points don't deviate much from the linear form. **4.** There are a few possible outliers around the clusters. However, there aren't many and potential outliers are not very distant from the main clusters of points. **5.** How long the previous eruption was.

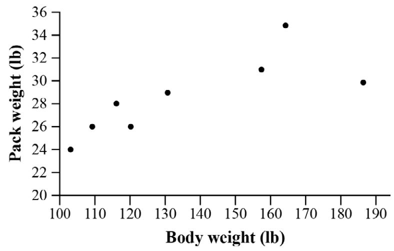
page 153: (**a**) $r \approx 0.9$. This indicates that there is a strong, positive linear relationship between the number of boats registered in Florida and the number of manatees killed. (**b**) $r \approx 0.5$. This indicates that there is a moderate, positive linear relationship between the number of named storms predicted and the actual number of named storms. (**c**) $r \approx 0.3$. This indicates that there is a weak, positive linear relationship between the healing rate of the two front limbs of the newts. (**d**) $r \approx -0.1$. This indicates that there is a weak, negative linear relationship between last year's percent return and this year's percent return in the stock market.

Answers to Odd-Numbered Section 3.1 Exercises

3.1 Explanatory: water temperature (quantitative). Response: weight change (quantitative).

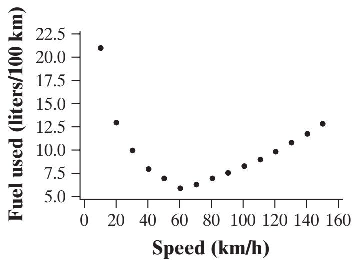
3.3 (**a**) Positive. Students with higher IQs tend to have higher GPAs and vice versa because both IQ and GPA are related to mental ability. (**b**) Roughly linear, because a line through the scatterplot of points would provide a good summary. Moderately strong, because most of the points would be close to the line. (**c**) IQ $\approx$ 103 and GPA $\approx$ 0.4.

3.5 A scatterplot is shown below.



3.7 (**a**) There is a positive association between backpack weight and body weight. For students under 140 pounds, there seems to be a linear pattern in the graph. However, for students above 140 pounds, the association begins to curve. Because the points vary somewhat from the linear pattern, the relationship is only moderately strong. (**b**) The hiker with body weight 187 pounds and pack weight 30 pounds. This hiker makes the form appear to be nonlinear for weights above 140 pounds. Without this hiker, the association would look very linear for all body weights.

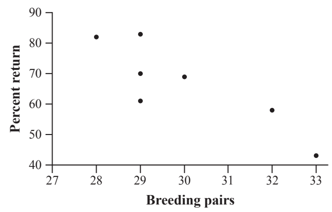
3.9 (**a**) A scatterplot is shown below. (**b**) The relationship is curved. Large amounts of fuel were used for low and high values of speed and smaller amounts of fuel were used for moderate speeds. This makes sense because the best fuel efficiency is obtained by driving at moderate speeds. (**c**) Both directions are present in the scatterplot. The association is negative for lower speeds and positive for higher speeds. (**d**) The relationship is very strong, with little deviation from a curve that can be drawn through the points.



3.11 (**a**) Most of the southern states fall in the same pattern as the rest of the states. However, southern states typically have lower mean SAT math scores than other states with a similar percent of students taking the SAT. (**b**) West Virginia has a much lower mean

SAT Math score than the other states that have a similar percent of students taking the exam.

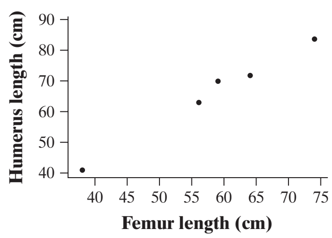
3.13 A scatterplot is shown below. There is a negative, linear, moderately strong relationship between the percent returning and the number of breeding pairs.



3.15 (a) $r = 0.9$ (b) $r = 0$ (c) $r = 0.7$ (d) $r = -0.3$ (e) $r = -0.9$

3.17 (a) Gender is a categorical variable and correlation r is for two quantitative variables. (b) The largest possible value of the correlation is $r = 1$. (c) The correlation r has no units.

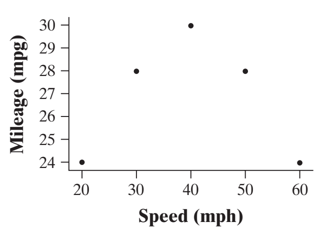
3.19 (a) The scatterplot below shows a strong, positive linear relationship between the two measurements. It appears that all five specimens come from the same species. (b) The femur measurements have $\bar{x} = 58.2$ and $s_x = 13.2$. The humerus measurements have $\bar{y} = 66$ and $s_y = 15.89$. The sum of the z-score products is 3.97620, so the correlation coefficient is $r = (1/4)(3.97620) = 0.9941$. The very high value of the correlation confirms the strong, positive linear association between femur length and humerus length in the scatterplot from part (a).



3.21 (a) There is a strong, positive linear association between sodium and calories. (b) It increases the correlation. It falls in the linear pattern of the rest of the data and observations with unusually small or unusually large values of x have a big influence on the correlation.

3.23 (a) The correlation would not change, because correlation is not affected by a change of units for either variable. (b) The correlation would not change, because it does not distinguish between explanatory and response variables.

3.25 (a) A scatterplot is shown below. (b) $r = 0$ (c) The correlation measures the strength of a *linear* association, but this plot shows a nonlinear relationship between speed and mileage.

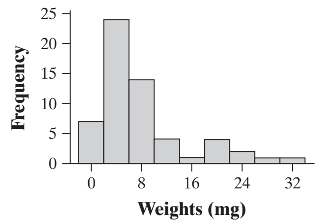


3.27 a

3.29 d

3.31 b

3.33 A histogram is shown below. The distribution is right-skewed, with several possible high outliers. Because of the skewness and outliers, we should use the median (5.4 mg) and IQR (5.5 mg) to describe the center and spread.



Section 3.2

Answers to Check Your Understanding

page 168: **1.** 40. For each additional week, we predict that a rat will gain 40 grams of weight. **2.** 100. The predicted weight for a newborn rat is 100 grams. **3.** $\hat{y} = 100 + 40(16) = 740$ grams **4.** 2 years = 104 weeks, so $\hat{y} = 100 + 40(104) = 4260$ grams. This is equivalent to 9.4 pounds (about the weight of a large newborn human). This is unreasonable and is the result of extrapolation.

page 172: The answer is given in the text.

page 174: **1.** $y - \hat{y} = 31{,}891 - 36{,}895 = -\$5004$ **2.** The actual price of this truck is \$5004 less than predicted based on the number of miles it has been driven. **3.** The truck with 44,447 miles and a price of \$22,896. This truck has a residual of −\$8120, which means that the line overpredicted the price by \$8120. No other truck had a residual that was farther below 0 than this one.

page 176: **1.** The backpack for this hiker was almost 4 pounds heavier than expected based on the weight of the hiker. **2.** Because there appears to be a negative-positive-negative pattern in the residual plot, a linear model is not appropriate for these data.

Answers to Odd-Numbered Section 3.2 Exercises

3.35 predicted weight = 80 − 6 (days)

3.37 (a) 1.109. For each 1-mpg increase in city mileage, the predicted highway mileage will increase by 1.109 mpg. (b) 4.62 mpg. This would represent the highway mileage for a car that gets 0 mpg in the city, which is impossible. (c) 22.36 mpg

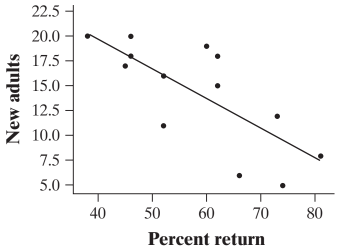
3.39 (a) −0.0053. For each additional week in the study, the predicted pH decreased by 0.0053 units. (b) 5.43. The predicted pH level at the beginning of the study (weeks = 0) is 5.43. (c) 4.635

3.41 No. 1000 months is well outside the observed time period and we can't be sure that the linear relationship continues after 150 weeks.

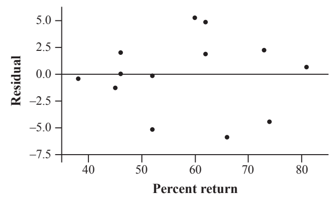
3.43 The line $\hat{y} = 1 - x$ is a much better fit. The sum of squared residuals for this line is only 3, while the sum of squared residuals for $\hat{y} = 3 - 2x$ is 18.

3.45 residual = 5.08 − 5.165 = −0.085. The actual pH value for that week was 0.085 less than predicted.

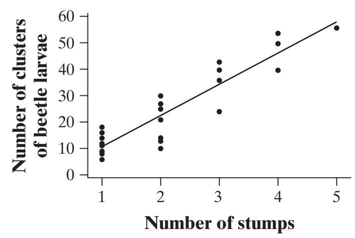
3.47 (a) The scatterplot (with regression line) is shown below. (b) $\hat{y} = 31.9 - 0.304x$. (c) For each increase of 1 in the percent of returning birds, the predicted number of new adult birds will decrease by 0.304. (d) residual = 11 − 16.092 = −5.092. In this colony, there were 5.092 fewer new adults than expected based on the percent of returning birds.

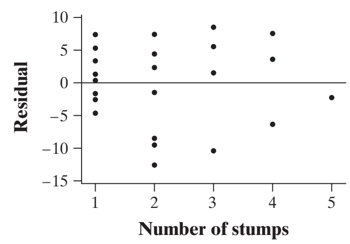


3.49 (a) Because there is no obvious leftover pattern in the residual plot shown below, a line is an appropriate model to use for these data. (b) The point with the largest residual (66% returning) has a residual of about −6. This means that the colony with 66% returning birds has about 6 fewer new adults than predicted based on the percent returning.

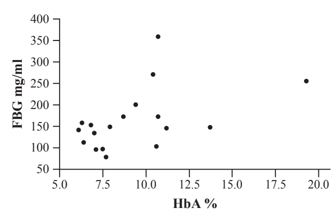


3.51 No. Because there is an obvious negative-positive-negative pattern in the residual plot, a linear model is not appropriate for these data.
3.53 (a) There is a positive, linear association between the two variables. There is more variation in the field measurements for larger laboratory measurements. (b) No. The points for the larger depths fall systematically below the line $y = x$, showing that the field measurements are too small compared to the laboratory measurements. (c) The slope would be closer to 0 and the y intercept would be larger.
3.55 (a) residual = 150.06 − 146.295 = 3.765. Yu-Na Kim's free skate score was 3.765 points higher than predicted based on her short program score. (b) Because there is no leftover pattern in the residual plot, a linear model is appropriate for these data. (c) When using the least-squares regression line with x = short program score to predict y = free skate score, we will typically be off by about 10.2 points. (d) About 73.6% of the variation in free skate scores is accounted for by the linear model relating free skate scores to short program scores.
3.57 r^2: About 56% of the variation in the number of new adults is accounted for by the linear model relating number of new adults to the percent returning. s: When using the least-squares regression line with x = percent returning to predict y = number of new adults, we will typically be off by 3.67 adults.
3.59 (a) $\hat{y} = 266.07 - 6.650x$, where y = percent of males that return the next year and x = number of breeding pairs. When $x = 30$, $\hat{y} = 66.57$. (b) R-Sq = 74.6% (c) $r = -\sqrt{0.746} = -0.864$. The sign is negative because the slope is negative. (d) When using the least-squares regression line with x = number of breeding pairs to predict y = percent returning, we will typically be off by 7.76%.
3.61 (a) $\hat{y} = 33.67 + 0.54x$. (b) If the value of x is 1 standard deviation below $\bar{x}$, the predicted value of y will be r standard deviations of y below $\bar{y}$. So the predicted value for the husband is $68.5 - 0.5(2.7) = 67.15$ inches.
3.63 (a) $r^2 = 0.25$. About 25% of the variation in husbands' heights is accounted for by the linear model relating husband's height to wife's height. (b) When using the least-squares regression line with x = wife's height to predict y = husband's height, we will typically be off by 1.2 inches.
3.65 (a) $\hat{y} = x$ where y = final and x = midterm (b) If $x = 50$, $\hat{y} = 67.1$. If $x = 100$, $\hat{y} = 87.6$. (c) The student who did poorly on the midterm (50) is predicted to do better on the final (closer to the mean), while the student who did very well on the midterm (100) is predicted to do worse on the final (closer to the mean).
3.67 *State*: Is a linear model appropriate for these data? If so, how well does the least-squares regression line fit the data? *Plan*: We will look at the scatterplot and residual plot to see if the association is linear or nonlinear. Then, if a linear model is appropriate, we will use s and r^2 to measure how well the line fits the data. *Do*: The scatterplot below shows a moderately strong, positive linear association between the number of stumps and the number of clusters of beetle larvae. The residual plot doesn't show any obvious leftover pattern, confirming that a linear model is appropriate.





$\hat{y} = -1.29 + 11.89x$, where y = number of clusters of beetle larvae and x = number of stumps. $s = 6.42$, meaning that our predictions will typically be off by about 6.42 clusters when we use the line to predict the number of clusters of beetle larvae from the number of stumps. Finally, $r^2 = 0.839$, meaning 83.9% of the variation in the number of clusters of beetle larvae is accounted for by the linear model relating number of clusters of beetle larvae to the number of stumps. *Conclude*: The linear model relating number of clusters of beetle larvae to the number of stumps is appropriate and fits the data well, accounting for more than 80% of the variation in number of clusters of beetle larvae.
3.69 (a) A scatterplot is shown below. There is a moderate, positive linear association between HbA and FBG. There are possible outliers to the far right (subject 18) and near the top of the plot (subject 15).



(b) Because the point is in the positive, linear pattern formed by most of the data values, it makes r closer to 1. Also, because the point is likely to be below the least-squares regression line, it will "pull down" the line on the right side, making the slope closer to 0. Without the outlier, r decreases from 0.4819 to 0.3837 as expected. Likewise, the equation changes from $\hat{y} = 66.4 + 10.4x$ to $\hat{y} = 52.3 + 12.1x$. (c) The point makes r closer to 0 because it is out of the linear pattern formed by most of the data values. Because this point's x coordinate is very close to $\bar{x}$ but the y coordinate is far above $\bar{y}$, it won't influence the slope very much but will increase the y intercept. Without the outlier, r increases from 0.4819 to 0.5684, as expected. Likewise, the equation changes from $\hat{y} = 66.4 + 10.4x$ to $\hat{y} = 69.5 + 8.92x$.

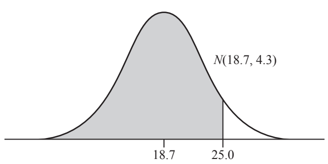
3.71 a

3.73 c

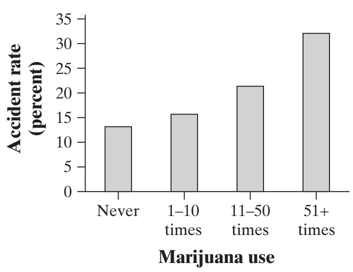
3.75 d

3.77 b

3.79 For these vehicles, the combined mileage follows a $N(18.7, 4.3)$ distribution and we want to find the percent of cars with lower mileage than 25 (see graph below). $z = \frac{25 - 18.7}{4.3} = 1.47$. From Table A, the proportion of z-scores below 1.47 is 0.9292. *Using technology:* `normalcdf(lower:-1000,upper:25,µ:18.7,σ:4.3)` = 0.9286. About 93% percent of vehicles get worse combined mileage than the Chevrolet Malibu.



3.81 (a) A bar graph is given below. The people who use marijuana more are more likely to have caused accidents. (b) Association does not imply causation. For example, it could be that drivers who use marijuana more often are more willing to take risks than other drivers and that the willingness to take risks is what is causing the higher accident rate.



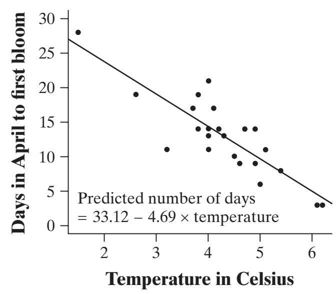
Answers to Chapter 3 Review Exercises

R3.1 (a) There is a moderate, positive linear association between gestation and life span. Without the outliers at the top and in the upper right, the association appears moderately strong, positive, and curved. (b) It makes r closer to 0 because it decreases the strength of what would otherwise be a moderately strong positive association. Because this point is close to $\bar{x}$ but far above $\bar{y}$, it won't affect the slope much but will increase the y intercept. Because it has such a large residual, it increases s. (c) Because it is in the positive, linear pattern formed by most of the data values, it will make r closer to 1. Also, because the point is likely to be above the least-squares regression line, it will "pull up" the line on the right side, making the slope larger and the intercept smaller. Because this point is likely to have a small residual, it decreases s.

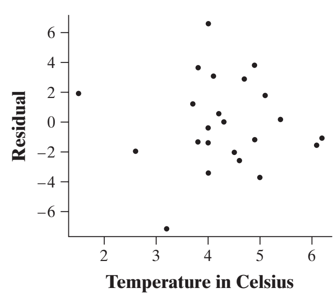
R3.2 (a) 0.0138. For each increase of 1 meter in dive depth, the predicted duration increases by 0.0138 minutes. (b) The y intercept suggests that a dive of 0 depth would last an average of 2.69 minutes; this obviously does not make any sense. (c) 5.45 minutes (d) If the variables are reversed, the correlation will remain the same. However, the slope and y intercept will be different.

R3.3 (a) $\hat{y} = 3704 + 12{,}188x$, where y represents the mileage of the cars and x represents the age. (b) residual = 65,000 − 76,832 = −11,832. This teacher has driven 11,832 fewer miles than predicted based on the age of the car. (c) $r = +\sqrt{0.837} = 0.915$. This shows that there is a strong, positive linear association between the age of cars and their mileage. (d) Yes, because there is no leftover pattern in the residual plot. (e) $s = 20{,}870.5$: When using the least-squares regression line with x = car's age to predict y = number of miles it has been driven, we will typically be off by about 20,870.5 miles. $r^2 = 83.7\%$: About 83.7% of the variability in mileage is accounted for by the linear model relating mileage to age.

R3.4 (a) The scatterplot is shown below. Average March temperature, because changes in March temperature probably have an effect on the date of first bloom.



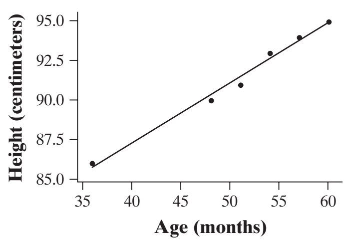
(b) $r = -0.85$ and $\hat{y} = 33.12 - 4.69x$, where y represents the number of days and x represents the temperature. r: There is a strong, negative linear association between the average March temperature and the days in April until first bloom. *Slope*: For every 1° increase in average March temperature, the predicted number of days in April until first bloom decreases by 4.69. *y intercept*: If the average March temperature was 0°C, the predicted number of days in April to first bloom is 33.12 (May 3). (c) No, $x = 8.2$ is well beyond the values of x we have in the data set. (d) residual = 10 − 12.015 = −2.015. In this year, the actual date of first bloom occurred about 2 days earlier than predicted based on the average March temperature. (e) There is no leftover pattern in the residual plot shown below, indicating that a linear model is appropriate.



R3.5 **(a)** $\hat{y} = 30.2 + 0.16x$, where y = final exam score and x = total score before the final examination. **(b)** 78.2 **(c)** Of all the lines that the professor could use to summarize the relationship between final exam score and total points before the final exam, the least-squares regression line is the one that has the smallest sum of squared residuals. **(d)** Because $r^2 = 0.36$, only 36% of the variability in the final exam scores is accounted for by the linear model relating final exam scores to total score before the final exam. More than half (64%) of the variation in final exam scores is *not* accounted for, so Julie has reason to question this estimate.
R3.6 Even though there is a high correlation between number of calculators and math achievement, we shouldn't conclude that increasing the number of calculators will *cause* an increase in math achievement. It is possible that students who are more serious about school have better math achievement and also have more calculators.

Answers to Chapter 3 AP® Statistics Practice Test

T3.1 d
T3.2 e
T3.3 c
T3.4 a
T3.5 a
T3.6 c
T3.7 b
T3.8 e
T3.9 b
T3.10 c
T3.11 **(a)** A scatterplot with regression line is shown below. **(b)** $\hat{y} = 71.95 + 0.3833x$, where y = height and x = age. **(c)** 255.934 cm, or 100.76 inches **(d)** This was an extrapolation. Our data were based only on the first 5 years of life and the linear trend will not continue forever.



T3.12 **(a)** The point in the upper-right-hand corner has a very high silicon value for its isotope value. **(b)** **(i)** r would get closer to -1 because it does not follow the linear pattern of the other points. **(ii)** Because this point is "pulling up" the line on the right side of the plot, removing it will make the slope steeper (more negative) and the y intercept smaller (note that the y axis is to the *right* of the points in the scatterplot). **(iii)** Because this point has a large residual, removing it will make s a little smaller.
T3.13 **(a)** $\hat{y} = 92.29 - 0.05762x$, where y is the percent of the grass burned and x is the number of wildebeest. **(b)** For every increase of 1000 wildebeest, the predicted percent of grassy area burned decreases by about 0.058. **(c)** $r = -\sqrt{0.646} = -0.804$. There is a strong, negative linear association between the percent of grass burned and the number of wildebeest. **(d)** Yes, because there is no obvious leftover pattern in the residual plot.

Chapter 4

Section 4.1

Answers to Check Your Understanding

page 213: **1.** Convenience sampling. This could lead the inspector to overestimate the quality of the oranges if the farmer puts the best oranges on top. **2.** Voluntary response sampling. In this case, those who are happy that the UN has its headquarters in the U.S. already have what they want and so are less likely to respond. The proportion who answered "No" in the sample is likely to be higher than the true proportion in the U.S. who would answer "No."
page 223: **1.** You would have to identify 200 different seats, go to those seats in the arena, and find the people who are sitting there, which would take a lot of time. **2.** It is best to create strata where the people within a stratum are very similar to each other but different than the people in other strata. In this case, it would be better to take the lettered rows as the strata because each lettered row is the same distance from the court and so would contain only seats with the same (or nearly the same) ticket price. **3.** It is best if the people in each cluster reflect the variability found in the population. In this case, it would be better to take the numbered sections as the clusters because they include all different seat prices.
page 228: **1.** **(a)** Undercoverage **(b)** Nonresponse **(c)** Undercoverage **2.** By making it sound like they are not a problem in the landfill, this question will result in fewer people suggesting that we should ban disposable diapers. The proportion who would say "Yes" to this survey question is likely to be smaller than the proportion who would say "Yes" to a more fairly worded question.

Answers to Odd-Numbered Section 4.1 Exercises

4.1 Population: all local businesses. Sample: the 73 businesses that return the questionnaire.
4.3 Population: the 1000 envelopes stuffed during a given hour. Sample: the 40 randomly selected envelopes.
4.5 This is a voluntary response sample. In this case, it appears that people who strongly support gun control volunteered more often, causing the proportion in the sample to be greater than the proportion in the population.
4.7 This is a voluntary response sample and overrepresents the opinions of those who feel most strongly about the issue being surveyed.
4.9 **(a)** A convenience sample **(b)** The first 100 students to arrive at school likely had to wake up earlier than other students, so 7.2 hours is probably less than the true average.
4.11 **(a)** Number the 40 students from 01 to 40. Pick a starting point on the random number table. Record two-digit numbers, skipping numbers that aren't between 01 and 40 and any repeated numbers, until you have 5 unique numbers between 01 and 40. Use the 5 students corresponding to these numbers. **(b)** Using line 107, skip the numbers not in bold: 82 73 95 78 90 **20** 80 74 75 **11** 81 67 65 53 00 94 **38** **31** 48 93 60 94 **07**. Select Johnson (20), Drasin (11), Washburn (38), Rider (31), and Calloway (07).
4.13 **(a)** *Using calculator*: Number the plots from 1 to 1410. Use the command `randInt(1,1410)` to select 141 different integers from 1 to 1410 and use the corresponding 141 plots. **(b)** Answers will vary.
4.15 **(a)** False—although, on average, there will be four 0s in every set of 40 digits, the number of 0s can be less than 4 or greater than 4 by chance. **(b)** True—there are 100 pairs of digits 00 through 99,

and all are equally likely. (**c**) False—0000 is just as likely as any other string of four digits.

4.17 (**a**) It might be difficult to locate the 20 phones from among the 1000 produced that day. (**b**) The quality of the phones produced may change during the day, so that the last phones manufactured are not representative of the day's production. (**c**) Because each sample of 20 phones does not have the same probability of being selected. In an SRS, it is possible for 2 consecutive phones to be selected in a sample, but this is not possible with a systematic random sample.

4.19 Assign numbers 01 to 30 to the students. Pick a starting point on the random digit table. Record two-digit numbers, skipping any that aren't between 01 and 30 and any repeated numbers, until you have 4 unique numbers between 01 and 30. Use the corresponding four students. Then assign numbers 0 to 9 to the faculty members. Continuing on the table, record one-digit numbers, skipping any repeated numbers, until you have 2 unique numbers between 0 and 9. Use the corresponding faculty members. Starting on line 123 gives 08-Ghosh, 15-Jones, 07-Fisher, and 27-Shaw for the students and 1-Besicovitch and 0-Andrews for the faculty.

4.21 (**a**) Use the three types of seats as the strata because people who can afford more expensive tickets probably have different opinions about the concessions than people who can afford only the cheaper tickets. (**b**) A stratified random sample will include seats from all over the stadium, which would make it very time-consuming to obtain. A cluster sample of numbered sections would be easier to obtain, because the people selected for the sample would be sitting close together.

4.23 No. In an SRS, each possible sample of 250 engineers is equally likely to be selected, including samples that aren't exactly 200 males and 50 females.

4.25 (**a**) Cluster sampling. (**b**) To save time and money. In an SRS, the company would have to visit individual homes all over the rural subdivision instead of only 5 locations.

4.27 (**a**) It is unlikely, because different random samples will include different students and produce different estimates of the proportion of students who use Twitter. (**b**) An SRS of 100 students. Larger random samples give us better information about the population than smaller random samples.

4.29 Because you are sampling only from the lower-priced ticket holders, this will likely produce an estimate that is too small, as fans in the club seats and box seats probably spend more money at the game than fans in cheaper seats.

4.31 (**a**) 89.1% (**b**) Because the people who have long commutes are less likely to be at home and be included in the sample, this will likely produce an estimate that is too small.

4.33 We would not expect very many people to claim they have run red lights when they haven't, but some people will deny running red lights when they have. Thus, we expect that the sample proportion underestimates the true proportion of drivers who have run a red light.

4.35 (**a**) The wording is clear, but the question is slanted in favor of warning labels because of the first sentence stating that some cell phone users have developed brain cancer. (**b**) The question is clear, but it is slanted in favor of national health insurance by asserting it would reduce administrative costs and not providing any counterarguments. (**c**) The wording is too technical for many people to understand. For those who do understand the question, it is slanted because it suggests reasons why one should support recycling.

4.37 c

4.39 d

4.41 d

4.43 (**a**) For each additional day, the predicted sleep debt increases by about 3.17 hours. (**b**) The predicted sleep debt for a 5-day school week is $2.23 + 3.17(5) = 18.08$ hours. This is about 3 hours more than the researcher claimed for a 5-day week, so the students have reason to be skeptical of the research study's reported results.

Section 4.2

Answers to Check Your Understanding

page 237: **1.** Experiment, because a treatment (brightness of screen) was imposed on the laptops. **2.** Observational study, because students were not assigned to eat a particular number of meals with their family per week. **3.** Explanatory: number of meals per week eaten with their family. Response: GPA. **4.** There are probably other variables that are influencing the response variable. For example, students who have part-time jobs may not be able to eat many meals with their families and may not have much time to study, leading to lower grades.

page 247: **1.** Randomly assign the 29 students to two treatments: evaluating the performance in small groups or evaluating the performance alone. The response variable will be the accuracy of their final performance evaluations. To implement this design, use 29 equally sized slips of paper. Label 15 of them "small group" and 14 of them "alone." Then shuffle the papers and hand them out at random to the 29 students, assigning them to a treatment. **2.** The purpose of the control group is to provide a baseline for comparison. Without a group to compare to, it is impossible to determine if the small group treatment is more effective.

page 249: **1.** No. Perhaps seeing the image of their unborn child encouraged the mothers who had an ultrasound to eat a better diet, resulting in healthier babies. **2.** No. While the people weighing the babies at birth may not have known whether that particular mother had an ultrasound or not, the mothers knew. This might have affected the outcome because the mothers knew whether they had received the treatment or not. **3.** Treat all mothers as if they had an ultrasound, but for some mothers the ultrasound machine wouldn't be turned on. To avoid having mothers know the machine was turned off, the ultrasound screen would have to be turned away from all the mothers.

Answers to Odd-Numbered Section 4.2 Exercises

4.45 Experiment, because students were randomly assigned to the different teaching methods.

4.47 (**a**) Observational study, because mothers weren't assigned to eat different amounts of chocolate. (**b**) Explanatory: the mother's chocolate consumption. Response: the baby's temperament. (**c**) No, this study is an observational study so we cannot draw a cause-and-effect conclusion. It is possible that women who eat chocolate daily have less stressful lives and the lack of stress helps their babies to have better temperaments.

4.49 Type of school. For example, private schools tend to have smaller class sizes and students that come from families with higher socioeconomic status. If these students do better in the future, we wouldn't know if the better performance was due to smaller class sizes or higher socioeconomic status.

4.51 Experimental units: pine seedlings. Explanatory variable: light intensity. Response variable: dry weight at the end of the study. Treatments: full light, 25% light, and 5% light.

4.53 Experimental units: the individuals who were called. Explanatory variables: (1) information provided by interviewer; (2) whether caller offered survey results. Response variable: whether or not the call was completed. Treatments: (1) name/no offer; (2) university/no offer; (3) name and university/no offer; (4) name/offer; (5) university/offer; (6) name and university/offer.

4.55 Experimental units: 24 fabric specimens. Explanatory variables: (1) roller type; (2) dyeing cycle time; (3) temperature. Response variable: a quality score. Treatments: (1) metal, 30 min, 150°; (2) natural, 30 min, 150°; (3) metal, 40 min, 150°; (4) natural, 40 min, 150°; (5) metal, 30 min, 175°; (6) natural, 30 min, 175°; (7) metal, 40 min, 175°; (8) natural, 40 min, 175°.

4.57 There was no control group. We don't know if the improvement was due to the placebo effect or if the flavonols actually affected the blood flow.

4.59 **(a)** Write all names on slips of paper, put them in a container, and mix thoroughly. Pull out 40 slips of paper and assign these subjects to Treatment 1. Then pull out 40 more slips of paper and assign these subjects to Treatment 2. The remaining 40 subjects are assigned to Treatment 3. **(b)** Assign the students numbers from 1 to 120. Using the command `RandInt (1,120)` on the calculator, assign the students corresponding to the first 40 unique numbers chosen to Treatment 1, the students corresponding to the next 40 unique numbers chosen to Treatment 2, and the remaining 40 students to Treatment 3. **(c)** Assign the students numbers from 001 to 120. Pick a spot on Table D and read off the first 40 unique numbers between 001 and 120. The students corresponding to these numbers are assigned to Treatment 1. The students corresponding to the next 40 unique numbers between 001 and 120 are assigned to Treatment 2. The remaining 40 students are assigned to Treatment 3.

4.61 Random assignment. If players are allowed to choose which treatment they get, perhaps the more motivated players will choose the new method. If they improve more by the end of the study, the coach can't be sure if it was the exercise program or player motivation that caused the improvement.

4.63 *Comparison:* Researchers used a design that compared a low-carbohydrate diet with a low-fat diet. *Random assignment:* Subjects were randomly assigned to one of the two diets. *Control:* The experiment used subjects who were all obese at the beginning of the study and who all lived in the same area. *Replication:* There were 66 subjects in each treatment group.

4.65 Write the names of the patients on 36 identical slips of paper, put them in a hat, and mix them well. Draw out 9 slips. The corresponding patients will receive the antidepressant. Draw out 9 more slips. Those patients will receive the antidepressant plus stress management. The patients corresponding to the next 9 slips drawn will receive the placebo, and the remaining 9 patients will receive the placebo plus stress management. At the end of the experiment, record the number and severity of chronic tension-type headaches for each of the 36 subjects and compare the results for the 4 groups.

4.67 **(a)** Other variables include expense and condition of the patient. For example, if a patient is in very poor health, a doctor might choose not to recommend surgery because of the added complications. Then we won't know if a higher death rate is due to the treatment or the initial health of the subjects. **(b)** Write the names of all 300 patients on identical slips of paper, put them in a hat, and mix them well. Draw out 150 slips and assign the corresponding subjects to receive surgery. The remaining 150 subjects receive the new method. At the end of the study, count how many patients survived in each group.

4.69 The subjects developed rashes on the arm exposed to the placebo (a harmless leaf) simply because they thought they were being exposed to a poison ivy leaf. Likewise, most of the subjects didn't develop rashes on the arm that was exposed to poison ivy because they didn't think they were being exposed to the real thing.

4.71 Because the experimenter knew which subjects had learned the meditation techniques, he is not blind. If the experimenter believed that meditation was beneficial, he may subconsciously rate subjects in the meditation group as being less anxious.

4.73 **(a)** To make sure that the two groups were as similar as possible before the treatments were administered. **(b)** The difference in weight loss was larger than would be expected due to the chance variation created by the random assignment to treatments. **(c)** Even though the low-carb dieters lost 2 kg more over the year than the low-fat group, a difference of 2 kg could be due just to chance variation created by the random assignment.

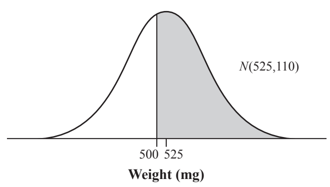
4.75 **(a)** The different diagnoses, because the treatments were randomly assigned to patients within each diagnosis. **(b)** Using a randomized block design allows us to account for the variability in response due to differences in diagnosis by initially comparing the results within each block. In a completely randomized design, this variability will be unaccounted for, making it harder to determine if there is a difference in health and satisfaction due to the difference between doctors and nurse-practitioners.

4.77 **(a)** A randomized block design would help us account for the variability in yield that is due to the differences in fertility in the field, making it easier to determine if one variety is better than the others. **(b)** The rows. There should be a stronger association between row number and yield than column number and yield. **(c)** Let the digits 1 to 5 correspond to the five corn varieties A to E. Begin with line 111 on the random digit table, and assign the letters to the top row from left to right, ignoring numbers 0 and 6–9 and repeated numbers. Use a different line (111, 112, 113, 114, and 115) for each row. Top row (left to right): ADECB, second row: ECDAB, third row: BEDCA, fourth row: DEACB, bottom row: ADCBE.

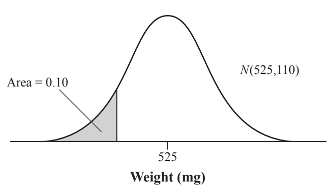
4.79 **(a)** If all rats from litter 1 were fed Diet A and if these rats gained more weight, we would not know if this was because of the diet or because of genetics and initial health. **(b)** Use a randomized block design with the litters as blocks. For each of the litters, randomly assign half of the rats to receive Diet A and the other half to receive Diet B. This will allow researchers to account for the differences in weight gain caused by the differences in genetics and initial health.

4.81 **(a)** Matched pairs design. **(b)** In a completely randomized design, the differences between the students will add variability to the response, making it harder to detect if there is a difference caused by the treatments. In a matched pairs design, each student is compared with himself (or herself), so the differences between students are accounted for. **(c)** If all the students used the hands-free phone during the first session and performed worse, we wouldn't know if the better performance during the second session is due to the lack of phone or to learning from their mistakes the first time. By randomizing the order, some students will use the hands-free phone during the first session and others during the second session. **(d)** The simulator, route, driving conditions, and traffic flow were all kept the same for both sessions, preventing these variables from adding variability to the response variable.

4.83 (**a**) Randomly assign the 20 subjects into two groups of 10. Write the name of each subject on a note card, shuffle the cards, and select 10 to be assigned to the 70º environment. The remaining 10 subjects will be assigned to the 90º environment. Then the number of correct insertions will be recorded for each subject and the two groups compared. (**b**) All subjects will perform the task twice, once in each temperature condition. Randomly choose the order by flipping a coin. Heads: 70º, then 90º. Tails: 90º, then 70º. For each subject, compare the number of correct insertions in each environment.
4.85 (**a**) If the students find a difference between the two groups, they will not know if the difference is due to gender or the deodorant. (**b**) Each student should have one armpit randomly assigned to receive Deodorant A and the other Deodorant B. Because each gender uses both deodorants, there is no longer any confounding between gender and deodorant.
4.87 c
4.89 b
4.91 c
4.93 b
4.95 (**a**) For these seeds, the weights follow a $N(525, 110)$ distribution and we want the proportion of seeds that weigh more than 500 mg (see graph below). $z = \dfrac{500 - 525}{110} = -0.23$. From Table A, the proportion of z-scores greater than -0.23 is $1 - 0.4090 = 0.5910$. *Using technology* `normalcdf(lower:500,upper:10000,µ:525,σ:110)` = 0.5899. About 59% of seeds will weigh more than 500 mg.



(**b**) For these seeds, the weights follow a $N(525, 110)$ distribution and we are looking for the boundary value x that has an area of 0.10 to the left (see graph below). A z-score of -1.28 gives the closest value to 0.10 (0.1003). Solving $-1.28 = \dfrac{x - 525}{110}$ gives $x = 384.2$. *Using technology*: `invNorm(area:0.10,µ:525,σ:110)` = 384.0. The smallest weight among the remaining seeds should be about 384 mg.

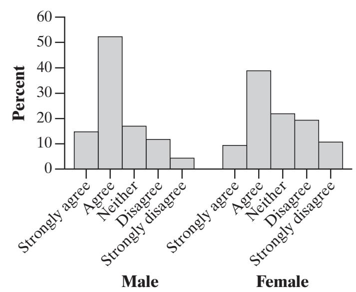


Section 4.3

Answers to Odd-Numbered Section 4.3 Exercises

4.97 If the study involves random sampling, we can make inferences about the population from which we sampled. If the study involves random assignment, we can make inferences about cause and effect.
4.99 Because this study involved random assignment to the treatments, we can infer that the difference between foster care or institutional care caused the difference in response.
4.101 Because this study did not involve random assignment to a treatment, we cannot infer cause and effect. Also, because the individuals were not randomly chosen, we cannot generalize to a larger population.
4.103 As daytime running lights become more common, they may be less effective at catching the attention of other drivers. Also, a driving simulator might not be very realistic.
4.105 Answers will vary.
4.107 Answers will vary.
4.109 Confidential. The person taking the survey knows who is answering the questions, but will not share the results of individuals with anyone else.
4.111 The subjects were not able to give informed consent. They did not know what was happening to them and they were not old enough to understand the ramifications.
4.113 The conditional distributions for males and females are displayed in the table and graph below. Men are more likely to view animal testing as justified if it might save human lives: over two-thirds of men agree or strongly agree with this statement, compared to slightly less than half of the women. The percentages who disagree or strongly disagree tell a similar story: 16% of men versus 30% of women.

Response	Male	Female
Strongly agree	14.7%	9.3%
Agree	52.3%	38.8%
Neither	16.9%	21.9%
Disagree	11.8%	19.3%
Strongly disagree	4.3%	10.7%



Answers to Chapter 4 Review Exercises

R4.1 (**a**) Population: all Ontario residents. Sample: the 61,239 people interviewed. (**b**) Because different samples will produce different estimates, it is unlikely that the percentages in the entire population would be exactly the same as the percentages in the sample. However, they should be fairly close.
R4.2 (**a**) Announce in a daily bulletin that there is a survey concerning student parking available in the main office for students who want to respond. Because those who feel strongly are more likely to respond, their opinions will be overrepresented. (**b**) Interview a group of students as they come in from the parking lot. People who already can park on campus might have different opinions about the parking situation than those who cannot.

R4.3 (a) Number the players from 01 to 25 in alphabetical order. Move from left to right, reading pairs of digits until you find three different pairs between 01 and 25, and select the corresponding players. (b) 17 (Musselman), 09 (Fuhrmann), and 23 (Smith).
R4.4 Stratified, because it is likely that the opinions of professors will vary based on which type of institution they are at. Then a stratified random sample will provide a more precise estimate than the other methods. Furthermore, the other methods might miss faculty from one particular type of institution.
R4.5 (a) People may not remember how many movies they watched in a movie theater in the past year. So shorten the amount of time that they ask about, perhaps 3 or 6 months. (b) This will underrepresent younger adults who use only cell phones. If younger adults go to movies more often than older adults, the estimated mean will be too small. (c) Because the frequent moviegoers will not be at home to respond, the estimated mean will be too small.
R4.6 (a) Different anesthetics were not randomly assigned to the subjects. (b) Type of surgery. If Anesthesia C is used more often with a type of surgery that has a higher death rate, we wouldn't know if the death rate was higher because of the anesthesia or the type of surgery.
R4.7 (a) Units: potatoes. Explanatory: storage method and time from slicing until cooking. Response: ratings of color and flavor. Treatments: (1) fresh/immediately, (2) fresh/after an hour, (3) room temperature/immediately, (4) room temperature/after an hour, (5) refrigerator/immediately, (6) refrigerator/after an hour. (b) Using 300 identical slips of paper, write "1" on 50 of them, "2" on 50 of them, and so on. Put the papers in a hat and mix well. Then select a potato and randomly select a slip from the hat to determine which treatment that potato will receive. Repeat this process for the remaining 299 potatoes, making sure not to replace the slips of paper into the hat. (c) Use a randomized block design with regular potatoes in one block and sweet potatoes in the other block. Randomly assign the 6 treatments within each block as in part (b).
R4.8 (a) No. The 1000 students were not randomly selected from any larger population. (b) Yes. The students were randomly assigned to the three treatments.
R4.9 (a) By giving some patients a treatment that should have no effect at all, but appears like the Saint-John's-wort, the researchers can account for the expectations of patients (the placebo effect) by comparing the results for the two groups. (b) To create two groups of subjects that are roughly equivalent at the beginning of the experiment. (c) The subjects should not know which treatment they are getting so that the researchers can account for the placebo effect. The researchers should be unaware of which subjects received which treatment so that they cannot influence how the results are measured. (d) The difference in improvement between the two groups wasn't large enough to rule out the chance variation caused by the random assignment to treatments.
R4.10 (a) Randomly assign 15 students to easy mazes and the other 15 to hard mazes. Use 30 identical slips of paper and write the name of each subject on a slip. Mix the slips in a hat, select 15 of them at random, and assign these subjects to hard mazes. The remaining 15 will be assigned to easy mazes. After the experiment, compare the time estimates of the two groups. (b) Each student does the activity twice, once with each type of maze. Randomly determine which set of mazes is used first by flipping a coin for each subject. Heads: easy, then hard. Tails: hard, then easy. After the experiment, compare each student's easy maze and hard maze time estimate. (c) The matched pairs design would be more likely to detect a difference because it accounts for the variability between subjects.
R4.11 (a) This does not meet the requirements of informed consent because the subjects did not know the nature of the experiment before they agreed to participate. (b) All individual data should be kept confidential and the experiment should go before an institutional review board before being implemented.

Answers to Chapter 4 AP® Statistics Practice Test

T4.1 c
T4.2 e
T4.3 d
T4.4 c
T4.5 b
T4.6 b
T4.7 d
T4.8 d
T4.9 d
T4.10 b
T4.11 d
T4.12 (a) Experimental units: acacia trees. Treatments: placing either active beehives, empty beehives, or nothing in the trees. Response: damage to the trees caused by elephants. (b) Assign the trees numbers from 01 to 72 and use a random number table to pick 24 different two-digit numbers in this range. Those trees will get the active beehives. The trees corresponding to the next 24 different two-digit numbers from 01 to 72 will get the empty beehives, and the remaining 24 trees will remain empty. Compare the damage caused by elephants to the three groups of trees.
T4.13 (a) Not all possible samples of size 1067 were possible. For example, using their method, they could not have had all respondents from the east coast. (b) If the household members who typically answer the phone have a different opinion than those who don't typically answer the phone, their opinions will be overrepresented. (c) If people without phones or with cell phones only have different opinions than the group of people with residential lines, these opinions will be underrepresented.
T4.14 (a) Each of the 11 individuals will be a block in this matched pairs design, with the order of treatments randomly assigned. This was to help account for the variability in tapping speed caused by the differences in subjects. (b) If all the subjects got caffeine the second time, the researchers wouldn't know if the increase was due to the caffeine or due to practice with the task. (c) Yes. Neither the subjects nor the people who come in contact with them during the experiment (including those who record the number of taps) need to know the order in which the caffeine or placebo was administered.

Answers to Cumulative AP® Practice Test 1

AP1.1 d
AP1.2 e
AP1.3 b
AP1.4 c
AP1.5 a
AP1.6 c
AP1.7 e
AP1.8 e
AP1.9 d
AP1.10 d
AP1.11 d