APPENDIX B

Answers to Selected Odd-Numbered Exercises

Chapter 1

1. **a.** An individual automobile **b.** All automobiles of that type used in the EPA tests **c.** All automobiles of that type that are or may be manufactured
3. **a.** All students at the University of Wisconsin **b.** A statistic, since calculated only for the 100 sampled students
5. **a.** All adult Americans **b.** Proportion of all adult Americans who would answer definitely or probably true **c.** Sample proportion 0.523 estimates population proportion **d.** No, it is an estimate of the population value but will not equal it exactly, because the sample is only a very small subset of the population.
7. **a.** 85.7% **b.** 85.8% **c.** 74.4%, higher for HEAVEN
9. a
15. Inferential statistics are used when you have data only for a sample and need to make predictions about the entire population.
17. **a.** The percentage in the Eurobarometer sample for a country who say "yes." **b.** The population percentage (or proportion) in a country who would say "yes." **c.** 45% of 631 sampled in the UK say "yes." **d.** The prediction that between 41% and 49% of the UK population would say "yes."

Chapter 2

3. **a.** Ordinal **b.** Nominal **c.** Interval **d.** Nominal **e.** Nominal **f.** Ordinal **g.** Interval **h.** Ordinal **i.** Nominal **j.** Interval **k.** Nominal
5. **a.** Interval **b.** Ordinal **c.** Nominal
7. **a.** Ordinal **b.** discrete **c.** Statistics, because they apply to a sample of size 1962, not the entire population
9. b, c, d, e, f **11.** Students numbered 10, 22, 24.
13. **a.** observational **b.** experimental **c.** observational **d.** experimental
15. **a.** Different organizations choose different samples, and so there is sampling variability (i.e., results naturally vary from sample to sample). They may also have used slightly different sampling methods and question wording. **b.** The difference between the predicted percentage and the actual percentage was −2.4 for Gore, 0.1 for Bush, and 1.3 for Nader.
19. Skip number is $k = 5000/100 = 50$. Pick a number at random between 01 and 50. Suppose it is 10, Then the first selection is the subject numbered 10; the next is numbered $10 + 50 = 60$; next is $60 + 50 = 110$; last is $4910 + 50 = 4960$.

21. **a.** (i) yes, (ii) no **b.** (i) no, (ii) yes **c.** Cluster: Samples all subjects in some of the groups; Stratified: Samples some subjects in all of the groups
25. Nonprobability
29. Because of skipping names, two subjects listed next to each other on the list cannot both be in the sample, so not all samples are equally likely.
31. Every possible sample is not equally likely. For example, the probability is 0 of a sample for which everyone is in the same cluster.
33. Cluster sampling followed by simple random sampling
35. c **37.** a **39.** False

Chapter 3

1. **c.** categorical **d.** Mode = Central America
3. **a.** 33 students, minimum = 65, maximum = 98
7. **a.** Mean = 57.4 **b.** Median = 17, very different because the outlier (California) affects the mean but not the median
9. **a.** Not far enough **b.** Median = not far enough, mean requires scores for categories
5. **b.** 16.6 **c.** 12.0 **d.** 13.9 **e.** Mean = 27.6, Median = 24.0, Standard deviation = 12.4; the lengths of stay tended to be longer 25 years ago **f.** Of the 11 observations, the middle in magnitude is 13.0, the median; cannot calculate mean, but substituting 40 for censored observation gives lower bound for it of 18.7.
7. **b.** Median = 2 or 3 times a month, Mode = Not at all. **c.** Mean = 4.5
9. **a.** Mean = 73.2 **b.** Median = 16, very different because the outlier (California) affects the mean but not the median
13. Skewed right, which pulls mean out in right tail above median
15. **a.** Mode = every day, median = a few times a week
17. **a.** Response = family income in 2003, explanatory = racial–ethnic group (white, black, Hispanic) **b.** No **c.** The sample size for each group
19. **a.** median = $10.13, mean = $10.18, range = $0.46, standard deviation = $0.22 **b.** median = $10.01, mean = $9.17, range = $5.31, standard deviation = $2.26. The small outlier drags the mean down, but increases the range and standard deviation substantially
21. Mean = 26.7, standard deviation = 11.1
23. **a.** (i) $40,000 to $60,000, (ii) $30,000 to $70,000, (iii) $20,000 to $80,000 **b.** Yes, it would be five standard deviations above the mean, which would be very unusual for a bell-shaped distribution.
25. **a.** 88.8 **b.** No, the distribution is extremely skewed to the right.
27. **a.** 0.4 **b.** −10.0
29. **a.** Skewed to right **b.** Yes, the maximum is 43.5 standard deviations above the mean.
31. **a.** $28,700 **b.** $9600
33. The large outlying observation increases the mean somewhat, increases the standard deviation moreso, and has a very strong effect on increasing the maximum and the range. The quartiles are unaffected.
35. Expect mean to be greater than median in cases a, b, d, since distributions are probably skewed to right; expect median to be greater in cases c, e since distributions are probably skewed to left.

39. **a.** minimum = 0, lower quartile = 2, median = 3, upper quartile = 5, maximum = 14 **c.** outliers at 12 and 14 **d.** 3
41. **b.** Skewed right
43. **a.** min = 1, LQ = 3, Median = 5, UQ = 6, max = 13 **b.** min = 1, LQ = 3, Median = 5, UQ = 6, max = 44, so the very large value affects only the maximum.
45. **a.** 3.88 **b.** 0.76 **c.** (i) 2.48, (ii) 3.58
47. **a.** Response: opinion about health insurance (favor or oppose); Explanatory: political party (Democratic, Republican)
49. **a.** 1.2 and 3.2 **b.** Nations with higher use of the Internet tend to have lower fertility rates.
51. **a.** positive **b.** Luxembourg is extremely high on both variables.
53. **a.** Sample mean and population mean **b.** Sample standard deviation and population standard deviation
63. Median = $86, 100
67. Any nominal variable, such as religious affiliation
69. **a.** Mean can be misleading with very highly skewed distributions or extreme outliers in one direction. **b.** Median can be uninformative with highly discrete data.
71. **a.** F **b.** F **c.** T **d.** T **73.** c
75. Standard deviation
77. Population sizes vary by state, and the overall rate gives more weight to states with larger population sizes, whereas the mean of the 50 measurements gives the same weight to each state.

Chapter 4

1. 0.80
3. **b.** (i) 30/96 = 0.312, (ii) 88/1021 = 0.086 **c.** (i) 30/1117, (ii) (0.086)(0.312) **d.** (30 + 933)/1117
5. **b.** 0.13
7. **a.** $P(0) = P(1) = \ldots = P(9) = 0.1$ **b.** 4.5 **c.** 2.9
9. **a.** $z = 1.0$ gives tail probability 0.1587, thus two-tail probability 2(0.1587) = 0.317, or probability between $\mu - \sigma$ and $\mu + \sigma$ equal to 1 − 0.317 = 0.683.
11. **a.** 0.67 **b.** 1.64 **c.** 1.96 **d.** 2.33 **e.** 2.58
13. 5% is in each tail, for which $z = 1.64$, and thus $\mu + 1.64\sigma$ is the 95th percentile.
15. **a.** 0.018 **b.** 0.018 **c.** 0.982 **d.** 0.964
17. **a.** 2.05 **b.** 133
19. **a.** 0.106 **b.** 120.5 **c.** 89, 100, 111
21. **a.** 0.21 **b.** 11.8 **c.** skewed right
23. **a.** The ACT score, which is $z = 1.7$ standard deviations above mean, compared to SAT score which is $z = 1.0$ standard deviations above mean
25. **a.** 27.8% **b.** No, probably skewed right since mean is only 1.2 standard deviations above 0.
27. **a.** P(0) = P(1) = 0.5 **b.** P(0) = 0.25, P(0.5) = 0.5, P(1) = 0.25 **c.** P(0) = 0.125, P(1/3) = 0.375, P(2/3) = 0.375, P(1) = 0.125 **d.** P(0) = 0.0625, P(0.25) = 0.250, P(0.50) = 0.375, P(0.75) = 0.250, P(1) = 0.0625 **e.** Becoming more bell shaped

29. a. 0.0104 **b.** Yes, the sample proportion would be 5.7 standard errors below the mean, which would happen very rarely. **c.** Predict that Brown won

31. a. Mean = 0.10, standard error of $\bar{y}$ is $\sigma/\sqrt{n} = 316.23/\sqrt{1,000,000} = 0.316$. **b.** For the sampling distribution of the sample mean, 1.0 has a z-score of $(1.0 - 0.10)/0.316 = 2.85$. The probability that the average exceeds 1.0 is the probability that a z-score exceeds 2.85, which equals 0.002.

33. a. $z = -0.67$, probability 0.25 **b.** By CLT, approximately normal with mean 100 and standard error $15/\sqrt{25} = 3.0$. $z = -3.33$, probability = 0.0004 below 90. **c.** No (only 0.67 standard deviations below mean). Yes, since probability is only 0.0004 of sample mean of 90 or less.

35. a. Number of people in a household **b.** mean = 2.6, standard deviation = 1.5 **c.** mean = 2.4, standard deviation = 1.4 **d.** mean = 2.6, standard error = 0.1

37. a. Standard error = $3.0/\sqrt{36} = 0.50$; distance of 0.5 has z-score of $0.5/0.5 = 1.00$, and 0.68 of a normal curve falls within 1.00 standard errors of mean. **b.** Standard error = $3.0/\sqrt{100} = 0.30$; 0.5 has z-score of $0.5/0.3 = 1.67$, and 0.90 of a normal curve falls within 1.67 standard errors of mean. **c.** Yes, because 4.0 falls $(4.0 - 5.2)/0.3 = -4.0$ standard errors from mean, which is extremely unlikely for a normal distribution.

39. a. Skewed left, mean 60, standard deviation 16
b. Mean 58.3, standard deviation 15.0, probably skewed left (It looks like the population distribution).
c. Mean 60, standard error 1.6, normal (by CLT)
d. An observation of 40 is 1.25 standard deviations below the mean, which is not unusual, but a sample mean of 40 is 12.5 standard errors below the mean of the sampling distribution of the sample mean (extremely unusual).

47. a. 4.41 **b.** 4

49. If half of population voted for Clinton, sample proportion would be 12.4 standard errors above 0.50, extremely unlikely. Predict Clinton won.

51. a, c, d **53.** False

55. a. $\sigma^2 = (0 - 0.5)^2(0.5) + (1 - 0.5)^2(0.5) = 0.25$, and $\sigma = 0.50$
b. $\mu = 0(1 - \pi) + 1(\pi) = \pi$
c. Substitute $\sigma = \sqrt{\pi(1 - \pi)}$ (from (b)) in standard error $\sigma/\sqrt{n}$.

57. a. Finite population correction = $\sqrt{(30{,}000 - 300)/(30{,}000 - 1)} = \sqrt{0.99} = 0.995$.
b. Finite population correction = 0, so $\sigma_{\bar{Y}} = 0$.
c. For $n = 1$, the sample mean is a single observation from the population, so the sampling distribution is the same as the population distribution.

Chapter 5

1. 0.716 **3.** 0.017 **5.** $\sqrt{(0.51)(0.49)/1008} = 0.0157$, and margin of error = $2(0.0157) = 0.031$

7. a. $\sqrt{(0.36)(0.64)/883} = 0.016$ **b.** $1.96(0.016) = 0.03$ **c.** 0.36 ± 0.03, or (0.33, 0.39)

9. 95% CI is $0.19 \pm 1.96(0.0113)$, which is (0.17, 0.21), and 99% CI is $0.19 \pm 2.58(0.0113)$, which is (0.16, 0.22)

11. a. 0.02 probability in two tails, so 0.01 in each tail, or $z = 2.33$. **b.** 1.64 **c.** 0.67 **d.** 3.0

13. a. 0.364, 0.636 **b.** The 95% confidence interval of (0.33, 0.40) suggests that a minority supports legalization. **c.** The proportion has somewhat of an increasing trend.

15. $0.255 \pm 2.58(0.002)$, or (0.25, 0.26)

17. a. $0.40 \pm 2.58\sqrt{(0.40)(0.60)/400} = 0.40 \pm 0.06$, or (0.34, 0.46). Can predict Jones loses, because the interval consists entirely of numbers below 0.50, corresponding to Jones receiving a minority of the vote.
b. $0.40 \pm 2.58\sqrt{(0.40)(0.60)/40} = 0.40 \pm 0.20$, or (0.20, 0.60). We would not predict a winner, because the interval contains numbers both below and above 0.50. The point estimate is the same as in (a), but the interval is much wider because the sample size is so much smaller.

19. a. 2.776 **b.** 2.145 **c.** 2.064 **d.** 2.060 **e.** 2.787

21. a. $52.554/\sqrt{1007}$ **c.** The large standard deviation relative to the mean suggests the distribution is highly skewed to the right, and there may be extreme outliers.

23. a. $1.77/\sqrt{397}$ **b.** $2.89 \pm 1.97(0.089)$ is (2.7, 3.1)

25. The confidence interval is a prediction about the population mean, not about where values of y fall for individual subjects. We can be 95% confident that the population mean TV watching falls between 2.60 and 2.93 hours per day.

27. a. No, the mean exceeds the median and is only $20.3/18.2 = 1.1$ standard deviations above 0, so the distribution is probably skewed to the right. **b.** Yes, since n is so large, the sampling distribution is normal by the Central Limit Theorem. The interval is $20.3 \pm 2.58(18.2)/\sqrt{1415}$, or (19.2, 21.5).

29. b. The variable cannot take negative values, but the standard deviation has similar size as the mean. Although the population distribution and sample data distribution are probably skewed right, the sampling distribution of the sample mean is bell-shaped by the Central Limit Theorem.

31. a. $4.23 \pm 2.58(0.0387)$ is 4.23 ± 0.10, or (4.13, 4.23)
b. (i) narrower, (ii) wider **c.** Interval scale, with equal spacings between each pair of adjacent categories

33. a.

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 5 : 69
 6 : 04
 7 : 003789
 8 : 33456
 9 : 022346
10 : 008
11 : 12
12 : 024
13 : 9
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It is probably roughly mound shaped. **b.** $\bar{y} = 90.0$, $s = 20.7$
c. $se = 20.7/\sqrt{30} = 3.77$, so 95% confidence interval is $90.0 \pm 2.045(3.77) = 90.0 \pm 7.7$, or (82.3, 97.7)

35. $n = (1.64)^2(0.30)(0.70)/(0.06)^2 = 157$

37. a. $n = (1.96)^2(0.1)(0.9)/(0.02)^2 = 864$ **b.** $n = (1.96)^2(0.5)(0.5)/(0.02)^2 = 2401$

39. $n = (1.96)^2(0.83)(0.17)/(0.03)^2 = 602$

41. If 0 to 18 encompasses the mean plus and minus about three standard deviations, then the standard deviation is approximately 3, and we need $n = (1.96)^2(3)^2/(1)^2 = 35$.

43. No, do not have at least 15 in one of the categories (death before adulthood). Use formula after adding 2 outcomes of each type to get $\hat{\pi} = 5/34 = 0.147$, with $se = \sqrt{(0.147)(0.853)/34} = 0.0607$ and CI $0.147 \pm 1.96(0.0607)$, or (0.028, 0.266).

45. Indices of the $n = 30$ ordered observations for the interval are $(n + 1)/2 \pm \sqrt{n} = 15.5 \pm 5.5$, or 10 and 21. The 10th smallest observation is 79 and the 21st smallest (10th largest) is 96. The confidence interval is ($7900, $9600).

49. **a.** $7.27 \pm 2.00(6.72)/\sqrt{60}$, or (5.5, 9.0) **b.** $\hat{\pi} = 31/60 = 0.517$, and CI is $0.517 \pm 1.96\sqrt{(0.517)(0.483)/60}$, or (0.39, 0.64).

57. **b.** $\bar{y} = 4.8, s = 2.89$

59. **a.** It would usually be too wide to be very useful, since we must use such a large z-score ($z = 3.9$) or t-score in forming the interval. **b.** A 25% confidence interval has too low a chance of containing the unknown parameter value.

61. The greater the heterogeneity, the greater the value of σ. Hence, the larger the sample size needed, since n is directly proportional to σ^2. It would require a larger sample to estimate mean age to within 1 year than to estimate mean number of years of education to within 1 year, since age is much more variable.

63. No, statistical inference is needed when you have only a sample from the population, but here you have data for the entire population.

65. **a.** With $n = 30$ and $\hat{\pi} = 0.50$, there were $30(0.50) = 15$ in each category, which is the minimum needed to use this method.

67. a **69.** b, e

71. We are 95% confident that the population mean age at first marriage fell between 21.5 and 23.0. If random samples of 50 records were repeatedly selected, then in the long run 95% of the confidence intervals formed would contain the population mean.

73. $y_n = n\bar{y} - (y_1 + y_2 + \cdots + y_{n-1})$ **75.** $\hat{\pi} = 0.0$

Chapter 6

1. **a.** null **b.** alternative **c.** alternative **d.** $H_0: \pi = 0.50, H_a: \pi < 0.24, H_a: \mu > 100$

3. **a.** $2(0.149) = 0.30$, so it is plausible that the population mean equals 0.
b. $2(0.0062) = 0.012$, which is much stronger evidence against the null. Smaller P-values give stronger evidence.
c. 0.149, 0.851

5. **a.** $t = (103 - 100)/2 = 1.50, P = 2(0.067) = 0.134$ **b.** $t = 3.00, P = 0.003$. An effect of a given size has smaller P-value when the sample size is larger.

7. **a.** $H_0: \mu = 500$, $H_a: \mu \neq 500, t = (410 - 500)/30 = -3.0, df = 8, 0.01 < P < 0.02$ (actual value is 0.017, which we could report at $P = 0.02$); there is strong evidence that the mean differs from 500, and a 95% confidence interval would suggest that it is less than 500.
b. $P = 0.01$, very strong evidence that mean less than 500. **c.** $P = 0.99$

9. **a.** $H_0 : \mu = 0$, $H_a : \mu \neq 0$ **b.** Standard error $= 1.253/\sqrt{996} = 0.0397$, $t = (-0.052 - 0)/0.0397 = -1.31, P = 0.19$. Do not reject H_0. It is plausible that true mean $= 0$.

c. No, the CI in (d) shows that many values are plausible other than 0. We can never accept H_0.
d. (−0.13, 0.03), and 0 in CI corresponds to not rejecting H_0 in (b).

11. $\alpha = 0.01$; when reject at $\alpha = 0.01$ level, the 99% CI does not contain H_0 value of parameter.

13. **a.** $z = (0.35 - 0.50)/\sqrt{(0.50)(0.50)/100} = -3.0$ **b.** $P = 0.00135$, which gives strong evidence in favor of H_a that $\pi < 0.50$.
c. Reject H_0 and conclude that $\pi < 0.50$.
d. Type I error. Use smaller α level.

15. **a.** $H_0: \pi = 0.5, H_a: \pi \neq 0.5$ **b.** $z = -3.9$ means the sample proportion is 3.9 standard errors below the H_0 value of 0.5. **c.** If H_0 were true, the probability of getting a sample proportion at least 3.9 standard errors from 0.5 would be 0.000 (rounded to three decimal places). **d.** This shows how far from 0.5 the population proportion may plausibly fall.

17. $z = (0.345 - 0.333)/\sqrt{(0.333)(0.667)/116} = 0.26$, P-value $= 0.40$. Cannot reject H_0, and it is plausible that the astrologers are randomly guessing.

19. **a.** $\hat{\pi} = 230/400 = 0.575, se_0 = \sqrt{(0.5)(0.5)/400} = 0.025, z = (0.575 - 0.5)/0.025 = 3.0$, P-value $= 2(.00135) = .003$ in testing $H_0 : \pi = 0.5$ against $H_a : \pi \neq 0.5$, giving strong evidence that $\pi < 0.5$.
b. $\hat{\pi} = 23/40 = 0.575$ again, but $se_0 = \sqrt{(0.5)(0.5)/40} = 0.079, z = (0.575 - 0.5)/0.079 = 0.95$, P-value $= 2(0.17) = 0.34$. We would not predict a winner, since there is a moderate probability (0.34) of one or the other candidate having at least 23 supporters out of a random sample of size 40, even if exactly half the population favored each candidate.

21. **a.** $H_0: \pi = 0.25$, $H_a: \pi > 0.25$, where π = population proportion correctly answering the question.
b. $\hat{\pi} = 125/400 = 0.3125$, $se_0 = \sqrt{(0.25)(0.75)/400} = 0.022$, $z = (0.3125 - 0.25)/0.022 = 2.84$, for which $P = .002$. There is very strong evidence against H_0. We conclude that the proportion answering correctly is greater than would be expected just due to chance.

23. **a.** Jones gets $t = (519.5 - 500)/10.0 = 1.95$ and $P = 0.051$; Smith gets $t = (519.7 - 500)/10.0 = 1.97$ and $P = 0.049$.
b. For $\alpha = 0.05$, Jones does not reject H_0 but Smith does. Only Smith's study is significant at the 0.05 level.
c. These two studies give such similar results that they should not yield different conclusions. Reporting the actual P-value shows that each study has moderate evidence against H_0.

25. $t = (497 - 500)/[100/\sqrt{10,000}] = -3.0$, P-value $= 0.003$, which is highly statistically sgnificant, yet 497 is so close to 500 as to be practically indistinguishable from it.

27. $40/(40 + 140) = 0.22$

29. **a.** $\hat{\pi} \geq 0.5 + 1.64\sqrt{0.5(0.5)/25} = 0.664$ gives $z \geq 1.64$ and $P \leq .05$.
b. $z = (0.664 - 0.60)/0.1 = 0.64$; fail to reject if $\hat{\pi} < 0.664$, which happens with probability 0.74.

31. **a.** 0.49; P(Type II error) gets larger as μ gets closer to the value in H_0.
b. 0.16, compared to 0.045 when $\alpha = 0.05$. The P(Type II error) increases as α decreases, for a fixed value in H_a.
c. P(Type II error) decreases as n increases, for a fixed value in H_a.

33. **a.** Let π = probability she guesses correctly on a particular flip. We test H_0: $\pi = 0.5$ against H_a: $\pi > 0.5$.
b. Find the right-tail probability for the binomial distribution with $n = 5$ and $\pi = 0.5$. That is, the P-value is $P(4) + P(5) = 5/32 + 1/32 = 0.19$. This outcome is not unusual if she does not actually possess ESP. Her claim is not convincing.

35. **a.** Binomial mean and standard deviation for $n = 1{,}000{,}000$ and $\pi = 0.0001$ are $\mu = 1{,}000{,}000(0.0001) = 100$ and $\sigma = \sqrt{1000000(0.0001)(0.9999)} = 10.0$
b. Yes, 0 is $(0 - 100)/10.0 = -10$ standard deviations from the expected value.
c. Region within two standard deviations of the mean is (80, 120).
d. $\mu = 200$, $\sigma = 14.1$, values tend to be larger and more variable than for females.

37. **a.** $\bar{y} = 3.033, s = 1.64, z = -4.57, P < 0.0001$, so there is strong evidence that political ideology differs from 4.0. The sample mean suggests that $\mu < 4.0$.
b. $\hat{\pi} = 0.783$, for which $z = 5.32$ and $P < 0.0001$. There is very strong evidence that the proportion favoring legalized abortion differs from 0.50 (in fact, is larger than 0.50).

39. $\bar{y} = 4.0, s = 2.0, t = (4.0 - 0)/1.0 = 4.0, df = 3, 0.01 < P < 0.025$ for H_a: $\mu > 0$ (actual $P = 0.014$); moderately strong evidence that $\mu > 0$.

43. $\bar{y} = 2.39, s = 6.45, se = 1.20, t = 1.99, P = 0.056$ for H_a: $\mu \neq 0$. This observation makes difference in terms of whether the two-sided test is significant at the 0.05 level.

45. **a.** A Type I error occurs when one convicts the defendant, when he or she is actually innocent; a Type II error occurs when one acquits the defendant even though he or she is actually guilty.
b. To decrease P(Type I error), one gives the defendant additional rights and makes it more difficult to introduce evidence that may be inadmissible in some way. This makes it more likely that the defendant will not be convicted, hence that relatively more guilty parties will be incorrectly acquitted.
c. You will be unlikely to convict someone even if they are truly guilty.

47. **a.** The P-value is less than 0.05. If H_0 were true, the probability of getting a sample result like the observed or even more extreme (more contradictory to H_0) would be less than 0.05. Thus, the data suggest that H_0 is false, meaning that the population mean has changed.
b. $P = 0.001$ would provide much more evidence against H_0 than $P = 0.04$, for instance, yet both are significant at the 0.05 level. It would also be informative to report the sample mean and standard error, so the reader can construct a confidence interval of any specified confidence level, if desired.

49. Assumptions are never exactly satisfied, so the actual sampling distribution is only approximated by the nominal one (standard normal or t), and it is overly optimistic to report P-values to several decimal places.

51. **a.** For each test, the probability equals 0.05 of falsely rejecting H_0 and committing a Type I error. For 20 tests, the number of false rejections has the binomial distribution with $n = 20$ and $\pi = 0.05$. The expected number of false rejections is the binomial mean, $\mu = n\pi = 20(0.05) = 1$. That is, we expect about 1 researcher to reject H_0, and the result of this study may then be the one published. This policy encourages the publishing of Type I errors.
b. Of all the studies conducted, the one with the most extreme or unusual results is the one that gets substantial attention. That result may be an unusual sample, with the sample mean far from the actual population mean. Further studies in later research would reveal that the true mean is not so extreme.

53. b, e **55.** a, c **57.** F, T, F, T

59. The value in H_0 is only one of many plausible values for the parameter. A confidence interval would display a range of possible values for the parameter. The terminology "Accept H_0" makes it seem as if the null value is the only plausible one.

61. **a.** H_0 either is, or is not, correct. It is not a variable, so one cannot phrase probability statements about it.
b. If H_0 is true, the probability that $\bar{y} \geq 120$ or that $\bar{y} \leq 80$ (i.e., that $\bar{y}$ is at least 20 from $\mu_0 = 100$, so that $|z|$ is at least as large as observed) is 0.057.
c. This is true if "$\mu = 100$" is substituted for "$\mu \neq 100$."
d. The probability of Type I error equals α (which is not specified here), not the P-value. The P-value is compared to α in determining whether one can reject H_0.
e. Better to say, "We do not reject H_0 at the $\alpha = 0.05$ level."
f. No, we need $P \leq 0.05$ to be able to reject H_0.

63. **a.** Binomial, $n = 100$, $\pi = 0.05$
b. No, if H_0 is correct each time, the probability she would get a P-value ≤ 0.05 all five times is $(0.05)^5 = 0.0000003$.

65. Would get $\hat{\pi} = 0.0$, $se = 0.0$, and $z = -\infty$. This cannot happen using se_0.

67. **a.** $x = 5$, P-value $= 1/32 = 0.03$. **b.** No value of x has P-value < 0.01. **c.** 1/32, the probability of x such that the P-value is ≤ 0.05.

Chapter 7

1. Independent samples **3.** 0.204, $\sqrt{(0.02)^2 + (0.02)^2} = 0.028$

5. 24 pounds, $se = \sqrt{(2)^2 + (2)^2} = 2.83$ **b.** $164/140 = 1.17$, which is 17% higher **c.** Difference = 25 pounds, ratio = 1.15

7. **a.** $832/58 = 14.3$ **b.** $0.00832 - 0.00058 = 0.00774$ **c.** relative risk

9. **a.** We can be 95% confident that the population proportion who have started sexual intercourse is between 0.18 and 0.26 higher for those who listen to lots of music with degrading sexual messages than for those who listen to little or none.
b. Extremely strong evidence that the population proportion who have started sexual intercourse is higher for those who listen to lots of music with degrading sexual messages.

11. **a.** $\sqrt{(0.399)(0.601)/12708 + (0.482)(0.518)/8783} = 0.0069$ **b.** $0.083 \pm 1.96(0.0069) = (0.07, 0.10)$

13. $0.19 \pm 1.96(0.0216) = (0.15, 0.23)$

15. **b.** $\hat{\pi} = 0.36, se = 0.0324, z = 0.62$. **c.** $P = 0.53$. **d.** Educational level, for which the estimated difference is 0.14, compared to 0.02 for gender.

17. 95% confidence interval comparing proportions for women and men is $(0.060 - 0.055) \pm 1.96(0.010)$, which is $(-0.015, 0.025)$. The population proportions could be the same, and if they differ, the difference is quite small.

19. **a.** We can be 95% confident that the mean number of close friends for males is between 1.5 lower and 2.7 higher than the mean number of close friends for females.
b. The standard deviations exceeding the mean suggests that the distributions may be highly skewed to the right. This does not affect the method, because the

sampling distribution of the difference between the sample means is approximately bell-shaped for such large sample sizes. Extreme skew may make the means less useful than the medians, especially if there are also extreme outliers.

21. **a.** Difference between sample means = 4.9. **b.** We can be 95% confident that the population mean HONC score is between 4.1 and 5.7 higher for smokers than for ex-smokers. **c.** Probably highly skewed to the right. This does not affect inference, because the sampling distribution of the difference between sample means would be bell-shaped for such large samples.

23. There is strong evidence that the population mean is slightly higher for females, but the confidence interval shows that the difference is small.

25. **a.** Can conclude that population mean is higher for blacks.
b. If population means were equal, it would extremely unlikely to observe a difference as large as we did or even larger.
c. The 95% CI does not contain 0, and the null hypothesis of a 0 difference between the population means would be rejected at the $\alpha = 0.05$ level (since the P-value is smaller than 0.05).

27. Estimated standard error is $49.4/\sqrt{12} = 14.3$, and test statistic is $t = 70.1/14.3 = 4.9$.

29. **a.** The evidence is weak against H_0 of equal population means. **b.** The 95% confidence interval contains 0, and the hypothesis of 0 difference between population means is not rejected at the 0.05 level.

31. **a.** 20 in each case **c.** $20 \pm 4.303(2.887)$, which is 20 ± 12.4, or (7.6, 32.4) **d.** $t = 20/2.887 = 6.93$, $df = 3 - 1 = 2$, $P = 2(0.01) = 0.02$, so relatively strong evidence that therapy B has higher population mean improvement scores.

33. The sample standard deviations are quite different, so we might not trust the results based on assuming equal variances. The approximate test without that assumption shows very strong evidence ($P < 0.01$) that the population means differ.

35. **a.** $t = -4.0$ ($df = 8$) and two-sided P-value = 0.004. There is very strong evidence that the mean drop was higher for course B. A 95% confidence interval for the difference in means is $(2.0 - 6.0) \pm 2.306(1)$, or $(-6.3, -1.7)$.
c. $4.0/1.58 = 2.5$. The difference between the sample means is 2.5 standard deviations, which is quite large.
d. There are $5 \times 5 = 25$ pairs of observations. B is higher on 23 pairs and gets 1/2 credit for the two pairs with $y_B = 3$ and $y_A = 3$, so the estimated probability is $24/25 = 0.96$. This is a very strong effect.

37. **a.** $\hat{\pi}_1 = (108 + 157)/294 = 265/294 = 0.90$ for environment, $\hat{\pi}_2 = 113/294 = 0.38$ for cities.
b. McNemar statistic $z = (n_{12} - n_{21})/\sqrt{n_{12} + n_{21}} = (5 - 157)/\sqrt{5 + 157} = -152/12.7 = -11.9$. The P-value is essentially 0. There is extremely strong evidence that the proportion supporting increased spending is higher for the environment.
c. $(0.90 - 0.38) \pm 1.96(0.031) = 0.52$, or (0.46, 0.58). We conclude that the population proportion of approval is between 0.46 and 0.58 higher for spending on the environment.

39. **a.** The groups have small samples, with only 2 and 0 observations in the B/L/G category. **b.** P-value = 0.30, so not much evidence that the probabilities differ for the two groups.

49. **a.** (i) 95% CI 4 ± 3.4, or (0.6, 7.6) comparing population mean parental support for single-mother households and households with both biological parents. (ii) P-value = 0.02 for testing equality of population means.

51. **a.** The samples are dependent, so you need to know the sample proportions for the four possible sequences of responses on the two questions (i.e., (favorable, good), (favorable, not good), (unfavorable, good), (unfavorable, not good)).
b. The sample size for the 2000 survey

53. Each standard error is 3.16. The standard error for the difference between two sample means is $\sqrt{(3.16)^2 + (3.16)^2} = 4.47$. The margin of error for a 95% confidence interval comparing two means is about $2(4.47) = 8.9$. For comparing Canada and the U.S., the interval would be 9.0 ± 8.9, or (0.1, 17.9), so we conclude an actual difference exists between the population means.

55. Since se for the difference is $\sqrt{(se_1)^2 + (se_2)^2}$, the se for comparing two means is larger than the se for estimating one of those means. The same is true for the margins of error.

57. **a.**

Number Males In Sample	Possible Samples Of Size 3
0	(F_1, F_2, F_3)
1	(M_1, F_1, F_2) (M_1, F_1, F_3) (M_1, F_2, F_3)
1	(M_2, F_1, F_2) (M_2, F_1, F_3) (M_2, F_2, F_3)
1	(M_3, F_1, F_2) (M_3, F_1, F_3) (M_3, F_2, F_3)
2	(F_1, M_1, M_2) (F_1, M_1, M_3) (F_1, M_2, M_3)
2	(F_2, M_1, M_2) (F_2, M_1, M_3) (F_2, M_2, M_3)
2	(F_3, M_1, M_2) (F_3, M_1, M_3) (F_3, M_2, M_3)
3	(M_1, M_2, M_3)

b. Each of the 20 samples is equally likely. The 10 samples with 2 or 3 males chosen have $\hat{\pi}_1 - \hat{\pi}_2 \geq 1/3$. **c.** $P = 1/20 = 0.05$.

59. **a.** False **b.** False **61.** True **63.** a, c, d

65. **a.** The sample proportion correct has approximately a normal sampling distribution with mean 0.5 and standard error $\sqrt{0.5(0.5)/100} = 0.05$. A score of 70 has $z = (0.7 - 0.5)/0.05 = 4.0$. The probability of a score of at least 70 is about 0.00003.
b. The sampling distribution of the difference between Jane's and Joe's proportions is approximately normal with mean $0.6 - 0.5 = 0.1$ and standard error $\sqrt{\frac{0.6(0.4)}{100} + \frac{0.5(0.5)}{100}} = 0.07$. The probability the difference is negative is the probability that a z-score is less than $(0 - 0.1)/0.07 = -1.43$, which is 0.08.
c. The standard errors decrease as the number of questions increases, and the probabilities decrease.

Chapter 8

1. **a.** (40%, 60%) in each row **b.** Yes

3. **a.** Dependent, **b.** (40%, 60%) in each row

5. **a.** For those with breast cancer, the conditional proportion is 0.86 for a positive test and 0.14 for a negative test. For those not having breast cancer, the conditional proportion is 0.12 for a positive test and 0.88 for a negative test. Yes, it seems to perform well as a diagnostic tool. **b.** Of those who test positive, the conditional probability of actual breast cancer is 860/12,660 = 0.068. The 12% of false diagnoses for those who do not have breast cancer are much larger in number than the 86% of correct diagnoses for those who have it, because the number having it is relatively very small.

7. 3.84 ($df = 1$), b. 9.49 ($df = 4$) c. 9.49 d. 26.30 e. 26.30

9. **a.** H_0: GRNSOL is independent of sex, H_a: GRNSOL and sex are statistically dependent. **b.** $df = 4$ for 2×5 table **c.** (i) Cannot reject H_0, (ii) Reject H_0

13. **a.** Extremely strong evidence of association between income and happiness. **b.** The count in the first cell was 5.34 standard errors larger than we'd expect if the variables were independent. More people were (below average in income, not happy) and (above average in income, very happy) than we'd expect if variables were independent. Fewer people were (below average in income, very happy) and (above average in income, not happy) than we'd expect if variables were independent.

15. More females are very religious and more males are not at all religious than we'd expect if variables were independent. Fewer females are not at all religious and fewer males are very religious than we'd expect if variables were independent.

17. Very strong, as difference between proportions approving was 0.73.

19. **a.** 0.60 **b.** 0.33 **c.** 17.7, no

21. **a.** 1.04, 0.22 **b.** 4.7

23. 1.37 for Democrat and Independent, 1.40 for Democrat and Republican, 1.03 for Independent and Republican

23. **a.** (i) 15, (ii) 27 **b.** −0.29 **c.** 15/42 − 27/42

25. **a.** Sample gamma = 0.163, a weak positive association. There is a slight tendency for students with higher family incomes to have higher aspirations.
b. Test statistic $\chi^2 = 8.87, df = 6$. The P-value of $P = 0.18$ does not provide much evidence against the null hypothesis of independence of aspirations and family income.
c. A 90% confidence interval for the population value of gamma is $0.163 \pm 1.96(.080) = 0.163 \pm 0.157$, or (0.006, 0.320). It seems that the population value of gamma is positive, although the association may be very weak since the interval contains values very close to 0.
d. Test based on gamma has test statistic $z = 0.163/0.080 = 2.04$, and two-sided P-value $2(0.0207) = 0.04$. There is evidence of a positive association. The chi-squared test ignores the ordinal nature of the variables and does not detect this evidence.

37. **a.** Size of χ^2 is directly proportional to n, for a particular set of cell proportions; small P can occur for large n even when association is weak in practical terms. **b.** The standard error for $\bar{y}$ or $\hat{\pi}$ or a comparison of two values gets smaller as the sample size increases. So, for a given size of effect, the test statistic tends to be larger as the sample size is.

39. a, b, c, d

41. **a.** Each expected frequency equals $n/4$. Substituting into χ^2 formula gives the result. **b.** Since χ^2 cannot exceed n, $\hat{\phi}^2$ cannot exceed 1. Similarly, since χ^2 cannot be negative, neither can $\hat{\phi}^2$.

43.

a.	L	M	H	b.	L	M	H	c.	L	M	H
Low	10	0	0		0	0	10		10	10	10
Medium	0	10	0		0	10	0		5	15	5
High	0	0	10		10	0	0		10	5	10

45. CI for log odds ratio of $4.37 \pm 1.96(0.0833)$ exponentiates to CI for odds ratio of (67.3, 93.2).

Chapter 9

1. y = college GPA in (a), number of children in (b), annual income in (c), and assessed value of home in (d).

3. **a.** y-intercept = 61.4, slope = 2.4, predicted height increases 2.4 cm for each 1 cm increase in femur length. **b.** 181.4 cm

5. y-intercept about 18, slope about 0.5

7. **a.** (i) 1.5, (ii) 13.1 **b.** $\hat{y} = 13.1$, residual = 6.6, carbon dioxide emissions much higher than predicted for level of GDP. **c.** $\hat{y} = 11.0$, residual = −5.3, carbon dioxide emissions much lower than predicted for level of GDP.

9. **a.** 209.9 = predicted violent crime rate for state with poverty rate = 0, 25.5 = increase in predicted violent crime rate for an increase of 1 in percentage below the poverty level.
b. $\hat{y} = 482.8$, $805 - 482.8 = 322.2$, so violent crime rate much higher than predicted for this level of poverty.
c. $10(25.5) = 255$
d. Positive, since it has same sign as the slope.

11. **a.** (i) $x = 20$, $y = 87$, (ii) $x = 36$, $y = 41$ **b.** $\hat{y} = 89.7$, residual = −44.6, much lower use of cell phones that predicted for that GDP level. **c.** Positive, so cell-phone use tends to increase as GDP increases.

13. $r = b(s_X/s_Y)$, so $b = r(s_Y/s_X) = 0.60(120/80) = 0.90$; $a = \bar{y} - b\bar{x} = 500 - 0.9(480) = 68$. Thus, $\hat{y} = a + bx = 68 + 0.9x$.

15. **a.** $\hat{y} = 5.0 - 0.4x$; predicted daily number of hours watching television decreases by 0.4 for an increase of 1 in number of books read.
b. $r = -1$, since the line has a negative slope and passes through all the data points.

17. **a.** There is a 23.7% reduction in error in predicting GPA using TV watching (with the linear prediction equation), compared to using the sample mean TV watching. **b.** $-\sqrt{0.237} = -0.49$ **c.** Weaker

19. **a.** $4000(2/16,000) = 0.50$ **b.** $\hat{y} = -16,000 + 3200x$, with correlation 0.50

21. Strongest association between PAEDUC and MAEDUC, each variable has tendency to increase as another variable increases.

23. **a.** No, fertility and GDP have different units. **b.** Units are same for cell-phone use and Internet use.

25. **a.** Positive **b.** $\hat{y} = -5.18 + 1.13x$, D.C. has $\hat{y} = 15.7$ and residual 28.3. **c.** 0.585 Yes. Now, slope = 0.49, less than half as large.

27. **b.** $\hat{y} = 4.845 - 0.039x$ **c.** $r = -0.57$, $r^2 = 0.32$

29. **a.** $t = 19.7$, P-value = 0 to many decimal places, extremely strong evidence of a positive association **b.** (0.265, 0.323) **c.** When mother's education is a certain number of standard deviations from the mean, the predicted education is 37% of that many standard deviations from its mean.

31. **a.** H_0: $\beta = 0$, H_a: $\beta \neq 0$, $t = 0.00739/0.1706 = 0.43$, P-value = 0.66, plausible that variables are independent, as shown also by 95% CI for β of $(-0.03, 0.04)$ **b.** the correlation = 0.0155

33. **b.** Stronger, because the correlation tends to be larger when the range of x values observed is larger.

43. **a.** y = salary, x = height, slope = \$789 **b.** 7(\$789)

47. **a.** New slope = old slope divided by 2.0. **b.** Correlation does not change.

49. **a.** Over time, y would fluctuate rather than follow linear trend.
b. Much more variability in y at high levels of x. **c.** Relationship may be U-shaped rather than linear.
d. As x increases, y tends to increase but eventually levels off.

51. Regression toward the mean

53. Bridgeport, because of more variability in x = high school GPA values

55. **a.** Sample standard deviation of y scores **b.** Sample standard deviation of x scores **c.** Estimated standard deviation of conditional distribution of y at each fixed value of x **d.** Estimated standard error of sample slope b

59. **a.** b **61.** c, f, g

63. $r = b(s_x/s_y) = b(1/1) = b$, so slope = correlation. Formula for y-intercept is $a = \bar{y} - b\bar{x} = 0 - b(0) = 0$, so prediction equation is $\hat{y} = 0 + rx = rx$.

67. **a.** Interchange x and y in the formula and you get the same value.
b. If the units of measurement change, the z-score does not. For instance, if the values are doubled, then the deviation of an observation from the mean doubles, but so does the standard deviation, and the ratio of the deviation to the standard deviation does not change.

69. **c.** As the sample size increases, the width of the confidence interval for the mean goes to 0, and we can estimate the mean nearly perfectly. However large the sample size, even if we know the true mean, we cannot predict individual observations. They fluctuate around the mean with a certain variability that does not depend on the sample size.
d. (i) For instance, the width of the prediction interval is the same at an x-value that is c units above $\bar{x}$ as it is at an x value that is c units below $\bar{x}$. But if the variability increases, the interval should be wider above the mean than below the mean.

Chapter 10

3. **a.** No, perhaps more firefighters are called to fires that are more severe, involving larger buildings. **b.** Z = size of structure that burned

5. **b.** A third variable dealing with a factor such as the subject's natural curiosity or inquisitiveness could be positively associated with both variables. Subjects who tend to be higher in this characteristic might tend to have higher GPAs and to be more likely to experiment with marijuana.

7. **a.** Positive correlation between shoe size and number of books read is explained by age, which is strongly positively correlated with each of these.

9. **b.** Common cause

11. The difference would need to disappear (except for sampling error) after family income is controlled.

13. **a.**

	White C.	Blue C.
Democrat	265	735
Republican	735	265

Yes, the percentage of white collar occupations is 26.5% for Democrats and 73.5% for Republicans.
b. No, conditional distributions are identical in each partial table; differences of proportions = 0 and odds ratio = 1 in each table. Controlling for income, the variables are independent.
c. Income tends to be higher for Republicans than Democrats, and it tends to be higher for white-collar than blue-collar occupations.
d. Occupation affects income, which affects party choice
e. Income jointly affects occupation and party choice. Chain relationship is more appropriate, since it is more plausible that occupation affects income than the reverse.

15. **b.** Size of home and number of bedrooms are both associated with selling price but also associated with each other. Because size of home is associated both with number of bedrooms and selling price, the effect of number of bedrooms on selling price depends on whether we control for size of home.

19. Ignoring the subject of the exam, there is no association, but there is a substantial association in each partial table.

21. **a.** \$10,689, **b.** \$5150, so the effect of gender is greater for whites than for blacks.

23. **a.** Response = whether have cancer, explanatory = whether a smoker, control = age
b. Yes, the association is stronger for older subjects. Smoking seems to have a stronger effect for older subjects, who have presumably been smoking for a longer period.

29. **a.** Mean number of children higher for families for which English is the primary language.
b. For each province, the mean number of children is higher for families for which French is the primary language.
c. Most French-speaking families are in Quebec, where the means are lower regardless of language, and most English-speaking families are in other provinces.

31. **a.** Plausibly prayer has an effect only if done by a relative of the patient.
b. Other variables could be associated with whether one prayed and with whether the patient had complications.

33. Socioeconomic status may be a common cause of birth defects and of buying bottled water.

35. Yes, because the U.S. may have relatively more people who are old.

37. **a.** For females, mean GPA is higher for those with an employed mother. For males, mean GPA is about the same for those with an employed mother as for those with an nonemployed mother. Since the results differ according to gender, there is evidence of interaction.

b. The two means are about equal for males, yet for females the mean is higher for those with an employed mother.

39. Income is associated with whether one is a compulsive buyer, and both these variables are associated with credit card balance. So, the effect of whether one is a compulsive buyer on the credit card balance depends on whether income is controlled.

41. False **43.** b **45.** a

Chapter 11

1. **a.** (i) $E(y) = 0.2 + 0.5(4.0) + 0.001(800) = 3.0$; (ii) 2.0
b. $E(y) = 0.2 + 0.5x_1 + 0.002(500) = 1.2 + 0.5x_1$
c. $E(y) = 0.2 + 0.5x_1 + 0.002(600) = 1.4 + 0.5x_1$
d. For instance, consider $x_1 = 3$ for which $E(y) = 1.7 + 0.002x_2$; by contrast, when $x_1 = 2$, $E(y) = 1.2 + .002x_2$, having a different y-intercept but the same slope of 0.002.

3. **a.** 18.9 square feet **b.** The y-intercept is 10.536 thousand dollars, and a 1-unit change in x_1 or x_2 has only 1/1000 of the impact in thousands of dollars.

5. **a.** $\hat{y} = -3.601 + 1.280x_1 + 0.102x_2$ **b.** 14.3% **c.** $\hat{y} = -3.601 + 1.280x_1$, $\hat{y} = 6.61 + 1.280x_1$, so at a fixed value of cell-phone use, Internet use is predicted to increase by 1.28% for each thousand-dollar increase in per capita GDP. **d.** The effect of x_1 is the same (slope 1.28) at each fixed value of x_2.

7. **a.** Positive **b.** Negative
c. $\hat{y} = -11.5 + 2.6x_1$; predicted crime rate increases by 2.6 (per 1000 residents) for every thousand-dollar increase in median income.
d. $\hat{y} = 40.3 - 0.81x_1 + 0.65x_2$; predicted crime rate decreases by 0.8 for each thousand-dollar increase in median income, controlling for level of urbanization. Compared to (c), effect is weaker and has different direction.
e. Urbanization is highly positively correlated both with income and with crime rate. This makes overall bivariate association between income and crime rate more positive than the partial association.
f. (i) $\hat{y} = 40.3 - 0.81x_1$, (ii) $\hat{y} = 40.3 - 0.81x1_1 + 0.65(50) = 73 - 0.81x_1$, (iii) $\hat{y} = 105 - 0.81x_1$. The slope stays constant, but at a fixed level of x_1, the crime rates are higher at higher levels of x_2.

9. **a.** -0.13 = change in predicted birth rate for unit increase in women's economic activity, controlling for GNP.
b. Parallel lines, so effect of x_1 the same at each level of x_2, but at fixed x_1, predicted birth rates lower at higher levels of x_2.
c. x_1 and x_2 are moderately positively correlated and explain some of the same variation in y. Controlling for x_2, the effect of x_1 weakens.

11. **a.** $\hat{y} = -498.7 + 32.6x_1 + 9.1x_2$
b. $\hat{y} = -498.7 + 32.6(10.7) + 9.1(96.2) = 725.5$; residual $= 805 - 725.5 = 79.5$, so observed violent crime rate somewhat higher than model predicts.
c. (i) $\hat{y} = -498.7 + 32.6x_1$, (ii) $\hat{y} = -43.1 + 32.6x_1$, (iii) $\hat{y} = 412.5 + 32.6x_1$
d. Violent crime rate tends to increase as poverty rate increases or as percent in metropolitan areas increases; weak negative association between poverty rate and percent in metropolitan areas.
e. $R^2 = 0.57$ = PRE in using x_1 and x_2 together to predict y, $R = \sqrt{0.57} = 0.76$ = correlation between observed and predicted y-values.

13. **a.** $\hat{y} = -1197.5 + 18.3x_1 + 7.7x_2 + 89.4x_3$
b. x_1 and x_3 are highly positively correlated, and explain some of the same variability in y; controlling for x_3, the effect of x_1 weakens.

15. **a.** $\hat{y} = 135.3 - 14.07x_1 - 2.95x_2$
b. $\hat{y} = 135.3 - 14.07(7) - 2.95(9) = 10.3$, residual $= 10 - 10.3 = -0.3$
c. $R^2 = 0.799$; 80% reduction in error by predicting y using x_1 and x_2 instead of $\bar{y}$.
d. $t = -14.07/3.16 = -4.45$, $df = 10 - 3 = 7$, $P < 0.01$ for two-sided test. Better to show actual P-value, since (for instance) 0.049 is not practically different from 0.051.
e. Using $R^2, F = [0.799/2]/[(1 - 0.799)/(10 - 3)] = 13.9, df_1 = 2, df_2 = 7, P < 0.01$; strong evidence that at least one predictor has an effect on y.
f. Ideology appears to have a stronger partial effect than religion; a standard deviation increase in ideology has a 0.79 standard deviation predicted decrease in feelings, controlling for religion.

17. **a.** df values are 5, 60, 65, regression sum of squares = 813.3, regression mean square $= 813.3/5 = 162.7$, residual mean square $= 2940.0/60 = 49$, $F = 162.7/49 = 3.3$ with $df_1 = 5, df_2 = 60$, the P-value (Prob > F) is 0.01, $R^2 = 0.217$, Root MSE = 7.0, t values are $2.22, -2.00, 0.50, -0.80, 2.40$, with P-values (Sig) 0.03, 0.05, 0.62, 0.43, 0.02.
b. No, could probably drop x_3 or x_4, or both, since the P-values are large for their partial tests.
c. The test of $H_0: \beta_1 = \beta_2 = \ldots = \beta_5 = 0$.
There is very strong evidence that at least one predictor has an effect on y.
d. Test of $H_0: \beta_1 = 0$; $P = 0.03$, so there is considerable evidence that x_1 has an effect on y, controlling for the other xs.

21. **a.** Increases **b.** $\hat{y} = 158.9 - 14.7x_1$, $\hat{y} = 94.4 + 23.3x_1$, $\hat{y} = 29.9 + 61.3x_1$. The effect of x_1 moves toward the positive direction and becomes greater as x_2 increases.

25. **a.** (i) -0.612, (ii) -0.819, (iii) 0.757, (iv) 2411.4, (v) 585.4, (vi) 29.27, (vii) 5.41, (viii) 10.47, (ix) 0.064, (x) -2.676, (xi) 0.0145, (xii) 0.007, (xiii) 31.19, (xiv) 0.0001
b. $\hat{y} = 61.7 - 0.17x_1 - 0.40x_2$; 61.7 = predicted birth rate at ECON = 0 and LITER = 0 (may not be useful), -0.17 = change in predicted birth rate for 1 unit increase in ECON, controlling for LITER, -0.40 = change in predicted birth rate for 1-unit increase in LITER, controlling for ECON.
c. -0.612; there is a moderate negative association between birth rate and ECON; -0.819; there is a strong negative association between birth rate and LITER.
d. $R^2 = (2411.4 - 585.4)/2411.4 = 0.76$; there is a 76% reduction in error in using these two variables (instead of $\bar{y}$) to predict birth rate.
e. $R = \sqrt{0.76} = 0.87$ = correlation between observed y-values and the predicted values $\hat{y}$.
f. $F = 31.2, df_1 = 2, df_2 = 20, P = 0.0001$; at least one of ECON and LITER has a significant effect.
g. $t = -0.171/0.064 = -2.68, df = 20, P = 0.014$; there is strong evidence of a relationship between birth rate and ECON, controlling for LITER.

27. Urbanization is highly positively correlated with both variables. Even though there is a weak association between crime rate and high school graduation rate at a fixed level of urbanization (since partial correlation = -0.15), as urbanization increases, so do both of these variables tend to increase, thus producing an overall moderate positive association (correlation = 0.47) between crime rate and high school graduation rate.

29. **a.** $\hat{z}_y = -0.075z_{x_1} - 0.125z_{x_2} - 0.30z_{x_3} + 0.20z_{x_4}$
b. x_3 has the greatest partial effect in standardized units.
c. $\hat{z}_y = -0.075(1) - 0.125(1) - 0.30(1) + 0.20(-1) = -0.7$, so the city is predicted to be 0.7 standard deviations below the mean in murder rate.

43. **a.** Political freedom, unemployment, divorce rate, and latitude had negative partial effects. **b.** $R^2 > 0.50$ **c.** Estimated standardized regression coefficients highest for life expectancy and GDP. A one standard deviation increase in these predictors (controlling for the others) had a greater impact than other predictors. **d.** GDP measured in per capita *dollars*, and a dollar change is extremely small. **e.** No, merely that whatever effect education has disappears after controlling for the other predictors in the model.

45. Different predictors have different units of measurement. Controlling the other predictors, a standard deviation increase in education corresponds to a 0.21 standard deviation increase in the predicted value of y.

47. b. The partial change is 0.34, not 0.45, which is the overall change ignoring rather than controlling the other variables.
c. Cannot tell, since variables have different units of measurement.
d. False, since this cannot exceed 0.38, the R^2 value for the model with x_3 and other variables in the model.

49. b **51.** c

53. Correlation measures linear association between two variables, multiple correlation measures correlation between a response variable and the predicted value given by a set of explanatory variables from the estimated regression equation, partial correlation measures association between two variables while controlling for one or more other variables.

55. For a sample of children of various ages, y = score on vocabulary achievement test, x_1 = height, x_2 = age.

59. $r^2_{yx_2 \cdot x_1}$, and hence its square root, equal 0.

61. **a.** 0.150, 0.303, 0.325, 0.338

65. **a.** Let b denote the minimum of the two standardized estimates, and let B denote the maximum. Then the squared partial correlation equals bB, and $bB \leq BB = B^2$ and $bB \geq bb = b^2$. Thus, since the partial correlation has the same sign as the standardized coefficient, it falls between b and B.
b. Because the partial correlation must fall between −1 and +1, and its square must fall between 0 and 1.

67. **a.** For new homes, $\hat{y} = -48.4 + 96.0x_1$
For older homes, $\hat{y} = -16.6 + 66.6x_1$
For new homes, the effect of size is greater than for older homes.
b. For new homes, $\hat{y} = -7.6 + 71.6x_1$
For older homes, $\hat{y} = -16.6 + 66.6x_1$, now only a slightly smaller effect of size than for new homes.

Chapter 12

1. y = number of reported firefights, explanatory variable is group (soldiers in Afghanistan, soldiers in Iraq, Marines in Iraq). Null hypothesis is that population mean number of firefights is the same for the three groups.

3. **a.** H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$, H_a: At least two population means unequal.
b. No, when H_0 is true one expects F values around 1.
c. If H_0 were true, the probability of getting a F test statistic of 0.80 or larger is 0.53, so there is not evidence against H_0.

5. **a.** (i) H_0: $\mu_1 = \mu_2 = \mu_3$, H_a: At least two population means unequal, (ii) $F = 3.03$, (iii) P-value = 0.049. At the $\alpha = 0.05$ level, there is barely enough evidence to reject H_0 and conclude that at least two population means differ.
b. For each group, the standard deviation is larger than the mean, suggesting the population distributions may have considerable skew to the right. ANOVA assumes normal population distributions.

9. Each CI is an ordinary 98% CI, and has plus and minus part $4.541\sqrt{4.0\left[\frac{1}{2} + \frac{1}{2}\right]} = 9.1$; only A and B are not significantly different.

11. **a.** Each pair except white and other. e.g., we can be 95% confident that the population mean time watching TV is between 1.1 and 1.7 hours higher for blacks than for whites.

13. For 10 groups, there are $10(9)/2 = 45$ comparisons. Using the Bonferroni method with error probability $0.20/45 = 0.0044$ for each guarantees at least 80% confidence for the entire set. Since df is very large (990), the t-score is very close to the z-score with single-tail probability 0.0022, which is 2.84. For 5 groups, there are 10 comparisons. The Bonferroni method with error probability 0.02 for each uses the t-score with single-tail probability 0.01, which is 2.33. The t-score increases, and the confidence intervals tend to be wider, as the number of groups increases.

15. **a.** $E(y) = \alpha + \beta_1 z_1 + \beta_2 z_2$, where $z_1 = 1$ group 1 and 0 otherwise and $z_2 = 1$ for group 1 and 0 otherwise. $H_0 : \mu_1 = \mu_2 = \mu_3$ equivalent to $H_0 : \beta_1 = \beta_2 = 0$
b. 18 is mean for group 3, −6 is difference between mean for group 1 and group 3, and −3 is difference between mean for group 2 and group 3.

17. Large differences between sample means for whites and blacks of a given sex but small differences for females and males of a given race correspond to small P-value for race but not for sex.

19. Females ($s = 1$): 3.79, 3.96, 4.50, Males ($s = 0$): 3.87, 4.04, 4.58. The difference between the estimated means for males and females is 0.08 for each party ID.

21. **a.** The estimated difference in mean TV watching between the Protestant and none or other categories of religion, controlling for sex.
b. $E(y) = \alpha + \beta_1 s + \beta_2 r_1 + \beta_3 r_2 + \beta_4 r_3$, need $\beta_2 = \beta_3 = \beta_4 = 0$

23. **a.** Response variable = income, factors = sex and race.
b. (i) \$10,689 (ii) \$5150. The difference is much greater for whites than blacks, suggesting interaction between sex and race in their effects on income.
c. \$30,000 for white females, \$25,000 for black females, \$40,000 for white males, \$35,000 for black males

25. $n = 206$, SSE = 3600, df values are 1, 2, 2, 200, Mean Square values are 100, 100, 50, 18, F-values are 5.6, 5.6, 2.8, P-values are $P < 0.05, P < 0.01, P > 0.05$

27. Predicted means 16 for black women, 19 for white women, 18 for black men, 29 for white men. If the predicted value for men changes to $29 - 8 = 21$, there is no interaction.

29. **a.** Treats the distance between very negative and negative, and between positive and very positive, as double the distance between negative and neutral and the distance between neutral and positive.

31. Between-subjects: gender; within-subjects: issue. For test of interaction, $F = 1.23$, $P = 0.32$. For sex main effect, $F = 0.26, P = 0.62$. For issue effect, $F = 9.48, P = 0.002$. The margin of error for each interval comparing means for the issues is $2.12(0.719)\sqrt{\frac{1}{10} + \frac{1}{10}} = 0.7$. The sample means for the issues are 2.5, 3.8, and 2.7, so the mean for safety of neighborhoods is significantly higher than the other two means.

39. **a.** Each of the four sample means equal 60, so the between-groups SS = 0 and $F = 0$.
b. Within each group, all five observations are identical. Then the within-groups SS = 0, so the mean square error = 0 and the F statistic is infinite.

45.

a.	10	10	**b.**	10	20	**c.**	10	20	**d.**	10	10
	20	20		30	40		30	60		10	10

47. No, not unless at each level of B, the sample sizes are equal for each level of A.

51. a, b, c, d **53.** c, e, f

55. You have enough information. The sample standard deviations can be combined to obtain the pooled (within-groups) estimate. The between-groups estimate can be calculated from the separate sample means, since the overall mean is a weighted average of their values.

Chapter 13

1. **a.** 13, 11, difference = 2 **c.** −.6 **d.** 12.0, 12.6

3. **a.** The predicted proportion of pro-choice votes was 0.167 lower for Democrats, controlling for the other predictors.
b. Ideology seems to be, by far, the most important predictor of proportion of pro-choice votes. A standard deviation increase in ideology corresponds to a 0.83 standard deviation predicted increase in the response, controlling for the other variables in the model.

5. **a.** $\hat{y} = 8.3 + 9.8f - 5.3s + 7.0m_1 + 2.0m_2 + 1.2m_3 + 0.501x$
b. $\hat{y} = 8.3 + 9.8(1) + 7.0(1) + .501(10) = 30.1$

7. **a.** $\hat{y} = -40{,}230.9 + 116.1x + 57{,}736.3z$, where $z = 1$ for new and 0 for not new. For new homes, $\hat{y} = 17{,}505.4 + 116.1x$ and for not new homes, $\hat{y} = -40{,}230.9 + 116.1x$.
b. \$365,901 for new homes, \$308,165 for not new homes

11. **a.** Anglos: $-4.09 + 0.74(60.4) = 40.6$. From ANOVA model, unadjusted mean for Anglos equals $26.6 + 25.7 = 52.3$.

13. **a.** $F = 1.43, df_1 = 3, df_2 = 82, P = 0.24$
b. $F = 2.06, df_1 = 3, df_2 = 85, P = 0.11$
c. Test statistic $t = 7.9, df = 85, P = 0.0001$
d. The standard error of this estimate equals 2.20, and the t score for 94% Bonferroni confidence intervals is identical to the ordinary t score (when $df = 85$) for a 99% interval, which is 2.63. The interval is $-5.36 \pm 2.63(2.20)$, or $(-11.1, 0.4)$.

25. $E(y) = \alpha + \beta_1 x + \beta_2 z + \beta_3(xz)$, where x = frequency of going to bars, $z = 1$ for married subjects and $z = 0$ for unmarried subjects.

27. See Figure 13.3b. **29.** a, d

Chapter 14

1. **a.** No interaction model with LIFE and SES predictors **b.** No interaction model with LIFE and SES predictors

3. **a.** BEDS, because it is least significant in the model with all the predictors.
b. SIZE, because it is most highly correlated with selling price and would have the smallest P-value.
c. BEDS can be predicted well knowing SIZE, BATHS, and NEW, so it does not uniquely explain much variability in selling price.

7. **a.** Observation 25 **b.** Most noticeably, observations 38 and 39 **c.** No observations have both large studentized residuals and large leverage. **d.** Observation 39 **e.** Observation 39

11. Partial correlations, like partial regression coefficients, have large standard errors when there is multicollinearity.

13. **a.** The variability increases as $\hat{y}$ increases, which the gamma distribution allows but the ordinary normal model (i.e., normal distribution with constant standard deviation) does not.
b. For the gamma model, the estimated education effect is a bit weaker and there is stronger evidence of a difference between Hispanics and whites.
c. (i) $20\sqrt{0.117} = 6.8$ thousand dollars, (ii) 17.1 thousand dollars

17. **a.** Continually increasing and "bowl shaped." **b.** (i) \$84,764, (ii) \$192,220, (iii) \$327,877, because with the increasing bowl shape the curve keeps climbing more quickly as s increases.

21. **a.** 100,000 = predicted number of articles January 1, 2003, and predicted number is multiplied by 2.1 for each successive year.
b. (i) 4,084,101 (ii) 166,798,810

23. **a.** Predicted world population size (in billions) x years from now if there is a 5% decrease in population size each year.
c. $\beta > 1$ ever increasing, $\beta < 1$ ever decreasing.

25. **a.** Death rate changes more quickly at higher ages, and there appears to be a linear relation between age and log of death rate, which suggest exponential model.
c. $\log(\hat{\mu}) = -1.146 + 0.0747x$
d. $\hat{y} = 0.318(1.0776)^x$. The death rate increases by 7.8% for each additional year of age.

33. y = height, x_1 = length of left leg, x_2 = length of right leg.

35. In the U.S., for each of the past 60 years, y = the cumulative federal deficit, x = year. This might be well modeled by an exponential regression model.

37. Precision improves (i.e., the standard error of b_j decreases) when (a) multicollinearity, as described by R_j^2, decreases, (b) conditional variability of the response variable decreases, (c) the variability of x_j increases, (d) the sample size increases.

39. A 1.27% growth rate per year corresponds to a multiplicative effect after 10 years of $(1.0127)^{10} = 1.1345$, or 13.45%. Or, to find the yearly multiplicative factor corresponding to a 10-year multiplicative effect of 1.1345, set $1.1345 = \beta^{10}$, and solve for β; then $\log(1.1345) = 10\log(\beta)$, so $\log(\beta) = \log(1.1345)/10 = 0.01262$, and $\beta = e^{.01262} = 1.0127$.
b. If the growth rate is 1.27% per year, then after x years, the multiplicative effect is $(1.0127)^x$.

41. b, c, d **43.** b **45a.** True **b.** True **c.** False **d.** False
47. $E(y) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + \beta_4 x_1 x_2^2$

Chapter 15

1. a. Estimated probability of voting Republican increases as income increases.
b. (i) $e^{-1.0+0.02(10)}/[1 + e^{-1.0+0.02(10)}] = 0.31$, (ii) 0.73
c. (i) 1.00/0.02 = 50 thousand, (ii) above 50 thousand
d. $\hat{\beta}\pi(1 - \pi) = 0.02(0.5)(0.5) = 0.005$
e. Odds multiply by $e^{0.02} = 1.02$ for each thousand dollar increase in family income.

3. a. $2.043/0.282 = 7.2$
b. $\hat{P}(y = 1) = e^{2.043-0.282(20)}/[1 + e^{2.043-0.282(20)}] = 0.027$
c. $\hat{P}(y = 1) = 0.847 - 0.051(20) = -0.17$; no, probability cannot be negative.
d. $z = -0.282/0.101 = -2.80$, Wald $= (-2.80)^2 = 7.8, P = 0.005$, strong evidence of a negative association between WAIS and senility.

5. $\hat{P}(y = 1) = 0.60$ when wife's earnings = \$20,000 and increases to 0.95 when wife's earnings = \$100,000.

7. a. The probability the child obtains a high school degree increases with mother's education. Estimated odds of degree multiplied by $e^{0.09} = 1.09$ for each one-unit increase in mother's education, controlling for other variables.
b. Probability of degree is lower when mother is employed. Estimated odds of degree when mother is employed equal $e^{-0.92} = 0.40$ times odds when mother is not employed.
c. $e^{0.21} = 1.23$, which corresponds to a 23% increase in the odds.

9. a. Let $r = 1$ for black, 0 for white, let $a = 1$ for AZT = yes and 0 for AZT = no. Prediction equation is $\text{logit}[\hat{P}(y = 1)] = -1.074 - 0.7195a + .0555r$.
b. Estimated probability of AIDS symptoms decreases with AZT use (given race) and is slightly higher for blacks, given AZT use.
c. $\hat{P}(y = 1) = e^{-1.074}/[1 + e^{-1.074}] = 0.25$
d. $e^{-0.720} = 0.49$, so estimated odds of AIDS symptoms for those using AZT are 0.49 times estimated odds for those not using AZT, controlling for race.
e. Wald statistic is $(-0.720/0.279)^2 = 6.65, df = 1$ $(P = .01)$, so strong evidence that AIDS symptoms are less likely for those using AZT, controlling for race.

13. a. There are 3 categories of happiness and 2 cumulative probabilities in the model. The logit for each cumulative probability has its own intercept term.
b. $\hat{\beta} = 0.418$, so happiness tends to increase with income.
c. Wald statistic = $(0.418/0.223)^2 = 3.53$, with $df = 1$, P-value = 0.06 for H_a: $\beta \neq 0$ and 0.03 for H_a: $\beta > 0$
d. $\chi^2 = 3.8$, $df = 4$, P-value = 0.43. The cumulative logit model treats the response as ordinal and predictor as quantitative and results in much stronger evidence of an effect than the ordinary Pearson chi-squared test of independence, which treats both variables as nominal.

15. a. $\hat{\beta} = -0.54$ for gender, 0.77 for location, -0.82 for seat belt. Controlling for the other predictors, the chance of a more serious injury is lower for males, higher in the rural location, and lower for those wearing seat belts.

b. $e^{-0.824} = 0.44$; for those wearing seat belts, the estimated odds of injury more serious than any fixed category are 0.44 times the estimated odds for those not wearing seat belts.
c. The interval $(-0.878, -0.770)$ for the β coefficient of seat-belt use has exponentiated endpoints (0.42, 0.46), which form the interval for this odds ratio.
d. Wald statistic = 891.5, $df = 1$. Extremely strong evidence of effect.

17. a. $e^{0.3} = 1.35$, so estimated odds of voting Republican (given that one votes either for Republican or independent) multiply by 1.35 for each \$10,000 increase in annual income.
b. $\log[\hat{P}(y = 2)/\hat{P}(y = 1)] = (1.0 + 0.3x) - (3.3 - 0.2x) = -2.3 + 0.5x$. Given one votes for Republican or Democratic candidate, odds of voting Republican increase with income, by multiplicative factor of $e^{0.5} = 1.65$ for each \$10,000 increase in annual income.

23. a. (W, X, Y, Z), **b.** (XY, W, Z), **c.** (WX, WY, WZ, XY, XZ, YZ)

25. a. $\text{logit}[P(y = 1)] = \alpha + \beta_1 a + \beta_2 c$, where a and c are dummy variables for alcohol and cigarette use (1 for yes and 0 for no)
b. The model fits well.

29. The logistic model with additive factor effects for age and gender fits well (Pearson $\chi^2 = 0.1$, $df = 2$). The estimated odds of females still being missing are $e^{0.38} = 1.46$ times those for males, given age. The estimated odds are considerably higher for those aged at least 19 than for the other two age groups, given gender.

31. $e^{2.34} = 10.4$, but this is a ratio of *odds*, not probabilities (which the "more likely" interpretation suggests). The odds that a male is a hunter are estimated to be 10.4 times the odds that a female is a hunter, controlling for the other variables.

33. The effect of age is increasing and then decreasing. If age is in the model as a quantitative variable (rather than with categories), this might be described by a quadratic term for age.

35. At each level of victims' race, black defendants were more likely to get the death penalty. Adding together the two partial tables (and hence ignoring rather than controlling victims' race), white defendants were more likely to get the death penalty. The association changes direction, so Simpson's paradox holds.

37. a. (XZ, YZ) **b.** (XZ, YZ), **c.** (XZ, YZ), **d.** (XY, XZ, YZ), **e.** (XYZ), there is interaction, the effect of X on Y varying according to the level of Z.

39. $\log(f_e) = \log(r_i) + \log(c_j) - \log(n)$, which has the form $\log(f_e) = \alpha + \beta_i + \gamma_j$ with main effects for the two classications.

Chapter 16

1. Can use various correlation structures for the repeated measures on a subject, and do not need to delete subjects for which some observations are missing.

5. Estimated hazard rate for males is 0.94 times the rate for females. For test of race effect, $z = 0.353/0.0423 = 8.3$, $P < 0.0001$; extremely strong evidence that the rate is higher for blacks.

7. The estimated rate of termination for blacks was 2.13 times the estimated rate for whites, controlling for the other predictors.

9. G, L, T, and C all have direct effects on B, and G also has indirect effects through its effects on L, T, and C. One would need to fit the bivariate models for