CHAPTER NOTES

Chapter 1

1. Nicolle, J. (1961). *Louis Pasteur: The Story of His Major Discoveries*. New York: Basic Books. p. 170. © 1961 by Jacques Nicolle. © 1961 English translation Hutchinson & Co. (Publishers) Ltd. Reprinted by permission of Perseus Books Group.

2. Mizutani, T., and Mitsuoka, T. (1979). Effect of intestinal bacteria on incidence of liver tumors in gnotobiotic C3H/He male mice. *Journal of the National Cancer Institute* **63**, 1365–1370.

3. Tripepi, R. R., and Mitchell, C. A. (1984). Metabolic response of river birch and European Birch roots to hypoxia. *Plant Physiology* **76**, 31–35. Raw data courtesy of the authors.

4. Adapted from Potkin, S. G., Cannon, H. E., Murphy, D. L., and Wyatt, R. J. (1978). Are paranoid schizophrenics biologically different from other schizophrenics? *New England Journal of Medicine* **298**, 61–66. The data are approximate, having been reconstructed from the histograms and summary information given by Potkin et al. Reprinted by permission of the *New England Journal of Medicine*.

5. Wolfson, J. L. (1987). Impact of *Rhizobium* nodules on *Sitona hispidulus*, the clover root curculio. *Entomologia Experimentalis et Applicata* **43**, 237–243. Data courtesy of the author. The experiment actually included 11 dishes.

6. Webb, P. (1981). Energy expenditure and fat-free mass in men and women. *American Journal of Clinical Nutrition* **34**, 1816–1826.

7. The headline appeared on page 2 of the Sunday edition of *The New York Times*, 16 July 1911.

8. Allen, L. S., and Gorski, R. A. (1992). Sexual orientation and the size of the anterior commissure in the human brain. *Proceedings of the National Academy of Science* **89**, 7199–7202. The data are approximate, having been reconstructed from the dotplots and summary information given by Allen and Gorski. Regarding the first concern mentioned in Example 1.2.2, the authors were mindful of the effect that the two largest observations could have on their conclusions and calculated the average for the homosexual men a second time, after deleting these two values. As for the second concern, the authors calculated the averages for those who had AIDS and those who did not in each group of men. They found that AIDS is associated with smaller, not larger, AC areas, so that when only persons without AIDS are compared, the difference between homosexual and heterosexual men is even larger than the difference found in the full data set.

9. Hakansson, K., Rovio, S., Helkala, E. L., Vilska, A. R., Winblad, B., Soininen, H., Nissinen, A., Mohammed, A. H., and Kivipelto, M. (2009). Association between mid-life marital status and cognitive function in later life: Population based cohort study. *BMJ* **339**, b2462.

10. Bradstreet, T. E. (1992). Favorite data sets from early phases of drug research—part 2. *Proceedings of the Section on Statistical Education of the American Statistical Association*, 219–223.

11. Benson, H., and Friedman, R. (1996). Harnessing the power of the placebo effect and renaming it "remembered wellness." In *Annual Review of Medicine* **47**, 193–199. Annual Reviews, Inc., Palo Alto, Calif.

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16. The Coronary Drug Project Research Group (1980). Influence of adherence to treatment and response of cholesterol on mortality in the coronary drug project. *New England Journal of Medicine* **303**, 1038–1041. Several variables were measured on each subject at the start of the experiment. Adjusting for the effects of these covariates within the placebo group only slightly reduces the difference in mortality rates between adherers and nonadherers. Thus, differences in overall health explain only a small part of the "adherer versus nonadherer" mortality rate difference.

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18. Peto, R., Pike, M. C., Armitage, P., Breslow, N. E., Cox, D. R., Howard, S. V., Mantel, N., McPherson, K., Peto, J., and Smith, P. G. (1976). Design and analysis of randomized clinical trials requiring prolonged observation of each patient. I. Introduction and design. *British Journal of Cancer* **34**, 585–612.

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23. Pauling, L., and Cameron, E. (1976). Supplemental ascorbate in the supportive treatment of cancer: Prolongation of survival times in terminal human cancer. *Proceedings of the National Academy of Sciences* **73**, 3685–3789.

24. *Cleveland Plain Dealer*, 23 October 1997, page 15-A.

25. Huber, Ann M. (2005). Moisture requirements for the germination of early seedling survival of *Cirsium loncholepis*. Master's thesis in Biological Sciences, California Polytechnic State University.

26. Personal communication from L. Vredevoe regarding an ongoing research project (2009).

27. Parks, N. J., Krohn, K. A., Mathis, C. A., Chasko, J. H., Geiger, K. R., Gregor, M. E., and Peek, N. F. (1981). Nitrogen-13-labelled nitrite and nitrate: Distribution and metabolism after intratracheal administration. *Science* **212**, 58–61.

28. *Cleveland Plain Dealer*, 25 June 1991, page 3-A.

29. Hull, H. F., Bettinger, C. J., Gallaher, M. M., Keller, N. M., Wilson, J., and Mertz, G. J. (1988). Comparison of HIV-antibody prevalence in patients consenting to and declining HIV-antibody testing in an STD clinic. *Journal of the American Medical Association,* **260**, 935–938.

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31. Krummel, D. A., Seligson, F. H., and Guthrie, H. A. (1996). Hyperactivity: Is candy causal? *Critical Reviews in Food Science and Nutrition* **36**, 31–47.

Chapter 2

1. Stewart, R. N., and Arisumi, T. (1966). Genetic and histogenic determination of pink bract color in poinsettia. *Journal of Heredity* **57**, 217–220.

2. Haselgrove, C., Straker, L., Smith, A., O'Sulllivan, P., Perry, M., and Sloan, N. (2008). Perceived school bag load, duration of carriage, and method of transport to school are associated with spinal pain in adolescents: An observational study. *Australian Journal of Physiotherapy* **54**, 193–200.

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4. Unpublished data courtesy of C. M. Cox and K. J. Drewry.

5. Unpublished data courtesy of W. F. Jacobson.

6. Unpublished data collected at Oberlin College by J. Witmer.

7. Knoll, A. E., and Barghoorn, E. S. (1977). Archean microfossils showing cell division from the Swaziland system of South Africa. *Science* **198**, 396–398.

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11. Unpublished data courtesy of W. F. Jacobson.

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13. Adapted from Potkin, S. G., Cannon, H. F., Murphy, D. L., and Wyatt, R. J. (1978). Are paranoid schizophrenics biologically different from other schizophrenics? *New England Journal of Medicine* **298**, 61–66. The data given are approximate, having been reconstructed from the histogram and summary information given by Potkin et al. Reprinted by permission of the *New England Journal of Medicine.*

14. Peters, H. G., and Bademan, H. (1963). The form and growth of stellate cells in the cortex of the guinea-pig. *Journal of Anatomy* (London) **97**, 111–117.

15. Data courtesy of R. F. Jones, Indiana State Dairy Association, Inc.

16. Unpublished data courtesy of D. J. Honor and W. A. Vestre.

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18. Bruce, D., Harvey, D., Hamerton, A. E., and Bruce, L. (1913). Morphology of various strains of the trypanosome causing disease in man in Nyasaland. I. The human strain. *Proceedings of the Royal Society of London*, Series B **86**, 285–302. See also Pearson, K. (1914). On the probability that two independent distributions of frequency are really samples of the same population, with reference to recent work on the identity of trypanosome strains. *Biometrika* **10**, 85–143.

19. Shields, D. R. (1981). The influence of niacin supplementation on growing ruminants and *in vivo* and *in vitro* rumen parameters. Ph.D. thesis, Purdue University. Raw data courtesy of the author and D. K. Colby.

20. Gwynne, D. T. (1981). Sexual difference theory: Mormon crickets show role reversal in mate choice. *Science* **213**, 779–780. Copyright 1981 by the AAAS. Raw data courtesy of the author.

21. Unpublished data courtesy of M. A. Morse and G. P. Carlson.

22. Adapted from Anderson, J. W., Story, L., Sieling, B., Chen, W. L., Petro, M. S., and Story, J. (1984). Hypocholesterolemic effects of oat-bran or bean intake for hypercholesterolemic men. *American Journal of Clinical Nutrition* **40**, 1146–1155. There were actually 20 men in the study.

23. Unpublished data courtesy of C. H. Noller.

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25. Fictitious but realistic data. See Roberts, J. (1975). Blood pressure of persons 18–74 years, United States, 1971–72. U.S. National Center for Health Statistics, *Vital and Health Statistics*, Series 11, No. 150. Washington, D.C.: U.S. Department of Health, Education and Welfare.

26. Unpublished data collected from a sample of Oberlin College students.

27. Unpublished data courtesy of M. Kimmel.

28. Unpublished data courtesy of F. Delgado.

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31. Govind, C. K., and Pearce, J. (1986). Differential reflex activity determines claw and closer muscle asymmetry in developing lobsters. *Science* **233**, 354–356. Copyright 1986 by the AAAS.

32. Adapted from Gerdes, N. (2001). Morphological and life history variation in three populations of golden-mantled ground squirrels along a Pacific coast transect. Master's thesis California Polytechnic State University, San Luis Obispo.

33. Adapted from Barclay, A. M., and Crawford, R. M. M. (1984). Seedling emergence in the rowan (*Sorbus aucuparia*) from an altitudinal gradient. *Journal of Ecology* **72**, 627–636. Reprinted with permission of Blackwell Scientific Publications Limited.

34. Fictitious but realistic data. Based on Beyl, C. A., and Mitchell, C. A. (1977). Characterization of mechanical stress dwarfing in chrysanthemum. *Journal of the American Society for Horticultural Science* **102**, 591–594.

35. Based on a subset of the data in Tuddenham, R. D., and Snyder, M. M. (1954). Physical growth of California boys and girls from birth to age 18. *Calif. Publ. Child Develop*. **1**, 183–364. Data as reported in Weisberg, S. (1985). *Applied Linear Regression*, 2nd ed. New York: Wiley, p. 57.

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39. Tripepi, R. R., and Mitchell, C. A. (1984). Metabolic response of river birch and European birch roots to hypoxia. *Plant Physiology* **76**, 31–35. Raw data courtesy of the authors.

40. Ogilvie, R. I., Macleod, S., Fernandez, P., and McCullough, W. (1974). Timolol in essential hypertension. In B. Magnani (ed.). *Beta-Adrenergic Blocking Agents in the Management of Hypertension and Angina Pectoris.* New York: Raven Press. pp. 31–43.

41. Unpublished data courtesy of J. F. Nash and J. E. Zabik.

42. Schall, J. J., Bennett, A. F., and Putnam, R. W. (1982). Lizards infected with malaria: Physiological and behavioral consequences. *Science* **217**, 1057–1059. Copyright 1982 by the AAAS. Raw data courtesy of J. J. Schall.

43. Fictitious but realistic data. Each observation is the average of several measurements made on the same woman at different times. See Royston, J. P., and Abrams, R. M. (1980). An objective method for detecting the shift in basal body temperature in women. *Biometrics* **36**, 217–224.

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45. Adapted from Royston, J. P., and Abrams, R. M. (1980). An objective method for detecting the shift in basal body temperature in women. *Biometrics* **36**, 217–224.

46. Adapted from data provided courtesy of L. A. Nelson.

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49. Fictitious but realistic population. Adapted from LeClerg, E. L., Leonard, W. H., and Clark, A. G. (1962). *Field Plot Technique.* Minneapolis: Burgess.

50. Selawry, O. S. (1974). The role of chemotherapy in the treatment of lung cancer. *Seminars in Oncology* **1**, No. 3, 259–272.

51. Hayes, H. K., East, E. M., and Bernhart, E. G. (1913). *Connecticut Agricultural Experiment Station Bulletin 176.* Data reproduced in Strickberger, M. W. (1976). *Genetics*. New York: Macmillan, p. 288.

52. Unpublished data courtesy of J. Y. Latimer and C. A. Mitchell.

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58. Masty, J. (1983). Innervation of the equine small intestine. Master's thesis, Purdue University. Raw data courtesy of the author.

59. Fictitious but realistic data. Adapted from data presented in Falconer, D. S. (1981). *Introduction to Quantitative Genetics*, 2nd ed. New York: Longman, Inc., p. 97.

60. Dow, T. G. B., Rooney, P J., and Spence, M. (1975). Does anaemia increase the risks to the fetus caused by smoking in pregnancy? *British Medical Journal* **4**, 253–254.

61. Christophers, S. R. (1924). The mechanism of immunity against malaria in communities living under hyper-endemic conditions. *Indian Journal of Medical Research* **12**, 273–294. Data reproduced in Williams, C. B. (1964). *Patterns in the Balance of Nature.* London: Academic Press. p. 243.

62. Data taken from *Climatological Data, Ohio*, and *Local Climatological Data, Cleveland, Ohio*; National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce.

63. These data were published on page 8-A of the *Cleveland Plain Dealer*, 6 February 1997, from information compiled by the United Network for Organ Sharing. The mortality rate and volume variables are averages over a four-year period beginning in October 1987. There are 31 hospitals in the low-volume group and 76 in the high-volume group.

64. Erne, P., Bolli, P., Buergisser, E., and Buehler, F. R. (1984). Correlation of platelet calcium with blood pressure. *New England Journal of Medicine* **310**, 1084–1088. Reprinted by permission. Raw data courtesy of F. R. Buehler. The original data set had 47 subjects; we have omitted 9 patients with "borderline" high blood pressure.

Chapter 3

1. Based on an article by the Neonatal Inhaled Nitric Oxide Study Group (1997). See Inhaled nitric oxide in full-term and nearly full-term infants with hypoxic respiratory failure. *New England Journal of Medicine* **336**, 597–604.

2. Fictitious but realistic population. Adapted from Hubbs, C. L., and Schultz, L. P. (1932). *Cottus tubulatus*, a new sculpin from Idaho. *Occasional Papers of the Museum of Zoology, University of Michigan* **242**, 1–9. Data reproduced in Simpson, G. G., Roe, A., and Lewontin, R. C. (1960). *Quantitative Zoology*. New York: Harcourt, Brace. p. 81.

3. www.bloodbook.com/world-abo.html

4. This table is a modified version of data adapted from Ammon, O. (1899). *Zur Anthropologie der Badener.* Jena: G. Fischer. Ammon's data appear in Goodman, L. A., and Kruskal, W. H. (1954). Measures of association for cross classifications. *Journal of the American Statistical Association* **49**, 732–764. The numbers in the table have been rounded to aid the exposition.

5. Unpublished data courtesy of Diana Zumas and Lisa Yasuhara, Oberlin College.

6. Adapted from Taira, D. A., Safran, D. G., Seto, T. B., Rogers, W. H., and Tarlov, A. R. (1997). The relationship between patient income and physician discussion of health risk behaviors. *Journal of the American Medical Association* **278**, 1412–1417.

7. The population is fictitious but resembles the population of American women aged 18–24, excluding known or suspected diabetics, as reported in Gordon, T. (1964). Glucose tolerance of adults, United States 1960–62. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 2. Washington, D.C.: U.S. Department of Health, Education and Welfare.

8. Meyer, W. H. (1930). Diameter distribution series in even-aged forest stands. *Yale University School of Forestry Bulletin* **28**. The curve is fitted in Bliss, C. I., and Reinker, K. A. (1964). A lognormal approach to diameter distributions in even-aged stands. *Forest Science* **10**, 350–360.

9. Pearson, K. (1914). On the probability that two independent distributions of frequency are really samples of the same population, with reference to recent work on the identity of trypanosome strains. *Biometrika* **10**, 85–143. Reprinted by permission of the Biometrika Trustees.

10. Adapted from unpublished data courtesy of Gloria Zender, Oberlin College.

11. Fictitious but realistic situation. Based on data given by Lack, D. (1948). Natural selection and family size in the starling. *Evolution* **2**, 95–110. Data reproduced by Riclefs, R. E. (1973). *Ecology.* Newton, Mass.: Chiron Press. p. 37.

12. Adapted from unpublished data courtesy of Marni Hansill, Oberlin College.

13. Halpine, T., and Kerr, S. J. (1986). Mutant allele frequencies in the cat population of Omaha, Nebraska. *The Journal of Heredity* **77**, 460–462.

14. This is one of the crosses performed by Gregor Mendel in his classic studies of heredity; heterozygous plants (which are yellow seeded because yellow is dominant) are crossed with each other.

15. Fictitious but realistic value. See Hutchison, J. G. P., Johnston, N. M., Plevey, M. V. P., Thangkhiew, I., and Aidney, C. (1975). Clinical trial of Mebendazole, a broad-spectrum anthelminthic. *British Medical Journal* **2**, 309–310.

16. Fictitious but realistic population. Adapted from Owen, D. F. (1963). Polymorphism and population density in the African land snail, *Limicolaria martensiana. Science* **140**, 666–667.

17. Mathews, T. J., and Hamilton, B. E. (2005). Trend analysis of the sex ratio at birth in the United States. *National Vital Statistics Reports* **53**, No. 20. Hyattsville Md.; National Center for Health Statistics. The sex ratio varies slightly over time and by race.

18. Adapted from discussion in Galen, R. S., and Gambino, S. R. (1980). *Beyond Normality: The Predictive Value and Efficiency of Medical Diagnoses*. New York: Wiley. pp. 71–74.

19. This would be true for some central-city populations. See Annest, J. L., Mahaffey, K. R., Cox, D. H., and Roberts, J. (1982). Blood lead levels for persons 6 months–74 years of age: United States, 1976–80. *U.S. National Center for Health Statistics, Advance Data from Vital and Health Statistics*, No. 79. Hyattsville, Md.; U.S. Department of Health and Human Services.

20. Geissler, A. (1889). Beitrage zur Frage des Geschlechtsverhaltnisses der Geborenen. *Zeitschrift des K. Sachsischen Statistischen Bureaus* **35**, 1–24. Data reproduced by Edwards, A. W. F. (1958). An analysis of Geissler's data on the human sex ratio. *Annals of Human Genetics* **23**, 6–15. The data are also discussed by Stern, C. (1960). *Human Genetics.* San Francisco: Freeman.

21. Haseman, J. K., and Soares, E. R. (1976). The distribution of fetal death in control mice and its implications on statistical tests for dominant lethal effects. *Mutation Research* **41**, 277–288.

22. Data courtesy of S. N. Postlethwaite.

23. Adapted from Looker, A., et al. (1997). Prevalence of iron deficiency in the United States. *Journal of the American Medical Association* **277**, 973–976.

24. Fictitious but realistic situation. See Krebs, C. J. (1972). *Ecology: The Experimental Analysis of Distribution and Abundance.* New York: Harper & Row. p. 142.

25. See Mather, K. (1943). *Statistical Analysis in Biology.* London: Methuen. p. 38.

26. The technique is described in Waid, W. M., Orne, E. C., Cook, M. R., and Orne, M. T. (1981). Meprobamate reduces accuracy of physiological detection of deception. *Science* **212**, 71–73.

27. Fictitious but realistic population, closely resembling the population of males aged 45–59 years as described in Roberts, J. (1975). Blood pressure of persons 18–74 years, United States, 1971–72. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 150. Washington, D.C.: U.S. Department of Health, Education and Welfare.

Chapter 4

1. Data from the 2003–2004 National Health and Nutrition Examination Survey, which can be found at www.denofinquiry.com/nhanes/source/choose.php

2. Ikeme, A. I., Roberts, C., Adams, R. L., Hester, P. Y., and Stadelman, W. J. (1983). Effects of supplementary water-administered vitamin D_3 on egg shell thickness. *Poultry Science* **62**, 1120–1122. The normal curve was fitted to raw data provided courtesy of W. J. Stadelman and A. I. Ikeme.

3. Hengstenberg, R. (1971). Das Augenmuskelsystem der Stubenfliege Musca domestica. 1. Analyse der "clock-spikes" und ihrer Quellen. *Kybernetik* **2**, 56–57.

4. Adapted from Magath, T. B., and Betkson, J. (1960). Electronic blood-cell counting. *American Journal of Clinical Pathology* **34**, 203–213. Actually, the percentage error is somewhat less for high counts and somewhat more for low counts. Described in Coulter Electronics (1982). *Performance Characteristics and Specifications for Coulter Counter Model S-560.* Hialeah, Fl: Coulter Electronics.

5. Fictitious but realistic population. Adapted from data given by Hildebrand, S. F., and Schroeder, W. C. (1927). Fishes of Chesapeake Bay. *Bulletin of the United States Bureau of Fisheries* **43**, Part 1, p. 88. The fish are young of the year, observed in October; they are quite small. (The distribution of lengths in older populations is not approximately normal.)

6. Adapted from Pearl, R. (1905). Biometrical studies on man. I. Variation and correlation in brain weight. *Biometrika* **4**, 13–104.

7. Adapted from Swearingen, M. L., and Halt, D. A. (1976). Using a "blank" trial as a teaching tool. *Journal of Agronomic Education* **5**, 3–8. The standard deviation given in this problem is realistic for an idealized "uniform" field, in which yield differences between plots are due to local random variation rather than large-scale and perhaps systematic variation.

8. Adapted from Coulter Electronics (1982). *Performance Characteristics and Specifications for the Coulter Counter Model S-560*. Hialeah, Fl: Coulter Electronics.

9. Unpublished data courtesy of Susan Whitehead, Oberlin College.

10. Data taken from www.athlinks.com/results/50228/97027/u1/2008-Rome-Marathon.aspx

11. Unpublished data courtesy of Kaelyn Stiles, Oberlin College.

12. Unpublished data courtesy of Paul Harnik and Lydia Ries, Oberlin College.

13. Summary weather information derived from www.centralcoastweather.net

14. Summary weather information derived from www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akjune

15. Long, E. C. (1976). *Liquid Scintillation Counting Theory and Techniques*. Irvine, Calif.: Beckman Instruments. The distribution is actually a discrete distribution called a Poisson distribution; however, a Poisson distribution with large mean is approximately normal.

16. Fictitious but realistic population, based on data of Emerson, R. A., and East, E. M. (1913). Inheritance of quantitative characters in maize. *Nebraska Experimental Station Research Bulletin* **2**. Data reproduced by Mather, K. (1943). *Statistical Analysis in Biology*. London: Methuen. pp. 29, 34. Modern hybrid corn is taller and less variable than this population.

17. These percentiles are based on data in the National Health and Nutrition Examination Survey (NHANES), conducted by the National Center for Health Statistics Centers for Disease Control and Prevention. The following URL provides a link to the data table: www.cdc.gov/nchs/about/major/nhanes/hgtfem.pdf

18. This is the standard reference distribution for Stanford-Binet scores. See Sattler, J. M. (1982). *Assessment of Children's Intelligence and Special Abilities*, 2nd ed. Boston: Allyn and Bacon. p. 19 and back cover.

19. Unpublished data courtesy of Forrest Crawford and Yvonne Piper, Oberlin College.

Chapter 5

1. Data from the 2003–2004 National Health and Nutrition Examination Survey, which can be found at www.denofinquiry.com/nhanes/source/choose.php

2. Fictitious but realistic population. See Example 2.2.11.

3. The mean and standard deviation are realistic for American women aged 25–34. See O'Brien, R. J., and Drizd, T. A. (1981). Basic data on spirometry in adults 25–74 years of age: United States, 1971–75. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 222. Washington, D.C.: U.S. Department of Health and Human Services. The normality assumption may or may not be realistic.

4. Adapted from data given in Sebens, K. P. (1981). Recruitment in a sea anemone population; juvenile substrate becomes adult prey. *Science* **213**, 785–787.

5. Fictitious but realistic data. Adapted from distribution given for men aged 45–59 in Roberts, J. (1975). Blood pressure of persons 18–74 years, United States, 1971–72. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 150. Washington, D.C.: U.S. Department of Health, Education and Welfare.

6. Based on data in Roberts, J. D., et al. (1997). Inhaled nitric oxide and persistent pulmonary hypertension of the newborn. *New England Journal of Medicine* **336**, 605–610.

7. The distribution in Figure 5.3.1 is based on data given in Zeleny, C. (1922). The effect of selection for eye facet number in the white bar-eye race of *Drosophila melanogaster. Genetics* **7**, 1–115. The data are displayed in Falconer, D. S. (1981). *Introduction to Quantitative Genetics*, 2nd ed. New York: Longman. p. 97.

8. The distribution in Figure 5.3.3 is adapted from data described by Bradley, J. V. (1980). Nonrobustness in one-sample *Z* and *t* tests: A large-scale sampling study. *Bulletin of the Psychonomic Society* **15** (1), 29–32, used by permission of the Psychonomic Society, Inc.; and Bradley, J. V. (1977). A common situation conducive to bizarre distribution shapes. *American Statistician* **31**, 147–150. Bradley's distribution included additional peaks, because sometimes the subject fumbled the button more than once on a single trial.

9. Fictitious but realistic situation, adapted from data given in Bradley, D. D., Krauss, R. M., Petitte, D. B., Ramcharin, S., and Wingird, I. (1978). Serum high-density lipoprotein cholesterol in women using oral contraceptives, estrogens, and progestins. *New England Journal of Medicine* **299**, 17–20.

10. Kahneman, D., and Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology* **3**, 430–454.

11. Strickberger, M. W. (1976). *Genetics*, 2nd ed. New York: Macmillan. p. 206.

12. www.cureresearch.com/artic/other_important_stds_niaid_fact_sheet_niaid.htm

13. Fictitious but realistic situation. See Waugh, G. D. (1954). The occurrence of Mytilicola intestinalis (Steuer) on the east coast of England. *Journal of Animal Ecology* **23**, 364–367.

14. Mosteller, F., and Tukey, J. W. (1977). *Data Analysis and Regression.* Reading, Mass.: Addison-Wesley. p. 25.

15. Fictitious but realistic population, resembling the population of young American men aged 18–24, as described in Abraham, S., Johnson, C. L., and Najjar, M. F. (1979). Weight and height of adults 18–74 years of age: United States 1971–1974. *U.S. National Center for Health Statistics*, Series 11, No. 211. Washington, D.C.: U.S. Department of Health, Education and Welfare.

16. The mean and standard deviation are realistic, based on unpublished data provided courtesy of J. Y. Ustimer and C. A. Mitchell. The normality assumption may or may not be realistic.

17. The mean and standard deviation are realistic, based on unpublished data provided courtesy of S. Newman and D. L. Harris. The normality assumption may or may not be realistic.

Chapter 6

1. Data provided by Dennis Frey, California Polytechnic State University, San Luis Obispo.

2. Newman, S., Everson, D. O., Gunsett, F. C., and Christian, R. E. (1984). Analysis of two- and three-way crosses among Ramhouillet, Targhee, Columbia, and Suffolk sheep for three preweaning traits. Unpublished manuscript. Raw data courtesy of S. Newman.

3. Adapted from the following two papers. Potkin, S. G., Cannon, H. E., Murphy, D. L., and Wyatt, R. J. (1978). Are paranoid schizophrenics biologically different from other schizophrenics? *New England Journal of Medicine* **298**, 61–66. Murphy, D. L., Wright, C., Buchsbaum, M., Nichols, A., Costa, J. L., and Wyatt, R. J. (1976). Platelet and plasma amine oxidase activity in 680 normals: Sex and age differences and stability over time. *Biochemical Medicine* **16**, 254–265. The data displayed are fictitious but realistic, having been reconstructed from the histograms and summary information given by Potkin et al. and Murphy et al.

4. Based on data reported in Rea, T. M., Nash, J. F., Zabik, J. E., Born, G. S., and Kessler, W. V. (1984). Effects of toluene inhalation on brain biogenic amines in the rat. *Toxicology* **31**, 143–150.

5. Based on an experiment by M. Morales.

6. Adapted from Cherney, J. H., Volenec, J. J., and Nyquist, W. E. (1985). Sequential fiber analysis of forage as influenced by sample weight. *Crop Science* **25**, No. 6 (Nov./Dec. 1985), 1113–1115 (Table 1). By permission of the Crop Science Society of America, Inc. Raw data courtesy of W. E. Nyquist.

7. Dice, L. R. (1932). Variation in the geographic race of the deermouse, *Peromyscus maniculatus bairdii. Occasional Papers of the Museum of Zoology, University of Michigan*, No. 239. Data reproduced in Simpson, G. G., Roe, A., and Lewontin, R. C. (1960). *Quantitative Zoology.* New York: Harcourt, Brace, p. 79.

8. Bodor, N., and Simpkins, J. W. (1983). Redox delivery system for brain-specific, sustained release of dopamine. *Science* **221**, 65–67.

9. Student (W. S. Gosset) (1908). The probable error of a mean. *Biometrika* **6**, 1–25.

10. The Writing Group for the PEPI Trial (1996). Effects of hormone therapy on bone mineral density. *Journal of the American Medical Association* **276**, 1389–1396. This study compared change in bone mineral density over 36 months for four medications and a placebo. (Hip bone mineral density was measured at the beginning of the experiment and again 36 months later.) Only the data for those women who adhered to the experimental protocol are used in the example. Standard deviations are calculated based on the standard errors reported in the article.

11. Data collected by Denise D'Abundo, Oberlin College, April 1991.

12. Bockman, D. E., and Kirby, M. L. (1984). Dependence of thymus development on derivatives of the neural crest. *Science* **223**, 498–500. Copyright 1984 by the AAAS.

13. Brown, S. A., Riviere, J. E., Coppoc, G. L., Hinsman, E. J., Carlton, W. W., and Steckel, R. R. (1985). Single intravenous and multiple intramuscular dose pharmacokinetics and tissue residue profile of gentamicin in sheep. *American Journal of Veterinary Research* **46**, 69–74. Raw data courtesy of S. A. Brown and G. L. Coppoc.

14. Lobstein, D. D. (1983). A multivariate study of exercise training effects on beta-endorphin and emotionality in psychologically normal, medically healthy men. Ph.D. thesis, Purdue University. Raw data courtesy of the author.

15. Nicholson, R. L., and Moraes, W. B. C. (1980). Survival of *Colletotrichum graminicola:* Importance of the spore matrix. *Phytopathology* **70**, 255–261.

16. Adapted from Morris, J. G., Gripe, W. S., Chapman, H. L., Jr., Walker, D. F., Armstrong, J. B., Alexander, J. D., Jr., Miranda, R., Sanchez, A., Jr., Sanchez, B., Blair-West, J. R., and Denton, D. A. (1984). Selenium deficiency in cattle associated with Heinz bodies and anemia. *Science* **223**, 491–492. Copyright 1984 by the AAAS.

17. Shaffer, P. L., and Rock, G. C. (1983). Tufted apple budmoth (*Lepidoptera: Tortricidae*): Effects of constant daylengths and temperatures on larval growth rate and determination of larval-pupal ecdysis. *Environmental Entomology* **12**, 76–80.

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20. Based on data provided by C. H. Noller.

21. This is roughly the SD for the U.S. population of middle-aged men. See Moore, F. E., and Gordon, T. (1973). Serum cholesterol levels in adults, United States 1960–62. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 22. Washington, D.C.: U.S. Department of Health, Education and Welfare.

22. Pappas, T., and Mitchell, C. A. (1984). Effects of seismic stress on the vegetative growth of *Glycine max* (L.) Merr. cv. Wells II. *Plant, Cell and Environment* **8**, 143–148.

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26. Nicholson, R. L., and Moraes, W. B. C. (1980). Survival of *Colletotrichum graminicola:* Importance of the spore matrix. *Phytopathology* **70**, 255–261. Raw data courtesy of R. L. Nicholson.

27. The probabilities in Table 6.5.2 were estimated by computer simulation carried out by M. Samuels and R. P. Becker. The standard error of each probability estimate is less than 0.0015. The sources of the parent distributions are given in Notes 7 and 8 to Chapter 5.

28. Burnett, A., and Haywood, A. (1997). A statistical analysis of differences in sediment yield over time on the West Branch of the Black River. Unpublished manuscript, Oberlin College.

29. Hessell, E. A., Johnson, D. D., Ivey, T. D., and Miller, D. W. (1980). Membrane vs bubble oxygenator for cardiac operations. *Journal of Thoracic and Cardiovascular Surgery* **80**, 111–122.

30. Peters, H. G. and Bademan, H. (1963). The form and growth of stellate cells in the cortex of the guinea-pig. *Journal of Anatomy* (London) **97**, 111–117.

31. Kaneto, A., Kosaka, K., and Nakao, K. (1967). Effects of stimulation of the vagus nerve on insulin secretion. *Endocrinology* **80**, 530–536. Copyright © 1967 by the Endocrine Society.

32. Simmons, F. J. (1943). Occurrence of superparasitism in *Nemeritis canescens. Revue Canadienne de Biologie* **2**, 15–40. Data reproduced in Williams, C. B. (1964). *Patterns in the Balance of Nature.* London: Academic Press. p. 223.

33. These data are diameters at breast height of American Sycamore trees in the floodplain of the Vermilion River. Data collected Emily Norland, Oberlin College, March 1995.

34. Adapted from Sanders, K. (2004). A quantitative, vegetative, and reproductive comparison of *Centromadia parryi* ssp. congdonii in two locations. Master's Thesis, California Polytechnic State University.

35. Hunter, A., and Terasaki, T. (1993). Statistical analysis comparing vital capacities of brass majors in the Conservatory and a normal population. Unpublished manuscript, Oberlin College. All subjects were men, age 18–21, with heights between 175 and 183 cm. Because vital capacity is related to height, the raw data were adjusted slightly, using linear regression, to control for the effect of height.

36. Chang, K. (2005). Randomized controlled trial of Coblation versus electocautery tonsillectomy. *American Academy of Otolaryngology—Head and Neck Surgery* **132**, 273–280.

37. Knight, S. L., and Mitchell, C. A. (1983). Enhancement of lettuce yield by manipulation of light and nitrogen nutrition. *Journal of the American Society for Horticultural Science* **108**, 750–754. Raw data courtesy of the authors. (The actual sample sizes were equal; some observations have been omitted from the exercise.)

38. O'Marra, S. (1996). Antibacterial soaps: Myth or reality. Unpublished manuscript, Oberlin College. The primary purpose of this study was to assess the effectiveness of antibacterial soaps. A solution made from antibacterial soap killed all *E. coli*, in contrast to the non-antibacterial soap and the control. The soap solution was a 1:4 solution of soap and water.

39. Ahern, T. (1998). Statistical analysis of EIN plants treated with ancymidol and H_2O. Unpublished manuscript, Oberlin College. The mutant strain EIN (e-longated in-ternode) of *Brassica* was used in this experiment. The data presented here are a randomly selected subset of the full data set.

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43. Long, T. F., and Murdock, L. L. (1983). Stimulation of blowfly feeding behavior by octopaminergic drugs. *Proceedings of the National Academy of Sciences* **80**, 4159–4163. Raw data courtesy of the authors and L. C. Sudlow.

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45. Appel, L. J., et al. (1997). A clinical trial of the effects of dietary patterns on blood pressure. *New England Journal of Medicine* **336**, 1117–1124.

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48. Parks, N. J., Krohn, K. A., Mathis, C. A., Chasko, J. H., Geiger, K. R., Gregor, M. E., and Peek, N. F. (1981). Nitrogen-13-labelled nitrite and nitrate: Distribution and metabolism after intratracheal administration. *Science* **212**, 58–61. Copyright 1981 by the AAAS. Raw data courtesy of N. J. Parks.

49. Krick, J. A. (1982). Effects of seeding rate on culm diameter and the inheritance of culm diameter in soft red winter wheat *(Triticum aestivum* L. em Thell). Master's thesis, Department of Agronomy, Purdue University. Raw data courtesy of J. A. Krick and H. W. Ohm. Each diameter is the mean of measurements taken at six prescribed locations on the stem.

50. Data collected by Deborah Ignatoff, Oberlin College, spring 1997.

51. Bailey, J., and Marshall, J. (1970). The relationship of the post-ovulatory phase of the menstrual cycle to total cycle length. *Journal of Biosocial Science* **2**, 123–132.

52. Nansen, C., Tchabi, A., and Meikle, W. G. (2001). Successional sequence of forest types in a disturbed dry forest reserve in southern Benin, West Africa. *Journal of Tropical Ecology* **17**, 525–539.

53. Unpublished data courtesy of W. F. Jacobson.

54. Dale, E. M., and Housley, T. L. (1986). Sucrose synthase activity in developing wheat endosperms differing in maximum weight. *Plant Physiology* **82**, 7–10. Raw data courtesy of the authors.

55. See Note 23 of Chapter 3.

56. Adapted from data courtesy of the Morro Bay National Estuary Foundation, 2009.

57. Graph created from data included in Erne, P., Bolli, P., Buergisser, E., and Buehler, F. R. (1984). Correlation of platelet calcium with blood pressure. *New England Journal of Medicine* **310**, 1084–1088. Reprinted by permission. Raw data courtesy of F. R. Buehler.

58. Urban L. E., et al. (2010). The accuracy of stated energy contents of reduced-energy, commercially prepared foods. *J. Am. Diet Assoc.* **110**, 116–123.

Chapter 7

1. Kotler, D. (2000). A comparison of aerobics and modern dance training on health-related fitness in college women. Unpublished manuscript, Oberlin College.

2. Pappas, T., and Mitchell, C. A. (1985). Effects of seismic stress on the vegetative growth of *Glycine max* (L.) Merr. cv. Wells II. *Plant, Cell and Environment* **8**, 143–148. Reprinted with permission of Blackwell Scientific Publications Limited. Raw data courtesy of the authors. The original experiment included many treatments and more than nine observations per group; only a subset of the data is presented here, for simplicity.

3. Unpublished data courtesy of J. A. Henricks and V. J. K. Liu.

4. Rea, T. M., Nash, J. F., Zabik, J. E., Born, G. S., and Kessler, W. V. (1984). Effects of toluene inhalation on brain biogenic amines in the rat. *Toxicology* **31**, 143–150. Raw data courtesy of J. F. Nash and J. E. Zabik.

5. Sagan, C. (1977). *The Dragons of Eden.* New York: Ballantine. p. 7.

6. Lemenager, R. P., Nelson, L. A., and Hendrix, K. S. (1980). Influence of cow size and breed type on energy requirements. *Journal of Animal Science* **51**, 566–576. Some of the animals *lost* weight during the 78 days, so that the mean weight gains are based on both positive and negative values.

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11. Bockman, D. E., and Kirby, M. L. (1984). Dependence of thymus development on derivatives of the neural crest. *Science* **223**, 498–500. Copyright 1984 by the AAAS.

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15. Ahne, A., and Myers, S. (1999). The effect of Miracle Grow on radish growth. Unpublished manuscript, Oberlin College. The data presented here are a subset of the full data set. (The means and standard deviations for the full data set are similar to those for the subset presented here. In particular, the sample mean for the control group is greater than for the fertilizer group.)

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30. Yerushalmy, J., and Hilleboe, H. E. (1957). Fat in the diet and mortality from heart disease. *New York State Journal of Medicine* **57**, 2343–2354. Reprinted by permission. Copyright by the Medical Society of the State of New York.

31. *Cleveland Plain Dealer*, 10 February 1999, page 17–A.

32. David, R. J., and Collins, J. W. (1997). Differing birth weight among infants of U.S.-born blacks, African-born blacks, and U.S.-born whites. *New England Journal of Medicine* **337**, 1209–1214. Low birth weight means a weight of less than 1500 g, which the authors referred to as "very low birth weight" in the article.

33. Gwilyn, S., Howard, D. P. J., Davies, N., and Willett, K. (2005). Harry Potter casts a spell on accident prone children. *British Medical Journal* **331**, 1505–1506. The authors note that the weather on "Harry Potter" weekends was good and was not appreciably different from weather on other weekends.

34. Adapted from data provided courtesy of D. R. Shields and D. K. Colby. See Shields, D. R. (1981). The influence of niacin supplementation on growing ruminants and *in vivo* and *in vitro* rumen parameters. Ph.D. thesis, Purdue University.

35. Schall, J. J., Bennett, A. F., and Putnam, R. W. (1982). Lizards infected with malaria: Physiological and behavioral consequences. *Science* **217**, 1057–1059. Copyright 1982 by the AAAS.

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37. Adapted from Knight, S. L., and Mitchell, C. A. (1983). Enhancement of lettuce yield by manipulation of light and nitrogen nutrition. *Journal of the American Society for Horticultural Science* **108**, 750–754.

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40. Fictitious but realistic data.

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43. Adapted from Williams, G. Z., Widdowson, G. M., and Penton, J. (1978). Individual character of variation in time-series studies of healthy people. II. Differences in values for clinical chemical analytes in serum among demographic groups, by age and sex. *Clinical Chemistry* **24**, 313–320.

44. Fictitious but realistic data. See Abraham, S., Johnson, C. L., and Najjar, M. F. (1979). Weight and height of adults 18–74 years of age, United States 1971–74. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 211. Washington, D.C.: U.S. Department of Health, Education and Welfare.

45. Example communicated by D. A. Holt.

46. Petrie, B., and Segalowitz, S. J. (1980). Use of fetal heart rate, other perinatal and maternal factors as predictors of sex. *Perceptual and Motor Skills* **50**, 871–874. Copyright 1980 by Ammons Scientific, Ltd. Reproduced with permission of Ammons Scientific, Ltd. via Copyright Clearance Center.

47. Hagerman, A. E., and Nicholson, R. L. (1982). High-performance liquid chromatographic determination of hydroxycinnamic acids in the maize mesocotyl. *Journal of Agricultural and Food Chemistry* **30**, 1098–1102. Copyright 1982 American Chemical Society. Reprinted with permission.

48. Ressler, S. (1977) AnthroKids—Anthropometric data of children. Data are taken from the file individuals.csv at ovrt.nist.gov/projects/anthrokids/

49. Adapted from Williams, G. Z., Widdowson, G. M., and Penton, J. (1978). Individual character of variation in time-series studies of healthy people. II. Difference in values for clinical chemical analytes in serum among demographic groups, by age and sex. *Clinical Chemistry* **24**, 313–320. Reprinted by permission.

50. Hamill, P. V. V., Johnston, F. E., and Lemeshow, S. (1973). Height and weight of youths 12–17 years, United States. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 124. Washington, D.C.: U.S. Department of Health, Education and Welfare.

51. Phelan, S., and Schaffner, A. (2009). NIH grant proposal: Prevention of postpartum weight retention in low-income WIC women.

52. Roberts, J. (1975). Blood pressure of persons 18–74 years, United States, 1971–72. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 150. Washington, D.C.: U.S. Department of Health, Education and Welfare. However, the distribution of systolic blood pressure is more skewed (see Exercise 5.2.18).

53. Pearson, E. S., and Please, N. W. (1975). Relation between the shape of population distribution and the robustness of four simple test statistics. *Biometrika* **62**, 223–241.

54. Mena, E. A., Kossovsky, N., Chu, C., and Hu, C. (1995). Inflammatory intermediates produced by tissues encasing silicone breast implants. *Journal of Investigative Surgery* **8**, 31–42. [*Note*: There were two control groups in this study. The control group included in this analysis is "patients undergoing reverse augmentation mammaplasty" (the "scar" group discussed in the article). Also, the authors neglected to transform the data before conducting a *t* test. Thus, they got a large *P*-value, although they noted that the two groups looked quite different.]

55. Fictitious but realistic data. Based on unpublished data provided by Bill Plummer.

56. Fierer, N. (1994). Statistical analysis of soil respiration rates in a light gap and surrounding old-growth forest. Unpublished manuscript, Oberlin College.

57. Noether, G. E. (1967). *Elements of Nonparametric Statistics*. New York: Wiley.

58. It is sometimes stated that the validity of the Mann–Whitney test requires that the two population distributions have the same shape and differ only by a shift. This is not correct. The computations underlying Table 6 require only that the common population distribution (under the null hypothesis) be continuous. A further property, technically called *consistency* of the test, requires that the two distributions be *stochastically ordered*, which is the technical way of saying that one of the variables has a consistent tendency to be larger than the other. In fact, the title of Mann and Whitney's original paper is "On a test of whether one of two random variables is stochastically larger than the other" *(Annals of Mathematical Statistics* **18**, 1947). In Section 7.12 we discuss the requirement of stochastic ordering, calling it an "implicit assumption." (The confidence interval procedure mentioned at the end of Section 7.10 does require the stronger assumption that the distributions have the same shape.)

59. Zimmerman, D. W., and Zumbo, B. D. (1993). The relative power of parametric and nonparametric statistical methods in G. Keren and C. Lewis (Eds.), *A Handbook for Data Analysis in the Behavioral Sciences: Methodological Issues.* pp. 481–517. Hillsdale, N.J.: Lawrence Erlbaum Associates. The authors use simulations to show that the Wilcoxon-Mann-Whitney test is more powerful than the *t* test in the presence of outliers, but that in the absence of outliers, the *t* test is slightly preferable for a variety of population distributions.

60. Agosti, E., and Camerota, G. (1965). Some effects of hypnotic suggestion on respiratory function. *International Journal of Clinical and Experimental Hypnosis* **13**, 149–156.

61. Connolly, K. (1968). The social facilitation of preening behaviour in *Drosophila melanogaster. Animal Behaviour* **16**, 385–391.

62. Unpublished data courtesy of G. P. Carlson and M. A. Morse.

63. Lobstein, D. D. (1983). A multivariate study of exercise training effects on beta-endorphin and emotionality in psychologically normal, medically healthy men. Ph.D. thesis, Purdue University. Raw data courtesy of the author.

64. Erne, P., Bolli, P., Buergisser, E., and Buehler, F. R. (1984). Correlation of platelet calcium with blood pressure. *New England Journal of Medicine* **310**, 1084–1088. Reprinted by permission of the *New England Journal of Medicine.* Summary statistics calculated from raw data provided courtesy of F. R. Buehler.

65. Adapted from unpublished data provided by F. Delgado. The extremely high somatic cell counts probably represent cases of mastitis.

66. Pappas, T., and Mitchell, C. A. (1985). Effects of seismic stress on the vegetative growth of *Glycine max* (L.) Merr. cv. Wells II. *Plant, Cell and Environment* **8**, 143–148. Reprinted with permission of Blackwell Scientific Publications Limited. Raw data courtesy

of the authors. The original experiment included more than two treatment groups.

67. Wee, K. (1995). Species diversity in floodplain forests. Unpublished manuscript, Oberlin College.

68. Cicirelli, M. F., Robinson, K. R., and Smith, L. D. (1983). Internal pH of *Xenopus* oocytes: A study of the mechanism and role of pH changes during meintic maturation. *Developmental Biology* **100**, 133–146. Raw data courtesy of M. F. Cicirelli.

69. Manski, T. J., et al. (1997). Endolymphatic sac tumors: A source of morbid hearing loss in von Hippel-Lindau disease. *Journal of the American Medical Association* **277**, 1461–1466.

70. Unpublished data courtesy of J. A. Henricks and V. J. K. Liu.

71. Schall, J. J., Bennett, A. F., and Putnam, R. W. (1982). Lizards infected with malaria: Physiological and behavioral consequences. *Science* **217**, 1057–1059. Copyright 1982 by the AAAS. Raw data courtesy of J. J. Schall.

72. Unpublished data courtesy of M. B. Nichols and R. P. Maickel.

73. The neonatal inhaled nitric oxide study group (1997). Inhaled nitric oxide in full-term and nearly full-term infants with hypoxic respiratory failure. *New England Journal of Medicine* **336**, 597–604.

74. Gleason, P. P., et al. (1997). Medical outcomes and antimicrobial costs with the use of American Thoracic Society guidelines for outpatients with community-acquired pneumonia. *Journal of the American Medical Association* **278**, 32–39.

75. Hodapp, M. (1998). A Study of CDS Nutrition. Unpublished manuscript, Oberlin College.

76. Laurance, W. F., Perez-Salicrup, D., Delamonica, P., Fearside, P. M., D'Angelo, S., Jerozolinski, A., Pohl, L., and Lovejoy, T. E. (2001). Rain forest fragmentation and the structure of Amazonian liana communities. *Ecology* **82**, 105–116. The data presented were read by J. Witmer from Figure 2 in the paper and may not be completely accurate.

77. King, D. S., Sharp, R. L., Vukovich, M. D., Brown, G. A., Reifenrath, T. A., Uhl, N. L., and Parsons, K. A. Effect of oral androstenedione on serum testosterone and adaptations to resistance training in young men. *Journal of the American Medical Association* **281**, 2020–2028. Raw data courtesy of the authors. The response variable shown here is change in "maximum muscle strength," which is the greatest weight the subject could lift. There were several other measurements taken in the experiment; generally they showed the same results seen in the lat pulldown data. A primary purpose of the experiment was to study the effect of andro on testosterone level. The researchers found that andro had no effect on serum testosterone level.

78. Fleming, M. F., Barry, K. L., Manwell, L. B., Johnson, K., and London, R. (1997). Brief physician advice for problem alcohol drinkers. *Journal of the American Medical Association* **277**, 1039–1045.

79. Conner, E. M., Sperling, R. S., Gerber, R., Kisalev, P., Scott, G., O'Sullivan, M. J., Van Dyke, R., Bey, M., Shearer, W., Jacobsen, R. L., Jimenez, E., O'Neill, E., Bazin, B., Delfraissy, J.-F., Culname, M., Coombs, R., Elkins, M., More, J., Stratton, P., and Balsley, J. (1994). Reduction of maternal-infant transmission of Human Immunodeficiency Virus Type I with zidovudine treatment. *New England Journal of Medicine* **331**, 1173–1180. Some people feel that this study should not have been conducted as a randomized experiment, since there was reason to believe that AZT would be helpful in preventing the transfer of HIV to the babies and since HIV is such a serious disease.

80. Gattinoni, L., Tognoni, G., Pesenti, A., Taccone, P., Mascheroni, D., Labarta, V., Malacrida, R., Di Giulio, P., Fumagalli, R., Pelosi, P., Brazzi, L., and Latini, R. (2001). Effect of prone positioning on the survival of patients with acute respiratory failure. *New England Journal of Medicine* **345**, 568–573.

81. Petitti, D. B., Perlman, J. A., and Sidney, S. (1987). Noncontraceptive estrogens and mortality: Long-term follow-up of women in the Walnut Creek Study. *Obstetrics & Gynecology* **70**, 289–293.

Chapter 8

1. Namdar, M., Koepfli, P., Grathwohl, R., Siegrist, P. T., Klainguti, M., Schepis, T., Delaloye, R., Wyss, C. A., Fleischmann, S. P., Gaemperli, O., and Kaufmann, P. A. (2006). Caffeine decreases exercise-induced myocardial flow reserve. *Journal of the American College of Cardiology* **47**, 405–410.

2. Sargent, P. A., Sharpley, A. L., Williams, C., Goodall, E. M., and Cowen, P. J. (1997). 5-HT$_{2C}$ receptor activation decreases appetite and body weight in obese subjects. *Psychopharmacology* **133**, 309–312. Hunger ratings were recorded "on 10 cm visual analogue scales."

3. Unpublished data courtesy of R. Buchman. The data were collected in Oberlin, Ohio, during the spring of 2001.

4. Day, K. M., Patterson, F. L., Luetkemeier, O. W., Ohm, H. W., Polizotto, K., Roberts, J. J., Shaner, G. E., Huber, D. M., Finney, R. E., Foster, J. E., and Gallun, R. L. (1980). Performance and adaptation of small grains in Indiana. *Station Bulletin*, No. 290. West Lafayette, Ind.: Agricultural Experiment Station of Purdue University. Raw data provided courtesy of W. E. Nyquist. The actual trial included more than two varieties.

5. Unpublished data courtesy of C. H. Noller.

6. Cicirelli, M. F., and Smith, L. D. (1985). Cyclic AMP levels during the maturation of *Xeno pus* oocytes. *Developmental Biology* **108**, 254–258. Raw data courtesy of M. F. Cicirelli.

7. Judge, M. D., Aberle, E. D., Cross, H. R., and Schanbacher, B. D. (1984). Thermal shrinkage temperature of intramuscular collagen of bulls and steers. *Journal of Animal Science* **59**, 706–709. Raw data courtesy of the authors and E. W. Mills.

8. Swedo, S. E., Leonard, H. L., Rapoport, J. L., Lenane, M. C., Goldberger, E. L., and Cheslow, B. S. (1989). A double-blind comparison of clomipramine and desipramine in the treatment of trichotillomania (hair pulling). *New England Journal of Medicine* **321**, 497–501.

9. Unpublished data courtesy of A. Ladavac. The data were collected in Oberlin, Ohio, in November 1996.

10. In a study in which there is no natural pairing (for example, if identical twins are not available), one may wish to take two equal size groups and create pairs by using covariates such as age and weight. If an experiment is conducted in which members of a pair are randomly assigned to opposite treatment groups, then a paired data analysis has good properties. However, if an observational study is conducted (so that there is no random assignment within pairs), then a paired analysis, such as a paired *t* test, will tend to understate the true variability of the difference being studied and the true Type I error rate of a *t* test will be greater than the nominal level of the test. For discussion, see David, H. A., and Gunnink, J. L. (1997). The paired *t* test under artificial pairing. *The American Statistician* **51**, 9–12.

11. Schriewer, H., Guennewig, V., and Assmann, G. (1983). Effect of 10 weeks endurance training on the concentration of lipids and lipoproteins as well as on the composition of high-density lipoproteins in blood serum. *International Journal of Sports Medicine* **4**, 109–115. Reprinted with permission of Georg Thieme Verlag KG.

12. Data from experiments reported in several papers, for example, Fout, G. S., and Simon, E. H. (1983). Antiviral activities directed against wild-type and interferon-sensitive mengovirus. *Journal of General Virology* **64**, 1543–1555. Raw data courtesy of E. H. Simon. The unit of measurement is proportional to the number of plaques formed by the virus on a monolayer of mouse cells. Because they are obtained by a serial dilution technique, the measurements have varying numbers of significant digits; the final zeroes of the three-digit numbers are not significant digits.

13. Adapted from Batchelor, J. R., and Hackett, M. (1970). HL-A matching in treatment of burned patients with skin allografts. *Lancet* **2**, 581–583.

14. Sallan, S. E., Cronin, C., Zelen, M., and Zinberg, N. E. (1980). Antiemetics in patients receiving chemotherapy for cancer. *New England Journal of Medicine* **302**, 135–138. Reprinted by permission.

15. Koh, K. K., Mincemoyer, R., Bui, M. N., Csako, G., Pucino, F., Guetta, V., Waclawiw, M., and Cannon, R. O. (1997). Effects of hormone replacement therapy on fibrinolysis in postmenopausal women. *New England Journal of Medicine* **336**, 683–690. Raw data courtesy of K. K. Koh.

16. Rosenzweig, M. R., Bennett, E. L., and Diamond, M. C. (1972). Brain changes in response to experience. *Scientific American* **226**, No. 2, 22–29. Also Bennett, E. L., Diamond, M. C., Krech, D., and Rosenzweig, M. R. (1964). Chemical and anatomical plasticity of brain. *Science* **146**, 610–619. Copyright 1964 by the American Association for the Advancement of Science.

17. Richens, A., and Ahmad, S. (1975). Controlled trial of valproate in severe epilepsy. *British Medical Journal* **4**, 255–256.

18. Wiedenmann, R. N., and Rabenold, K. N. (1987). The effects of social dominance between two subspecies of dark-eyed juncos, *Junco hyemalis. Animal Behavior* **35**, 856–864. Raw data courtesy of the authors.

19. Masty, J. (1983). Innervation of the equine small intestine. Master's thesis, Purdue University. Raw data courtesy of the author.

20. Golden, C. J., Graber, B., Blose, I., Berg, R., Coffman, J., and Block, S. (1981). Difference in brain densities between chronic alcoholic and normal control patients. *Science* **211**, 508–510. Raw data courtesy of C. J. Golden. Copyright 1981 by the AAAS.

21. Data from Namdar, M., et al. The experiment described in Example 8.1.1 was conducted under simulated high altitude, whereas the experiment described in Exercise 8.5.7 was conducted under conditions that mimic being at sea level.

22. Patel, C., Marmot, M. G., and Terry, D. J. (1981). Controlled trial of biofeedback-aided behavioural methods in reducing mild hypertension. *British Medical Journal* **282**, 2005–2008.

23. Forde, O. H., Knutsen, S. F., Arnesen, E., and Thelle, D. S. (1985). The Tromso heart study: Coffee consumption and serum lipid concentrations in men with hypercholesterolaemia: A randomised intervention study. *British Medical Journal* **290**, 893–895. (The sample sizes are unequal because the 25 no-coffee men actually represent three different treatment groups, which followed the same regimen for the first five weeks of the study and different regimens thereafter.)

24. Dalvit, S. P. (1981). The effect of the menstrual cycle on patterns of food intake. *American Journal of Clinical Nutrition* **34**, 1811–1815.

25. Unpublished data courtesy of D. J. Honor and W. A. Vestre.

26. Sesin, G. P. (1984). Pharmacokinetic dosing of Tobramycin sulfate. *American Pharmacy NS24*, 778. Vakoutis, J., Stein, G. E., Miller, P. B., and Clayman, A. E. (1981). Aminoglycoside monitoring program. *American Journal of Hospital Pharmacy* **38**, 1477–1480. Copyright 1981, American Society of Hospital Pharmacists, Inc. All rights reserved. Reprinted with permission.

27. Jovan, S. (2000). Catnip bonanza. *Stats*, No. 27, 25–27.

28. Dale, E. M., and Housley, T. L. (1986). Sucrose synthase activity in developing wheat endosperms differing in maximum weight. *Plant Physiology* **82**, 7–10. Raw data courtesy of the authors.

29. Unpublished data courtesy of M. Heithaus and D. Rogers. The samples were taken from the Vermilion River in northern Ohio during the spring of 1995.

30. Salib, N. M. (1985). The effect of caffeine on the respiratory exchange ratio of separate submaximal arms and legs exercise of middle distance runners. Master's thesis, Purdue University.

31. Adapted from Bodian, D. (1947). Nucleic acid in nerve-cell regeneration. *Symposia of the Society for Experimental Biology*, No. 1, *Nucleic Acid*, 163–178. Used with permission from The Society for Experimental Biology.

32. Knowlen, G. G., Kittleson, M. D., Nachreiner, R. F., and Eyster, G. E. (1983). Comparison of plasma aldosterone concentration among clinical status groups of dogs with chronic heart failure. *Journal of the American Veterinary Medical Association* **183**, 991–996.

33. Robinson, L. R. (1985). The effects of electrical fields on wound healing in *Notophthalmus viridescens.* Master's thesis, Purdue University. Raw data courtesy of the author and J. W. Vanable, Jr.

34. Agosti, E., and Camerota, G. (1965). Some effects of hypnotic suggestion on respiratory function. *International Journal of Clinical and Experimental Hypnosis* **13**, 149–156. The experiment actually included a third phase.

35. Koh, K. K., Mincemoyer, R., Bui, M. N., Csako, G., Pucino, F., Guetta, V., Waclawiw, M., and Cannon, R. O. (1997). Effects of hormone replacement therapy on fibrinolysis in postmenopausal women. *New England Journal of Medicine* **336**, 683–690. Raw data courtesy of K. K. Koh.

36. Savin, V. J., Sharma, R., Sharma, M., McCarthy, E. T., Swan, S. K., Ellis, E., Lovell, H., Warady, B., Gunwar, S., Chonko, A. M., Artero, M., and Vincenti, F. (1996). Circulating factor associated with increased glomerular permeability to albumin in recurrent focal segmental glomerulosclerosis. *New England Journal of Medicine* **334**, 878–883. Raw data courtesy of V. J. Savin.

Chapter 9

1. White, A. S., Godard, R. D., Belling, C, Kasza, V., and Beach, R. L. (2010). Beverages obtained from soda fountain machines in the U.S. contain microorganisms, including coliform bacteria. *International Journal of Food Microbiology* **137**, 61–66.

2. From the National Survey of Family Growth (2002). U.S. Dept. of Health and Human Services, *Vital and Health Statistics*, Series 23, No. 25. Data are taken from Table 75.

3. Agresti, A., and Coull, B. A. (1998). Approximate is better than "exact" for interval estimation of binomial proportions. *The American Statistician* **52**, 119–126. The authors show that 95% confidence intervals based on $\tilde{p}$ are superior to other commonly used confidence intervals. They also note that if one uses $\tilde{p}$, then it is not necessary to construct tables or rules for how large the sample size needs to be in order for the confidence interval to have good coverage properties.

4. Couch, F. J., et al. (1997). *BRCA1* mutations in women attending clinics that evaluate the risk of breast cancer. *New England Journal of Medicine* **336**, 1409–1415.

5. Ware, J. H. (1989). Investigating therapies of potentially great benefit: ECMO. *Statistical Science* **4**, 298–306. The ECMO data are discussed in greater detail in Section 10.4.

6. Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia* **9**, 97–113.

7. Adapted from McCloskey, R. V., Goren, R., Bissett, D., Bentley, J., and Tutlane, V. (1982). Cefotaxime in the treatment of infections of the skin and skin structure. *Reviews of Infectious Diseases* **4**, Supp., S444–S447.

8. Adapted from Petras, M. L. (1967). Studies of natural populations of *Mus.* III. Coat color polymorphisms. *Canadian Journal of Genetic Cytology* **9**, 287–296.

9. Miller, C. L., Pollock, T. M., and Clewer, A. D. F. (1974). Whooping-cough vaccination: An assessment. *The Lancet* **ii**, 510–513.

10. Erskine, A. G., and Socha, W. W. (1978). *The Principles and Practices of Blood Grouping.* St. Louis: Mosby, p. 209.

11. Curtis, H. (1983). *Biology*, 4th ed. New York: Worth, p. 908.

12. Mourant, A. E., Kopec, A. C., and Domaniewska-Sobczak, K. (1976). *The Distribution of Human Blood Groups and Other Polymorphisms*, 2nd ed. London: Oxford University Press, p. 44.

13. Based on an experiment described in Oellerman, C. M., Patterson, F. L., and Gallun, R. L. (1983). Inheritance of resistance in "Luso" wheat to Hessian fly. *Crop Science* **23**, 221–224.

14. Cogswell, M. E., Looker, A. C., Pfeiffer, C. M., Cook, J. D., Lacher, D. A., Beard, J. L., Lynch, S. R., and Grummer-Strawn, L. M. (2009). Assessment of iron deficiency in US preschool children and nonpregnant females of childbearing age: National Health and Nutrition Examination Survey 2003–2006. *American Journal of Clinical Nutrition* **89**, 1334–1342.

15. Hayes, D. L., et al. (1997). Interference with cardiac pacemakers by cellular telephones. *New England Journal of Medicine* **336**, 1473–1479. The data cited are for CDMA telephones. Although interference was recorded in 15.7% of the tests, a much smaller percentage of the tests caused symptoms that were clinically significant.

16. Duggan, D. J., Gorospe, J. R., Fanin, M., Hoffman, E. P., and Angelini, C. (1997). Mutations in the sarcoglycan genes in patients with myopathy. *New England Journal of Medicine* **336**, 618–624.

17. Rabenold, K. R., and Rabenold, P. P. (1985). Variation in altitudinal migration, winter segregation, and site tenacity in two subspecies of dark-eyed juncos in the Southern Appalachians. *The Auk* **102**, 805–819.

18. Fictitious but realistic data based on a personal communication with F. Villablanca.

19. Saeidi, G., and Rowland, G. G. (1997) The inheritance of variegated seed color and palmitic acid in flax. *Journal of Heredity* **88**, 466–468.

20. Phillips, D. P., and Smith, D. G. (1990). Postponement of death until symbolically meaningful occasions. *Journal of the American Medical Association* **263**, 1947–1951. For comparison purposes, the authors also examined deaths among elderly Jewish women during the same time period; they did not find any excess of deaths after the festival for this comparison group.

21. Sinnott, E. W., and Durham, G. B. (1922). Inheritance in the summer squash. *Journal of Heredity* **13**, 177–186.

22. Adapted from Gould, J. L. (1985). How bees remember flower shapes. *Science* **227**, 1492–1494. Figure copyright 1985 by the American Association for the Advancement of Science; used by permission.

23. Adapted from 1983 birth data for West Lafayette, Indiana.

24. Bateson, W., and Saunders, E. R. (1902). *Reports to the Evolution Committee of the Royal Society* **1**, 1–160. Feather color and comb shape are controlled independently; white feather is dominant and small comb is dominant. The parents in the experiment were first-generation hybrids (F_1) and thus were necessarily double heterozygotes.

25. This is a realistic value. See Exercise 3.6.6.

26. Jakkula, L. R., Knault, D. A., and Gorbet, D. W. (1997). Inheritance of a shriveled seed trait in peanut. *Journal of Heredity* **88**, 47–51. The data are taken from Table 5 of the paper.

27. Adapted from Mantel, N., Bohidar, N. R., and Ciminera, J. L. (1977). Mantel-Haenszel analyses of litter-matched time-to-response data, with modifications for recovery of inter-litter information. *Cancer Research* **37**, 3863–3868. (A more powerful analysis, which uses the partially informative triplets, is described in the paper.)

28. Adapted from Jacobs, G. H. (1978). Spectral sensitivity and colour vision in the ground-dwelling sciurids: Results from golden mantled ground squirrels and comparisons for five species. *Animal Behaviour* **26**, 409–421. See also Jacobs, G. H. (1981). *Comparative Color Vision*, Academic Press.

29. Petrij, F., van Veen, K., Mettler, M., and Bruckmann, V. (2001). A second acromelanistic allelomorph at the albino locus of the Mongolian gerbil (*Meriones unguiculatus*). *Journal of Heredity* **92**, 74–78. The gerbils we call "brown" are referred to as "Siamese" by the authors.

30. Kaitz, M. (1992). Recognition of familiar individuals by touch. *Physiology and Behavior* **52**, 565–567.

31. Fawole, I. (2001). Genetic analysis of mutations at loci controlling leaf form in cowpea (*Vigna unguiculata* [L.] Walp). *Journal of Heredity* **92**, 43–50. These data come from the 1993a generation listed in Table 8 of the article. The types we call I, II, and III are identified by the authors as trifoliolate, trifoliolate orbicular, and unifoliolate orbicular.

32. Baur, E., Fischer, E., and Lenz, F. (1931). *Human Heredity*, 3rd ed. New York: Macmillan, p. 52.

33. This is typical for U.S. populations. See, for example, Maccready, R. A., and Mannin, M. C. (1951). A typing study of one hundred and fifty thousand bloods. *Journal of Laboratory and Clinical Medicine* **37**, 634–636.

34. Fictitious but realistic situation. See Krebs, C. J. (1972). *Ecology: The Experimental Analysis of Distribution and Abundance.* New York: Harper and Row.

35. Cheatum, F. L., and Severinghaus, C. W. (1950). Variations in fertility of white-tailed deer related to range conditions. *Transactions of the North American Wildlife Conference* **15**, 170–189.

36. Ziegler, E. E., Nelson, S. E., and Jeter, J. M. (2009). Iron supplementation of breastfed infants from an early age. *American Journal of Clinical Nutrition* **89**, 525–532.

37. Fischer, C., and Fischer, U. (1997). Analysis of cork taint in wine and cork material at olfactory subthreshold levels by solid phase microextraction. *Journal of Agricultural and Food Chemistry* **45**, 1995–1997.

38. Freeland, W. J. (1981). Parasitism and behavioral dominance among male mice. *Science* **213**, 461–462. Copyright 1981 by the AAAS.

39. Collins, R. L. (1970). The sound of one paw clapping: An inquiry into the origin of left-handedness. In Lindzey, G., and Thiessen, D. D. (eds.). *Contributions to Behavior-Genetic Analysis: The Mouse as Prototype*. Appleton-Century-Crofts.

40. Fawole, I. op cit. These data are from Table 3 of the paper.

41. Floersheim, G. L., Weber, O., Tschumi, P., and Ulbrich, M. (1983). Research cited in *Scientific American* **248** (April 1983), No. 4, p. 75.

42. Fuchs, J. A., Smith, J. D., and Bird, L. S. (1972). Genetic basis for an 11:5 dihybrid ratio observed in *Gossypium hirsutum. Journal of Heredity* **63**, 300–303. The genetic basis for the 13:3 and 11:5 ratios is explained in Strickberger, M. W. (1976). *Genetics*, 2nd ed. New York: Macmillan, pp. 206–208.

43. Adapted from Goodyear, C. P. (1970). Terrestrial and aquatic orientation in the starhead top-minnow, *Fundulus noti. Science* **168**, 603–605. Copyright 1970 by the AAAS.

44. See Batschelet, E. (1981). *Circular Statistics in Biology.* Academic Press.

45. Unpublished data courtesy J. L. Wolfson, collected at Bard College in 1997.

46. Paris, H. S. (1997). Genes for developmental fruit coloration of acorn squash. *Journal of Heredity* **88**, 52–56. The experiment included crossing Table Queen squash (TQE) with Vegetable Spaghetti (VSP). The data presented in the exercise are from a back-cross of VSP with a TQE × VSP cross.

47. Chen, P., Ma, G., Buss, G. R., Gunduz, I., Roane, C. W., and Tolin, S. A. (2001). Inheritance and alleism tests of Raiden soybean for resistance to soybean mosaic virus. *Journal of Heredity* **92**, 51–55. The "resistant" classification includes both resistant and systemic necrotic plants.

48. Lamb, M. L., Fishbein, M., Douglas, J. M., Rhodes, F., Rogers, J., Bolan, G., Zenilman, J., Hoxworth, T., Malotte, K., Iatesta, M., Kent, C., Lentz, A., Graziano, S., Byers, R. H., and Peterman, T. A. (1998). Efficacy of risk-reduction counseling to prevent human immunodeficieny virus and sexually transmitted diseases. *Journal of the American Medical Association* **280**, 1161–1167.

Chapter 10

1. Guyuron, B., Reed, D., Kriegler, J., Davis, J., Pashmini, N., and Amini, S. (2009). A placebo-controlled surgical trial of the treatment of migraine headaches. *Plastic and Reconstructive Surgery* **124**, 461–468.

2. Unpublished data courtesy of D. Wallace, collected at Oberlin College in the fall of 1995.

3. Brodie, E. D., Jr., and Brodie, E. D. III. (1980). Differential avoidance of mimetic salamanders by free-ranging birds. *Science* **208**,181–182. Copyright 1980 by the AAAS.

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14. Adapted from Ammon, O. (1899). *Zur Anthropologie der Badener.* Jena: G. Fischer. Ammon's data appear in Goodman, L. A., and Kruskal, W. H. (1954). Measures of association for cross classifications. *Journal of the American Statistical Association* **49**, 732–764. Light hair was blonde or red; dark hair was brown or black. Light eyes were blue, grey, or green; dark eyes were brown.

15. Cruz-Coke, R. (1970). *Color Blindness; An Evolutionary Approach*. Springfield, Ill.: Thomas.

16. Bill-Alexson, A., et al. for the Scandinavian Prostate Cancer Study Group No. 4 (2005). Radical prostatectomy versus watchful waiting in early prostate cancer. *New England Journal of Medicine* **352**, 1977–1984.

17. Adapted from Porac, C., and Coren, S. (1981). *Lateral Preferences and Human Behavior.* New York: Springer-Verlag. The frequencies given are approximate, having been deduced from percentages on pages 36 and 45. People with neutral preference were counted as Left.

18. Upton, G., and Fingleton, B. (1985). *Spatial Data Analysis by Example: Point Pattern and Quantitative Data*, Vol. 1. New York: Wiley, p. 230. Adapted from Diggle, P. J. (1979). Statistical methods for spatial point patterns in ecology, pp. 95–150 in *Spatial and Temporal Analysis in Ecology*, R. M. Cormack and J. K. Ord (eds.). Fairland, Md.: International Cooperative Publishing House.

19. Based on an article by the Writing Group for Bypass Angioplasty Revascularization Investigation (BARI) Investigators (1997). See five-year clinical and functional outcome comparing bypass surgery and angioplasty in patients with multivessel coronary disease. *Journal of the American Medical Association* **277**, 715–721.

20. These data are fictitious, but the proportions of left-handed males and females are realistic and the independence of the twins is in agreement with published data. See Porac, C., and Coren, S. (1981). *Lateral Preferences and Human Behavior.* New York: Springer-Verlag, p. 36; and Morgan, M. C., and Corballis, M. J. (1978). On the biological basis of human laterality: I. Evidence for a maturational left-right gradient. *The Behavioral and Brain Sciences* **2**, p. 274.

21. Ware, J. H. (1989). Investigating therapies of potentially great benefit: ECMO. *Statistical Science* **4**, 298–306. There is controversy surrounding this experiment. An earlier experiment using a nonstandard randomization scheme had shown ECMO to be highly effective. Thus, some statisticians question whether this second experiment was necessary. For a discussion of these issues see the articles on pages 306–340 that follow the Ware article in *Statistical Science* **4**.

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24. Unpublished data courtesy of B. Rogers, collected at the Oberlin College Conservatory of Music in the spring of 1991.

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29. Adapted from Ammon, O. (1899). *Zur Anthropologie der Badener.* Jena: G. Fischer. Ammon's data appear in Goodman, L. A., and Kruskal, W. H. (1954). Measures of association for cross classifications. *Journal of the American Statistical Association* **49**, 732–764.

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33. Govind, C. K., and Pearce, J. (1986). Differential reflex activity determines claw and closer muscle asymmetry in developing lobsters. *Science* **233**, 354–356. Copyright 1986 by the AAAS.

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35. Unpublished data courtesy of L. Solimine.

36. Hudson, J. I., McElroy, S. L., Raymond, N. C., Crow, S., Keck, P. E., Carter, W. P., Mitchell, J. E., Strakowski, S. M., Pope, H. G., Coleman, B. S., and Jonas, J. M. (1998). Fluvoxamine in the treatment of binge-eating disorder: A multicenter placebo-controlled, double-blind trial. *American Journal of Psychiatry* **155**, 1756–1762. The response variable has ordered categories, so there are more powerful methods, beyond the scope of this text, that can be used to analyze the data.

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38. Wolfson, J. L. (1987). Impact of *Rhizobium* nodules on *Sitona hispidulus*, the clover root curculio. *Entomologia Experimentalis et Applicata* **43**, 237–243. Data courtesy of the author. The experiment actually included 11 dishes.

39. Adapted from Paige, K. N., and Whitham, T. G. (1985). Individual and population shifts in flower color by scarlet gilia: A mechanism for pollinator tracking. *Science* **227**, 315–317. The raw data given are fictitious but have been constructed to agree with the summary statistics given by Paige and Whitham.

40. Brusco, N. K., Shields, N., Taylor, N. F., and Paratz, J. (2007). A Saturday physiotherapy service may decrease length of stay in patients undergoing rehabilitation in hospital: A randomised controlled trial. *Australian Journal of Physiotherapy* **53**, 75–81.

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42. Pittet, P. G., Acheson, K. J., Wuersch, P., Maeder, E., and Jequier, E. (1981). Effects of an oral load of partially hydrolyzed wheatflour on blood parameters and substrate utilization in man. *The American Journal of Clinical Nutrition* **34**, 2438–2445.

43. Agresti, A., and Caffo, B. (2000). Simple and effective confidence intervals for proportions and differences of proportions result from adding two successes and two failures. *The American Statistician* **54**, 280–288. Agresti and Caffo conduct a series of simulations which show that adding 1 to each cell results in good coverage properties when the sample sizes, n_1 and n_2, are as small as 10. Unpublished calculations done by J. Witmer show that these good properties are also obtained when n_1 and n_2 are as small as 5, provided p_1 and p_2 are not both close to 0 or both close to 1, in which case the interval becomes quite conservative (i.e., the coverage rate approaches 100% for a nominal 95% confidence interval).

44. Agresti, A. Personal communication.

45. Lyles, K. W., et al. for the HORIZON Recurrent Fracture Trial (2007). Zolendronic acid and clinical hip fractures and mortality after hip fracture. *New England Journal of Medicine* **357**, 1799–1809.

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47. Lader, M., and Scotto, J.-C. (1998). A multicentre double-blind comparison of hydroxyzine, buspirone and placebo in patients with generalized anxiety disorder. *Psychopharmacology* **139**, 402–406. Improvement is taken to be a 50% or greater reduction in Hamilton Anxiety (HAM-A) score. There was a third treatment group in this study, which we are ignoring here.

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49. Collaborative Group for the Study of Stroke in Young Women (1973). Oral contraception and increased risk of cerebral ischemia or thrombosis. *New England Journal of Medicine* **288**, 871–878. Reprinted by permission.

50. Johnson, S. K., and Johnson, R. E. (1972). Tonsillectomy history in Hodgkin's disease. *New England Journal of Medicine* **287**, 1122–1125.

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52. Sidney, S., Tekawa, I. S., and Friedman, G. D. (1993). A prospective study of cigarette tar yield and lung cancer. *Cancer Causes and Control* **4**, 3–10.

53. The steering committee of the Physicians' Health Study Research Group. (1988). Preliminary report: Findings from the aspirin component of the ongoing physicians' health study. *New England Journal of Medicine* **318**, 262–264.

54. Witsberger, T. H., Villamil, J. A., Schultz, L. G., Hahn, A. W., and Cook, J. L. (2008). Prevalence of and risk factors for hip dysplasia and cranial cruciate ligament deficiency in dogs. *Journal of the American Veterinary Medical Association* **232**, 1818–1824.

55. Zwerling, C., Whitten, P. S., Davis, C. S., and Sprince, N. L. (1997). Occupational injuries among workers with disabilities. *Journal of the American Medical Association* **278**, 2163–2166. In this study an injury means an occupational injury in the year preceding when the person was interviewed.

56. Kernan, W. N., Viscoli, C. M., Brass, L. M., Broderick, J. P., Brott, T., Feldmann, E., Morgenstern, L. B., Wilterdink, J. L., and Horwitz, R. I. (2000). Phenypropanolamine and the risk of hemorrhagic stroke. *New England Journal of Medicine* **343**, 1826–1832.

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58. Howard, B. V., et al. (2006). Low-fat dietary pattern and risk of cardiovascular disease. *Journal of the American Medical Association* **295**, 655–666.

59. Conover, D. O., and Kynard, B. E. (1981). Environmental sex determination: Interaction of temperature and genotype in a fish. *Science* **213**, 577–579. Copyright 1981 by the AAAS.

60. Carson, J. L., Collier, A. M., and Hu, S. S. (1985). Acquired ciliary defects in nasal epithelium of children with acute viral upper respiratory infections. *New England Journal of Medicine* **312**, 463–468. Reprinted by permission.

61. Larson, E. B., Roach, R. C., Schoene, R. B., and Hombein, T. F. (1982). Acute mountain sickness and acetazolamide. *Journal of the American Medical Association* **248**, 328–332. Copyright 1982 American Medical Association.

62. Kluger, M. J., Ringler, D. H., and Anver, M. R. (1975). Fever and survival. *Science* **188**, 166–168. Copyright 1975 by the AAAS. The original article contains a misprint, but Dr. Kluger has kindly provided the correct mortality at 40 °C.

63. Ragaz, J., Jackson, S. M., Le, N., Plenderleith, I. H., Spinelli, J. J., Basco, V. E., Wilson, K. S., Knowling, M. A., Coppin, C. M. L., Paradis, M., Coldman, A. J., and Olivotto, I. A. (1997). Adjuvant radiotherapy and chemotherapy in node-positive premenopausal women with breast cancer. *New England Journal of Medicine* **337**, 956–962.

64. Englund, J. A., Baker, C. J., Raskino, C., McKinney, R. E., Petrie, B., Fowler, M. G., Pearson, D., Gershon, A., McSherry, G. D., Abrams, E. J., Schliozberg, J., and Sullivan, J. L. (1997). Zidovudine, didanosine, or both as the initial treatment for symptomatic HIV-infected children. *New England Journal of Medicine* **336**, 1704–1712. The data presented here are for an interim analysis that was conducted approximately two years into the study. As a result of the interim analysis of death rates and of rates of disease progression, the use of zidovudine alone was stopped before the end of the trial.

65. Gupta, M., and Chordhuri, A. N. R. (1980). Relationship between ABO blood groups and malaria. *Bulletin of the World Health Organization* **58**, 913–915.

66. Shorrocks, B., and Nigro, L. (1981). Microdistribution and habitat selection in *Drosophila subobscura* collin. *Biological Journal of the Linnean Society* **16**, 293–301.

67. Malacrida, R., Genoni, M., Maggioni, A. P., Spatato, V., Parish, S., Palmer, A., Collins, R., and Moccetti, T. (1998). A comparison of the early outcome of acute myocardial infarction in women and men. *New England Journal of Medicine* **338**, 8–14. Although the odds ratio for these data shows that men are more likely to survive than are women, the authors discuss the effect that age has on this finding. They calculate a new odds ratio after adjusting for age and other covariates (using methods that are beyond the scope of this text) and conclude that much of the difference in survival probability is due to these covariates.

68. Mochizuki, M., Marno, T., Masuko, K., and Ohtsu, T. (1984). Effects of smoking on fetoplacental-maternal system during pregnancy. *American Journal of Obstetrics and Gynecology* **149**, 413–420.

69. Redelmeier, D. A., and Tibshirani, R. J. (1997). Association between cellular-telephone calls and motor vehicle collisions. *New England Journal of Medicine* **336**, 453–458. Also see Redelmeier, D. A., and Tibshirani, R. J. (1997). Is using a car phone like driving drunk? *Chance* **10**, No. 2, 5–9.

70. Monto, A. S., Ohmit, S. E., Petrie, J. G., Johnson, E., Truscon, R., Teich, E., Rotthoff, J., Boulton, M., and Victor, J. (2009). Comparative efficacy of inactivated and live attenuated influenza vaccines. *New England Journal of Medicine* **361**, 1260–1267.

Chapter 11

1. Martinez, J. (1998). Organic practices for the cultivation of sweet corn. Unpublished manuscript, Oberlin College. For pedagogical purposes, the data presented here are a random sample from a larger study. The nematode used was *Steinernema carpocapsae*, the bacterium was *Bacillus thuringiensis*, and the wasp was *Trichogramma pretiosum.*

2. Shields, D. R. (1981). The influence of niacin supplementation on growing ruminants and *in vivo* and *in vitro* rumen parameters. Ph.D. thesis, Purdue University. Adapted from raw data provided courtesy of the author and D. K. Colby.

3. Adapted from Potkin, S. G., Cannon, H. E., Murphy, D. L., and Wyatt, R. J. (1978). Are paranoid schizophrenics biologically different from other schizophrenics? *New England Journal of Medicine*, **298**, 61–66. Reprinted by permission. The calculations are based on the data in Example 1.1.4 in this book, which are an approximate reconstruction from the histograms and summary information given by Potkin et al.

4. Adapted from Keller, S. E., Weiss, J. M., Schleifer, S. J., Miller, N. E., and Stein, M. (1981). Suppression of immunity by stress: Effect of a graded series of stressors on lymphocyte stimulation in the rat. *Science* **213**, 1397–1400. Copyright 1981 by the AAAS. The SDs and SSs were estimated from the SEs given by Keller et al.

5. Lobstein, D. D. (1983). A multivariate study of exercise training effects on beta-endorphin and emotionality in psychologically normal, medically healthy men. Ph.D. thesis, Purdue University. Raw data courtesy of the author.

6. Hayden, F. G., Osterhaus, A. D., Treanor, J. J., Fleming, D. M., Aoki, F. Y., Nicholson, K. G., Bohnen, A. M., Hirst, H. M., Keene, O., and Wightman, K. (1997). Efficacy and safety of the neuraminidase inhibitor zanamivir in the treatment of influenzavirus infections. *New England Journal of Medicine* **337**, 874–880. The sums of squares have been calculated from the means and SDs given in the paper.

7. Person, A. (1999). Daffodil stem lengths. Unpublished manuscript, Oberlin College. The full data set is somewhat larger than that presented here.

8. Kotler, D. (2000). A comparison of aerobics and modern dance training on health-related fitness in college women. Unpublished manuscript, Oberlin College.

9. Unpublished data courtesy of H. W. Ohm.

10. Cameron, E., and Pauling, L. (1978). Supplemental ascorbate in the supportive treatment of cancer: Re-evaluation of prolongation of survival times in terminal human cancer. *Proceedings of the National Academy of Science USA* **75**, 4538–4542.

11. Neumann, A., Richards, A. -L., and Randa, J. (2001). Effects of acid rain on alfalfa plants. Unpublished manuscript, Oberlin College. The low acid group was given three drops of 1.5 M HCL as well as two droppers full of water each day. For the high acid group 3.0 M HCL was used. The control group was only given water. The original data have been modified slightly for pedagogical purposes.

12. This is the design described in the following papers. Rosenzweig, M. R., Bennett, E. L., and Diamond, M. C. (1972). Brain changes in response to experience. *Scientific American* **226**, No. 2, 22–29. Bennett, E. L., Diamond, M. C., Krech, D., and Rosenzweig, M. R. (1964). Chemical and anatomical plasticity of brain. *Science* **146**, 610–619.

13. Based on an experiment by Resh, W., and Stoughton, R. B. (1976). Topically applied antibiotics in acne vulgaris. *Archives of Dermatology* **112**, 182–184.

14. Swearingen, M. L., and Holt, D. A. (1976). Using a "blank" trial as a teaching tool. *Journal of Agronomic Education* **5**, 3–8. Reprinted by permission of the American Society of Agronomy, Inc via Copyright Clearance Center. In fact, in order to demonstrate the variability of plot yields, the experimenters planted the *same* variety of barley in all 16 plots.

15. Data adapted from McIntosh, A. R., and Townsend, C. R. (1996). Interactions between fish, grazing invertebrates and algae in a New Zealand stream: A trophic cascade mediated by fish-induced changes to grazer behavior. *Oecologia* **108**, 174–181.

16. Pappas, T., and Mitchell, C. A. (1985). Effects of seismic stress on the vegetative growth of *Glycine max* (L.) Merr. cv. Wells II. *Plant, Cell and Environment* **8**, 143–148. Raw data courtesy of the authors. The original experiment included more than four treatments. Reprinted with permission of Plant, Cell, and Environment.

17. Garcia-Nebot, M., Alegria, A., Barbera, R., Clemente, G., and Romero, F. (2010). Addition of milk or caseinophophopeptides to fruit beverages to improve iron bioavailability. *Food Chemistry* **119**, 141–148.

18. Kiesecker, J. M., Blaustein, A. R., and Belden, L. K. (2001). Complex causes of amphibian population declines. *Nature* **410**, 681–684. Sample means and standard deviation were read from Figure 2a in the article.

19. Tripepi, R. R., and Mitchell, C. A. (1984). Metabolic response of river birch and European birch roots to hypoxia. *Plant Physiology* **76**, 31–35. Raw data courtesy of the authors.

20. Adapted from Veterans Administration Cooperative Study Group on Antihypertensive Agents (1979). Comparative effects of ticrynafen and hydrochlorothiazide in the treatment of hypertension. *New England Journal of Medicine* **301**, 293–297. Reprinted by permission. The value of s_{pooled} was calculated from the SEs given in the paper. Copyright © 1979 Massachusetts Medical Society. All rights reserved.

21. Knight, S. L., and Mitchell, C. A. (1983). Enhancement of lettuce yield by manipulation of light and nitrogen nutrition. *Journal of the American Society for Horticultural Science* **108**, 750–754. Calculations based on raw data provided by the authors.

22. Fictitious but realistic data, adapted from O'Brien, R. J., and Drizd, T. A. (1981). Basic data on spirometry in adults 25–74 years of age: United States, 1971–75. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 222. Washington, D.C.: U.S. Department of Health and Human Services.

23. U.S. Bureau of the Census. The 2008 age distribution is taken from www.census.gov/compendia/statab/cats/population/estimates_and_projections_by_age_sex_raceethnicity.html The percentages have been rounded to sum to 1.

24. Chrisman, C. L., and Baumgartner, A. P. (1980). Micronuclei in bone-marrow cells of mice subjected to hyperthermia. *Mutation Research* **77**, 95–97. The original experiment included six treatments.

25. Baird, J. T., and Quinlivan, L. G. (1973). Parity and hypertension. *U.S. National Center for Health Statistics, Vital and Health Statistics*, Series 11, No. 38. Washington, D.C.: U.S. Department of Health, Education and Welfare.

26. U.S. Bureau of the Census (1997). *Statistical Abstract of the United States*, 1997 117th ed. Washington, D.C: U.S. Government Printing Office.

27. Adapted from Witelson, S. F. (1985). The brain connection: The corpus callosum is larger in left-handers. *Science* **229**, 665–668. Copyright 1985 by the AAAS. The SDs and MS (within) have been calculated from the standard errors given by Witelson. Reprinted with permission from AAAS.

28. Adapted from Booth, D. M., and Heck, K. L., (2009). Effects of the American oyster *Crassostrea* virginica on growth rates of the seagrass *Halodule wrightii. Marine Ecology Progress Series* **389**, 117–126. The article has the full data set; we present only part of the data for pedagogical purposes.

29. Latimer, J. (1985). Adapted from unpublished data provided by the investigator.

30. Adapted from Morris, J. G., Cripe, W. S., Chapman, H. L., Jr., Walker, D. F., Armstrong, J. B., Alexander, J. D., Jr., Miranda, R., Sanchez, A., Jr., Sanchez, B., Blair-West, J. R., and Denton, D. A. (1984). Selenium deficiency in cattle associated with Heinz bodies and anemia. *Science* **223**, 491–492. Copyright 1984 by the AAAS. The MS(within) is fictitious but agrees with the standard errors given by Morris et al.

31. Fictitious but realistic data. Adapted from Mizutani, T., and Mitsuoka, T. (1979). Effect of intestinal bacteria on incidence of liver tumors in gnotobiotic C3H/He male mice. *Journal of the National Cancer Institute* **63**, 1365–1370.

32. Becker, W. A. (1961). Comparing entries in random sample tests. *Poultry Science* **40**, 1507–1514.

33. Adapted from Rosner, B. (1982). Statistical methods in ophthalmology: An adjustment for the intraclass correlation between eyes. *Biometrics* **38**, 105–114. Reprinted with permission from The International Biometric Society. The medical study is reported in Berson, E. L., Rosner, B., and Simonoff, E. (1980). An outpatient population of retinitis pigmentosa and their normal relatives: Risk factors for genetic typing and detection derived from their ocular examinations. *American Journal of Ophthalmology* **89**, 763–775. The means and sums of squares have been estimated from data given by Rosner, after estimating missing values for two patients for whom only one eye was measured.

34. Heggestad, H. E., and Bennett, J. H. (1981). Photochemical oxidants potentiate yield losses in snap beans attributable to sulfur dioxide. *Science* **213**, 1008–1010. Copyright 1981 by the AAAS. Raw data courtesy of H. E. Heggestad.

35. Tardif, J., Cote, G., Lesperance, J., Bourassa, M., Lambert, J., Doucet, S., Bilodeau, L., Nattel, S., and DeGuise, P. (1997). Probucol and multivitamins in the prevention of restenosis after coronary angioplasty. *New England Journal of Medicine* **337**, 365–372.

36. Walker, P., Osredkar, M., and Bilancini, S. (1999). The effect of stimuli on pillbug movement. Unpublished manuscript, Oberlin College.

37. Hoppeler, H., and Vogt, M. (2001). Muscle tissue adaptations to hypoxia. *The Journal of Experimental Biology* **204**, 3133–3139.

38. Adapted from Tajkarimi, M., Riemann, H., Hajmeer, M., Gomez, E., Razavilar, V., and Cliver, D. (2008). Ammonia disinfection of animal feeds—laboratory study. *International Journal of Food Microbiology* **122**, 23–28.

Chapter 12

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Chapter 13

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Statistical Tables

TABLE 1 Random Digits

	01	06	11	16	21	26	31	36	41	46
01	06048	96063	22049	86532	75170	65711	29969	06826	39208	80631
02	25636	73908	85512	78073	19089	66458	06597	93985	14193	69366
03	61378	45410	43511	54364	97334	01267	28304	35047	38789	84896
04	15919	71559	12310	00727	54473	51547	09816	83641	72973	75367
05	47328	20405	88019	82276	33679	10328	25116	59176	64675	95141
06	72548	80667	53893	64400	81955	15163	06146	58549	75530	19582
07	87154	04130	55985	44508	37515	71689	80765	46598	45539	12792
08	68379	96636	32154	94718	22845	80265	92747	66238	58474	23783
09	89391	54041	70806	36012	30833	83132	39338	54753	00722	44568
10	15816	60231	28365	61924	66934	21243	09896	92428	51611	46756
11	29618	55219	18394	11625	27673	08117	89314	42581	36897	03738
12	30723	42988	30002	95364	45473	46107	34222	00739	84847	49096
13	54028	04975	92323	53836	76128	84762	32050	59516	40831	59687
14	40376	02036	48087	05216	26684	97959	85601	86622	70750	15603
15	64439	37357	90935	57330	79738	65361	85944	23619	30504	61564
16	83037	30144	29166	20915	53462	42573	75204	50064	08847	07082
17	71071	01636	31085	71638	77357	14256	89174	15184	81701	21592
18	67891	43187	58159	24144	29683	04276	02987	04571	18334	04291
19	52487	39499	97330	40045	47304	98528	00422	82693	87547	73525
20	67550	82107	27302	79145	73213	27217	19211	59784	63929	04609
21	86472	80165	70773	90519	49710	31921	36102	45042	04203	01439
22	08699	38051	60404	06609	98435	91560	22634	98014	43316	61099
23	59596	13000	07655	74837	81211	71530	28341	83110	72289	25180
24	31810	54868	92799	09893	97499	96509	71548	06462	40498	22628
25	71753	90756	21382	84209	95900	11119	34507	61241	17641	83147

Continued

TABLE 1 Random Digits *(continued)*

	51	56	61	66	71	76	81	86	91	96
01	64825	74126	86159	26710	49256	04655	06001	73192	67463	16746
02	46184	63916	89160	87844	53352	43318	70766	23625	09906	65847
03	79976	48891	69431	86571	25979	58755	08884	36704	01107	12308
04	10656	47210	48512	06805	42114	98741	51440	06070	49071	02700
05	18058	84528	56753	02623	81077	60045	06678	53748	10386	37895
06	58979	98046	88467	27762	24781	12559	98384	40926	79570	34746
07	12705	41974	14473	49872	29368	80556	95833	20766	76643	35656
08	39660	83664	18592	82388	27899	24223	36462	61582	95173	36155
09	00360	42077	84161	04464	45042	29560	37916	29889	00342	82533
10	09873	64084	34685	53542	09254	23257	14713	44295	94139	00403
11	12957	84063	79808	23633	77133	41422	26559	29131	74402	82213
12	06090	71584	48965	60201	02786	88929	19861	99361	27535	38297
13	66812	57167	28185	19708	74672	25615	61640	18955	40854	50749
14	91701	36216	66249	04256	31694	33127	67529	73254	72065	74294
15	02775	78899	36471	37098	50270	58933	91765	95157	01384	75388
16	75892	53340	92363	58300	77300	08059	63743	12159	05640	87014
17	18581	70057	82031	68349	55759	46851	33632	28855	74633	08598
18	69698	18177	52824	61742	58119	04168	57843	37870	50988	80316
19	30023	30731	00803	09336	87709	39307	09732	66031	04904	91929
20	94334	05698	97910	37850	77074	56152	67521	48973	29448	84115
21	64133	14640	28418	45405	86974	06666	07879	54026	92264	23418
22	93895	83557	17326	28030	09113	56793	79703	18804	75807	20144
23	54438	83097	52533	86245	02182	11746	58164	90520	99255	44830
24	90565	76710	42456	22612	00232	18919	24019	32254	30703	00678
25	90848	81871	24382	16218	98216	42323	75061	68261	09071	68776

TABLE 1 Random Digits *(continued)*

	01	06	11	16	21	26	31	36	41	46
26	17155	07370	65655	04824	53417	20737	70510	92615	89967	50216
27	36211	24724	94769	16940	43138	25260	75318	69037	95982	28631
28	94777	66946	16120	56382	58416	92391	81457	28101	69766	32436
29	52994	58881	81841	51844	75566	48567	18552	66829	91230	39141
30	84643	32635	51440	96854	35739	66440	82806	82841	56302	31640
31	95690	34873	11297	60518	72717	47616	55751	37187	31413	31132
32	64093	92948	21565	51686	40368	66151	82877	99951	85069	54503
33	89484	50055	67586	16439	96385	67868	66597	51433	44764	66573
34	70184	38164	74646	90244	83169	85276	07598	69242	90088	32308
35	75601	91867	80848	94484	98532	36183	28549	17704	28653	80027
36	99044	78699	34681	31049	40790	50445	79897	68203	11486	93676
37	10272	18347	89369	02355	76671	34097	03791	93817	43142	24974
38	69738	85488	34453	80876	43018	59967	84458	71906	54019	70023
39	93441	58902	17871	45425	29066	04553	42644	54624	34498	27319
40	25814	74497	75642	58350	64118	87400	82870	26143	46624	21404
41	29757	84506	48617	48844	35139	97855	43435	74581	35678	69793
42	56666	86113	06805	09470	07992	54079	00517	19313	53741	25306
43	26401	71007	12500	27815	86490	01370	47826	36009	10447	25953
44	40747	59584	83453	30875	39509	82829	42878	13844	84131	48524
45	99434	51563	73915	03867	24785	19324	21254	11641	25940	92026
46	50734	88330	39128	14261	00584	94266	99677	19852	49673	18680
47	89728	32743	19102	83279	68308	41160	32365	25774	39699	50743
48	71395	61945	41082	93648	99874	82577	26507	07054	29381	16995
49	50945	68182	23108	95765	81136	06792	13322	41631	37118	35881
50	36525	26551	28457	75699	74537	68623	50099	91909	23508	35751

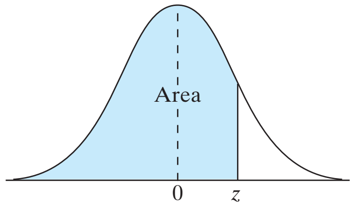
TABLE 1 Random Digits *(continued)*

	51	56	61	66	71	76	81	86	91	96
26	41169	08175	69938	61958	72578	31791	74952	71055	40369	00429
27	84627	70347	41566	00019	24481	15677	54506	54545	89563	50049
28	67460	49111	54004	61428	61034	47197	90084	88113	39145	94757
29	99231	60774	52238	05102	71690	72215	61323	13326	01674	81510
30	95775	73679	04900	27666	18424	59793	14965	22220	30682	35488
31	42179	98675	69593	17901	48741	59902	98034	12976	60921	73047
32	91196	05878	92346	45886	31080	21714	19168	94070	77375	10444
33	18794	03741	17612	65467	27698	20456	91737	36008	88225	58013
34	88311	93622	34501	70402	12272	65995	66086	04938	52966	71909
35	17904	33710	42812	72105	91848	39724	26361	09634	50552	98769
36	05905	28509	69631	69177	39081	58818	01998	53949	47884	91326
37	23432	22211	65648	71866	49532	45529	00189	80025	68956	26445
38	29684	43229	54771	90604	48938	13663	24736	83199	41512	43364
39	26506	65067	64252	49765	87650	72082	48997	04845	00136	98941
40	08807	43756	01579	34508	94082	68736	67149	00209	76138	95467
41	50636	70304	73556	32872	07809	20787	85921	41748	10553	97988
42	32437	41588	46991	36667	98127	05072	63700	51803	77262	31970
43	32571	97567	78420	04633	96574	88830	01314	04811	10904	85923
44	28773	22496	11743	23294	78070	20910	86722	50551	37356	92698
45	65768	76188	07781	05314	26017	07741	22268	31374	53559	46971
46	68601	06488	73776	45361	89059	59775	59149	64095	10352	11107
47	98364	17663	85972	72263	93178	04284	79236	04567	31813	82283
48	95308	70577	96712	85697	55685	19023	98112	96915	50791	31107
49	68681	24419	15362	60771	09962	45891	03130	09937	15775	51935
50	30721	22371	65174	57363	37851	71554	19708	23880	86638	05880

TABLE 2 Binomial Coefficients ${}_nC_j$

n	j = 0	1	2	3	4	5	6	7	8	9	10
1	1	1									
2	1	2	1								
3	1	3	3	1							
4	1	4	6	4	1						
5	1	5	10	10	5	1					
6	1	6	15	20	15	6	1				
7	1	7	21	35	35	21	7	1			
8	1	8	28	56	70	56	28	8	1		
9	1	9	36	84	126	126	84	36	9	1	
10	1	10	45	120	210	252	210	120	45	10	1
11	1	11	55	165	330	462	462	330	165	55	11
12	1	12	66	220	495	792	924	792	495	220	66
13	1	13	78	286	715	1,287	1,716	1,716	1,287	715	286
14	1	14	91	364	1,001	2,002	3,003	3,432	3,003	2,002	1,001
15	1	15	105	455	1,365	3,003	5,005	6,435	6,435	5,005	3,003
16	1	16	120	560	1,820	4,368	8,008	11,440	12,870	11,440	8,008
17	1	17	136	680	2,380	6,188	12,376	19,448	24,310	24,310	19,448
18	1	18	153	816	3,060	8,568	18,564	31,824	43,758	48,620	43,758
19	1	19	171	969	3,876	11,628	27,132	50,388	75,582	92,378	92,378
20	1	20	190	1,140	4,845	15,504	38,760	77,520	125,970	167,960	184,756

TABLE 3 Areas Under the Normal Curve

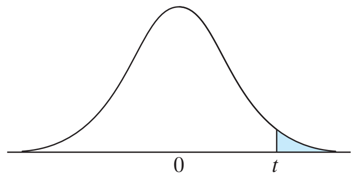


z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
–3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
–3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
–3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
–3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
–3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
–2.9	0.0019	0.0018	0.0017	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
–2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
–2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
–2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
–2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
–2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
–2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
–2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
–2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
–2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
–1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
–1.8	0.0359	0.0352	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
–1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
–1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
–1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
–1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0722	0.0708	0.0694	0.0681
–1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
–1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
–1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
–1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
–0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
–0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
–0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
–0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
–0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
–0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
–0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
–0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
–0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
–0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

TABLE 3 Areas Under the Normal Curve *(continued)*

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9278	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

TABLE 4 Critical Values of Student's *t* Distribution



	UPPER TAIL PROBABILITY									
df	0.20	0.10	0.05	0.04	0.03	0.025	0.02	0.01	0.005	0.0005
1	1.376	3.078	6.314	7.916	10.579	12.706	15.895	31.821	63.657	636.619
2	1.061	1.886	2.920	3.320	3.896	4.303	4.849	6.965	9.925	31.599
3	0.978	1.638	2.353	2.605	2.951	3.182	3.482	4.541	5.841	12.924
4	0.941	1.533	2.132	2.333	2.601	2.776	2.999	3.747	4.604	8.610
5	0.920	1.476	2.015	2.191	2.422	2.571	2.757	3.365	4.032	6.869
6	0.906	1.440	1.943	2.104	2.313	2.447	2.612	3.143	3.707	5.959
7	0.896	1.415	1.895	2.046	2.241	2.365	2.517	2.998	3.499	5.408
8	0.889	1.397	1.860	2.004	2.189	2.306	2.449	2.896	3.355	5.041
9	0.883	1.383	1.833	1.973	2.150	2.262	2.398	2.821	3.250	4.781
10	0.879	1.372	1.812	1.948	2.120	2.228	2.359	2.764	3.169	4.587
11	0.876	1.363	1.796	1.928	2.096	2.201	2.328	2.718	3.106	4.437
12	0.873	1.356	1.782	1.912	2.076	2.179	2.303	2.681	3.055	4.318
13	0.870	1.350	1.771	1.899	2.060	2.160	2.282	2.650	3.012	4.221
14	0.868	1.345	1.761	1.888	2.046	2.145	2.264	2.624	2.977	4.140
15	0.866	1.341	1.753	1.878	2.034	2.131	2.249	2.602	2.947	4.073
16	0.865	1.337	1.746	1.869	2.024	2.120	2.235	2.583	2.921	4.015
17	0.863	1.333	1.740	1.862	2.015	2.110	2.224	2.567	2.898	3.965
18	0.862	1.330	1.734	1.855	2.007	2.101	2.214	2.552	2.878	3.922
19	0.861	1.328	1.729	1.850	2.000	2.093	2.205	2.539	2.861	3.883
20	0.860	1.325	1.725	1.844	1.994	2.086	2.197	2.528	2.845	3.850
21	0.859	1.323	1.721	1.840	1.988	2.080	2.189	2.518	2.831	3.819
22	0.858	1.321	1.717	1.835	1.983	2.074	2.183	2.508	2.819	3.792
23	0.858	1.319	1.714	1.832	1.978	2.069	2.177	2.500	2.807	3.768
24	0.857	1.318	1.711	1.828	1.974	2.064	2.172	2.492	2.797	3.745
25	0.856	1.316	1.708	1.825	1.970	2.060	2.167	2.485	2.787	3.725
26	0.856	1.315	1.706	1.822	1.967	2.056	2.162	2.479	2.779	3.707
27	0.855	1.314	1.703	1.819	1.963	2.052	2.158	2.473	2.771	3.690
28	0.855	1.313	1.701	1.817	1.960	2.048	2.154	2.467	2.763	3.674
29	0.854	1.311	1.699	1.814	1.957	2.045	2.150	2.462	2.756	3.659
30	0.854	1.310	1.697	1.812	1.955	2.042	2.147	2.457	2.750	3.646
40	0.851	1.303	1.684	1.796	1.936	2.021	2.123	2.423	2.704	3.551
50	0.849	1.299	1.676	1.787	1.924	2.009	2.109	2.403	2.678	3.496
60	0.848	1.296	1.671	1.781	1.917	2.000	2.099	2.390	2.660	3.460
70	0.847	1.294	1.667	1.776	1.912	1.994	2.093	2.381	2.648	3.435
80	0.846	1.292	1.664	1.773	1.908	1.990	2.088	2.374	2.639	3.416
100	0.845	1.290	1.660	1.769	1.902	1.984	2.081	2.364	2.626	3.390
140	0.844	1.288	1.656	1.763	1.896	1.977	2.073	2.353	2.611	3.361
1000	0.842	1.282	1.646	1.752	1.883	1.962	2.056	2.330	2.581	3.300
∞	0.842	1.282	1.645	1.751	1.881	1.960	2.054	2.326	2.576	3.291
	60%	80%	90%	92%	94%	95%	96%	98%	99%	99.9%
	CRITICAL VALUE FOR CONFIDENCE LEVEL									

TABLE 5 Sample Sizes Needed for Selected Power Levels for Independent-Samples *t* Test

	SIGNIFICANCE LEVEL (TWO-TAILED TEST)																				
	$\alpha = 0.01$					$\alpha = 0.02$					$\alpha = 0.05$					$\alpha = 0.10$					
POWER→	0.99	0.95	0.90	0.80	0.50	0.99	0.95	0.90	0.80	0.50	0.99	0.95	0.90	0.80	0.50	0.99	0.95	0.90	0.80	0.50	
$\frac{\lvert \mu_1 - \mu_2 \rvert}{\sigma}$ 0.20																				137	0.20
0.25															124					88	0.25
0.30										123					87					61	0.30
0.35					110					90					64				102	45	0.35
0.40					85					70				100	50			108	78	35	0.40
0.45				118	68				101	55			105	79	39		108	86	62	28	0.45
0.50				96	55			106	82	45		106	86	64	32		88	70	51	23	0.50
0.55			101	79	46		106	88	68	38		87	71	53	27	112	73	58	42	19	0.55
0.60		101	85	67	39		90	74	58	32	104	74	60	45	23	89	61	49	36	16	0.60
0.65		87	73	57	34	104	77	64	49	27	88	63	51	39	20	76	52	42	30	14	0.65
0.70	100	75	63	50	29	90	66	55	43	24	76	55	44	34	17	66	45	36	26	12	0.70
0.75	88	66	55	44	26	79	58	48	38	21	67	48	39	29	15	57	40	32	23	11	0.75
0.80	77	58	49	39	23	70	51	43	33	19	59	42	34	26	14	50	35	28	21	10	0.80
0.85	69	51	43	35	21	62	46	38	30	17	52	37	31	23	12	45	31	25	18	9	0.85
0.90	62	46	39	31	19	55	41	34	27	15	47	34	27	21	11	40	28	22	16	8	0.90
0.95	55	42	35	28	17	50	37	31	24	14	42	30	25	19	10	36	25	20	15	7	0.95
1.00	50	38	32	26	15	45	33	28	22	13	38	27	23	17	9	33	23	18	14	7	1.00
	$\alpha = 0.005$					$\alpha = 0.01$					$\alpha = 0.025$					$\alpha = 0.05$					
	SIGNIFICANCE LEVEL (ONE-TAILED TEST)																				

Continued

TABLE 5 Sample Sizes Needed for Selected Power Levels for Independent-Samples *t* Test *(continued)*

	SIGNIFICANCE LEVEL (TWO-TAILED TEST)																				
	$\alpha = 0.01$					$\alpha = 0.02$					$\alpha = 0.05$					$\alpha = 0.10$					
POWER→	0.99	0.95	0.90	0.80	0.50	0.99	0.95	0.90	0.80	0.50	0.99	0.95	0.90	0.80	0.50	0.99	0.95	0.90	0.80	0.50	
1.1	42	32	27	22	13	38	28	23	19	11	32	23	19	14	8	27	19	15	12	6	1.1
1.2	36	27	23	18	11	32	24	20	16	9	27	20	16	12	7	23	16	13	10	5	1.2
1.3	31	23	20	16	10	28	21	17	14	8	23	17	14	11	6	20	14	11	9	5	1.3
1.4	27	20	17	14	9	24	18	15	12	8	20	15	12	10	6	17	12	10	8	4	1.4
1.5	24	18	15	13	8	21	16	14	11	7	18	13	11	9	5	15	11	9	7	4	1.5
1.6	21	16	14	11	7	19	14	12	10	6	16	12	10	8	5	14	10	8	6	4	1.6
1.7	19	15	13	10	7	17	13	11	9	6	14	11	9	7	4	12	9	7	6	3	1.7
1.8	17	13	11	10	6	15	12	10	8	5	13	10	8	6	4	11	8	7	5		1.8
1.9	16	12	11	9	6	14	11	9	8	5	12	9	7	6	4	10	7	6	5		1.9
$\frac{\lvert\mu_1 - \mu_2\rvert}{\sigma}$ 2.0	14	11	10	8	6	13	10	9	7	5	11	8	7	6	4	9	7	6	4		2.0
2.1	13	10	9	8	5	12	9	8	7	5	10	8	6	5	3	8	6	5	4		2.1
2.2	12	10	8	7	5	11	9	7	6	4	9	7	6	5		8	6	5	4		2.2
2.3	11	9	8	7	5	10	8	7	6	4	9	7	6	5		7	5	5	4		2.3
2.4	11	9	8	6	5	10	8	7	6	4	8	6	5	4		7	5	4	4		2.4
2.5	10	8	7	6	4	9	7	6	5	4	8	6	5	4		6	5	4	3		2.5
3.0	8	6	6	5	4	7	6	5	4	3	6	5	4	4		5	4	3			3.0
3.5	6	5	5	4	3	6	5	4	4		5	4	4	3		4	3				3.5
4.0	6	5	4	4		5	4	4	3		4	4	3			4					4.0
	$\alpha = 0.005$					$\alpha = 0.01$					$\alpha = 0.025$					$\alpha = 0.05$					
	SIGNIFICANCE LEVEL (ONE-TAILED TEST)																				

Source: "Number of observations for *t*-test of difference between two means." *Research*, Volume 1 (1948), pp. 520–525. Used with permission of the Longman Group UK Ltd. and Butterworth Scientific Publications.

TABLE 6 Critical values and *P*-values of U_s for the Wilcoxon-Mann-Whitney test

Note: Because the Wilcoxon-Mann-Whitney test null distribution is discrete, this table provides selected values of the test statistic U_s **in bold type** and corresponding *P*-values for a non-directional alternative *in italics*. Directional *P*-values are found by dividing the numbers in italics in half.

n	*n′*	0.20	0.10	0.05	0.025	0.01	0.005
3	2	**6** *0.200*					
	3	**8** *0.200*	**9** *0.100*				
4	2	**8** *0.133*					
	3	**11** *0.114*	**12** *0.057*				
	4	**13** *0.200*	**15** *0.057*	**16** *0.029*			
5	2	**9** *0.191*	**10** *0.095*				
	3	**13** *0.143*	**14** *0.071*	**15** *0.036*			
	4	**16** *0.191*	**18** *0.064*	**19** *0.032*	**20** *0.016*		
	5	**20** *0.151*	**21** *0.095*	**23** *0.032*	**24** *0.016*	**25** *0.0079*	
6	2	**11** *0.143*	**12** *0.071*				
	3	**15** *0.167*	**16** *0.095*	**17** *0.048*	**18** *0.024*		
	4	**19** *0.171*	**21** *0.067*	**22** *0.038*	**23** *0.019*	**24** *0.0095*	
	5	**23** *0.178*	**25** *0.082*	**27** *0.030*	**28** *0.017*	**29** *0.0087*	**30** *0.0043*
	6	**27** *0.180*	**29** *0.093*	**31** *0.041*	**33** *0.015*	**34** *0.0087*	**35** *0.0043*
7	2	**13** *0.111*	**14** *0.056*				
	3	**17** *0.183*	**19** *0.067*	**20** *0.033*	**21** *0.017*		
	4	**22** *0.164*	**24** *0.072*	**25** *0.042*	**26** *0.024*	**28** *0.0061*	
	5	**27** *0.149*	**29** *0.073*	**30** *0.048*	**32** *0.018*	**34** *0.0051*	**35** *0.0025*
	6	**31** *0.181*	**34** *0.073*	**36** *0.035*	**37** *0.022*	**39** *0.0082*	**40** *0.0047*
	7	**36** *0.165*	**38** *0.097*	**41** *0.038*	**43** *0.018*	**45** *0.0070*	**46** *0.0041*
8	2	**14** *0.178*	**15** *0.089*	**16** *0.044*			
	3	**19** *0.194*	**21** *0.085*	**22** *0.049*	**23** *0.024*		
	4	**25** *0.154*	**27** *0.073*	**28** *0.049*	**30** *0.016*	**31** *0.0081*	**32** *0.0040*
	5	**30** *0.171*	**32** *0.093*	**34** *0.045*	**36** *0.019*	**38** *0.0062*	**39** *0.0031*
	6	**35** *0.181*	**38** *0.081*	**40** *0.043*	**42** *0.020*	**44** *0.0080*	**45** *0.0047*
	7	**40** *0.189*	**43** *0.094*	**46** *0.041*	**48** *0.021*	**50** *0.0093*	**52** *0.0037*
	8	**45** *0.195*	**49** *0.083*	**51** *0.050*	**54** *0.021*	**57** *0.0070*	**58** *0.0047*
9	2	**16** *0.146*	**17** *0.073*	**18** *0.036*			
	3	**22** *0.146*	**23** *0.100*	**25** *0.036*	**26** *0.018*	**27** *0.0091*	
	4	**27** *0.199*	**30** *0.076*	**32** *0.034*	**33** *0.020*	**35** *0.0056*	**36** *0.0028*
	5	**33** *0.190*	**36** *0.083*	**38** *0.042*	**40** *0.019*	**42** *0.0070*	**43** *0.0040*
	6	**39** *0.181*	**42** *0.088*	**44** *0.050*	**47** *0.018*	**49** *0.0076*	**50** *0.0048*
	7	**45** *0.174*	**48** *0.091*	**51** *0.042*	**53** *0.023*	**56** *0.0079*	**58** *0.0033*
	8	**50** *0.200*	**54** *0.093*	**57** *0.046*	**60** *0.021*	**63** *0.0079*	**65** *0.0037*
	9	**56** *0.190*	**60** *0.094*	**64** *0.040*	**66** *0.024*	**70** *0.0078*	**72** *0.0040*
10	2	**17** *0.182*	**19** *0.061*	**20** *0.030*			
	3	**24** *0.161*	**26** *0.077*	**27** *0.049*	**29** *0.014*	**30** *0.0070*	
	4	**30** *0.188*	**33** *0.076*	**35** *0.036*	**36** *0.024*	**38** *0.0080*	**39** *0.0040*
	5	**37** *0.165*	**39** *0.099*	**42** *0.040*	**44** *0.019*	**46** *0.0080*	**47** *0.0047*
	6	**43** *0.181*	**46** *0.093*	**49** *0.042*	**51** *0.023*	**54** *0.0075*	**55** *0.0047*
	7	**49** *0.193*	**53** *0.088*	**56** *0.043*	**58** *0.025*	**61** *0.0097*	**63** *0.0046*
	8	**56** *0.173*	**60** *0.083*	**63** *0.043*	**66** *0.021*	**69** *0.0085*	**71** *0.0044*
	9	**62** *0.182*	**66** *0.095*	**70** *0.044*	**73** *0.022*	**77** *0.0076*	**79** *0.0041*
	10	**68** *0.190*	**73** *0.089*	**77** *0.043*	**80** *0.023*	**84** *0.0089*	**87** *0.0039*

Continued

TABLE 6 Critical values and P-values of U_s for the Wilcoxon-Mann-Whitney test *(continued)*

n	n'	0.20	0.10	0.05	0.025	0.01	0.005
11	2	**19** *0.154*	**21** *0.051*	**22** *0.026*			
	3	**26** *0.170*	**28** *0.088*	**30** *0.039*	**31** *0.022*	**33** *0.0055*	
	4	**33** *0.177*	**36** *0.078*	**38** *0.040*	**40** *0.018*	**42** *0.0059*	**43** *0.0029*
	5	**40** *0.180*	**43** *0.090*	**46** *0.038*	**48** *0.019*	**50** *0.0087*	**52** *0.0032*
	6	**47** *0.180*	**50** *0.098*	**53** *0.048*	**56** *0.020*	**59** *0.0071*	**60** *0.0048*
	7	**54** *0.179*	**58** *0.085*	**61** *0.044*	**64** *0.020*	**67** *0.0083*	**69** 0.0041
	8	**61** *0.177*	**65** *0.091*	**69** *0.041*	**72** *0.020*	**75** *0.0091*	**77** *0.0050*
	9	**68** *0.175*	**72** *0.095*	**76** *0.047*	**80** *0.020*	**83** *0.0097*	**86** *0.0042*
	10	**74** *0.197*	**79** *0.099*	**84** *0.043*	**87** *0.024*	**92** *0.0079*	**94** *0.0048*
	11	**81** *0.193*	**87** *0.088*	**91** *0.047*	**95** *0.023*	**100** *0.0083*	**103** *0.0041*
12	2	**20** *0.198*	**22** *0.088*	**23** *0.044*	**24** *0.022*		
	3	**28** *0.180*	**31** *0.070*	**32** *0.048*	**34** *0.018*	**35** *0.0088*	**36** *0.0044*
	4	**36** *0.170*	**39** *0.078*	**41** *0.042*	**43** *0.020*	**45** *0.0077*	**46** *0.0044*
	5	**43** *0.195*	**47** *0.082*	**49** *0.049*	**52** *0.019*	**54** *0.0094*	**56** *0.0039*
	6	**51** *0.180*	**55** *0.083*	**58** *0.042*	**60** *0.025*	**63** *0.0097*	**65** *0.0047*
	7	**58** *0.196*	**63** *0.083*	**66** *0.045*	**69** *0.022*	**72** *0.0098*	**75** *0.0037*
	8	**66** *0.181*	**70** *0.098*	**74** *0.047*	**78** *0.020*	**81** *0.0096*	**84** *0.0041*
	9	**73** *0.193*	**78** *0.096*	**82** *0.049*	**86** *0.023*	**90** *0.0093*	**93** *0.0043*
	10	**81** *0.180*	**86** *0.093*	**91** *0.043*	**94** *0.025*	**99** *0.0090*	**102** *0.0044*
	11	**88** *0.190*	**94** *0.091*	**99** *0.044*	**103** *0.023*	**108** *0.0086*	**111** *0.0045*
	12	**95** *0.198*	**102** *0.089*	**107** *0.045*	**111** *0.024*	**117** *0.0083*	**120** *0.0045*
13	2	**22** *0.171*	**24** *0.076*	**25** *0.038*	**26** *0.019*		
	3	**30** *0.189*	**33** *0.082*	**35** *0.039*	**36** *0.025*	**38** *0.0071*	**39** *0.0036*
	4	**39** *0.163*	**42** *0.079*	**44** *0.045*	**46** *0.023*	**49** *0.0059*	**50** *0.0034*
	5	**47** *0.173*	**50** *0.095*	**53** *0.046*	**56** *0.019*	**58** *0.0098*	**60** *0.0044*
	6	**55** *0.179*	**59** *0.087*	**62** *0.046*	**65** *0.022*	**68** *0.0092*	**70** *0.0047*
	7	**63** *0.183*	**67** *0.097*	**71** *0.046*	**74** *0.024*	**78** *0.0085*	**80** *0.0047*
	8	**71** *0.185*	**76** *0.089*	**80** *0.045*	**83** *0.025*	**87** *0.0099*	**90** *0.0045*
	9	**79** *0.186*	**84** *0.096*	**89** *0.043*	**93** *0.021*	**97** *0.0089*	**100** *0.0043*
	10	**87** *0.186*	**93** *0.088*	**97** *0.049*	**102** *0.021*	**106** *0.0099*	**110** *0.0041*
	11	**95** *0.186*	**101** *0.093*	**106** *0.047*	**111** *0.022*	**116** *0.0088*	**119** *0.0048*
	12	**103** *0.186*	**109** *0.098*	**115** *0.046*	**120** *0.022*	**125** *0.0096*	**129** *0.0045*
	13	**111** *0.186*	**118** *0.091*	**124** *0.044*	**129** *0.022*	**135** *0.0086*	**139** *0.0042*
14	2	**23** *0.200*	**25** *0.100*	**27** *0.033*	**28** *0.017*		
	3	**32** *0.197*	**35** *0.091*	**37** *0.047*	**39** *0.021*	**41** *0.0059*	**42** *0.0029*
	4	**41** *0.192*	**45** *0.079*	**47** *0.046*	**49** *0.025*	**52** *0.0078*	**53** *0.0046*
	5	**50** *0.186*	**54** *0.087*	**57** *0.044*	**60** *0.019*	**63** *0.0072*	**64** *0.0050*
	6	**59** *0.179*	**63** *0.091*	**67** *0.041*	**70** *0.020*	**73** *0.0087*	**75** *0.0046*
	7	**67** *0.197*	**72** *0.094*	**76** *0.046*	**79** *0.025*	**83** *0.0097*	**86** *0.0042*
	8	**76** *0.188*	**81** *0.095*	**86** *0.042*	**89** *0.024*	**94** *0.0081*	**96** *0.0050*
	9	**85** *0.179*	**90** *0.096*	**95** *0.046*	**99** *0.023*	**104** *0.0086*	**107** *0.0043*
	10	**93** *0.192*	**99** *0.096*	**104** *0.048*	**109** *0.022*	**114** *0.0089*	**117** *0.0048*
	11	**102** *0.183*	**108** *0.095*	**114** *0.044*	**118** *0.025*	**124** *0.0090*	**128** *0.0042*
	12	**110** *0.193*	**117** *0.095*	**123** *0.046*	**128** *0.023*	**134** *0.0091*	**138** *0.0045*
	13	**119** *0.185*	**126** *0.095*	**132** *0.048*	**138** *0.022*	**144** *0.0091*	**148** *0.0047*
	14	**127** *0.194*	**135** *0.094*	**141** *0.050*	**147** *0.024*	**154** *0.0091*	**158** *0.0049*
15	2	**25** *0.177*	**27** *0.088*	**29** *0.029*	**30** *0.015*		
	3	**35** *0.164*	**35** *0.076*	**40** *0.039*	**42** *0.017*	**43** *0.0098*	**44** *0.0049*
	4	**44** *0.185*	**48** *0.080*	**50** *0.049*	**53** *0.020*	**55** *0.0093*	**57** *0.0036*

TABLE 6 Critical values and *P*-values of U_s for the Wilcoxon-Mann-Whitney test *(continued)*

n	*n′*	0.20	0.10	0.05	0.025	0.01	0.005
	5	**53** *0.197*	**57** *0.098*	**61** *0.042*	**64** *0.019*	**67** *0.0077*	**69** *0.0037*
	6	**63** *0.178*	**67** *0.095*	**71** *0.045*	**74** *0.023*	**78** *0.0084*	**80** *0.0046*
	7	**72** *0.185*	**77** *0.091*	**81** *0.047*	**85** *0.021*	**89** *0.0085*	**92** *0.0038*
	8	**81** *0.190*	**87** *0.087*	**91** *0.047*	**95** *0.024*	**100** *0.0085*	**103** *0.0042*
	9	**90** *0.194*	**96** *0.096*	**101** *0.048*	**106** *0.021*	**111** *0.0083*	**114** *0.0044*
	10	**99** *0.196*	**106** *0.091*	**111** *0.048*	**116** *0.023*	**121** *0.0096*	**125** *0.0044*
	11	**108** *0.198*	**115** *0.097*	**121** *0.047*	**126** *0.024*	**132** *0.0092*	**136** *0.0045*
	12	**117** *0.200*	**125** *0.093*	**131** *0.047*	**136** *0.025*	**143** *0.0087*	**147** *0.0044*
	13	**127** *0.185*	**134** *0.098*	**141** *0.046*	**147** *0.022*	**153** *0.0096*	**158** *0.0044*
	14	**136** *0.186*	**144** *0.093*	**151** *0.046*	**157** *0.023*	**164** *0.0091*	**169** *0.0043*
	15	**145** *0.187*	**153** *0.098*	**161** *0.045*	**167** *0.024*	**174** *0.0099*	**179** *0.0049*
16	2	**27** *0.157*	**29** *0.078*	**31** *0.026*	**32** *0.013*		
	3	**37** *0.171*	**40** *0.085*	**42** *0.048*	**44** *0.023*	**46** *0.0083*	**47** *0.0041*
	4	**47** *0.178*	**50** *0.100*	**53** *0.050*	**56** *0.022*	**59** *0.0074*	**60** *0.0050*
	5	**57** *0.179*	**61** *0.091*	**65** *0.040*	**67** *0.025*	**71** *0.0082*	**73** *0.0041*
	6	**67** *0.178*	**71** *0.098*	**75** *0.049*	**79** *0.021*	**83** *0.0080*	**85** *0.0045*
	7	**76** *0.198*	**82** *0.089*	**86** *0.047*	**90** *0.023*	**94** *0.0096*	**97** *0.0046*
	8	**86** *0.192*	**92** *0.093*	**97** *0.045*	**101** *0.023*	**106** *0.0087*	**109** *0.0045*
	9	**96** *0.187*	**102** *0.095*	**107** *0.049*	**112** *0.023*	**117** *0.0096*	**121** *0.0043*
	10	**106** *0.182*	**112** *0.097*	**118** *0.047*	**123** *0.023*	**129** *0.0087*	**133** *0.0041*
	11	**115** *0.195*	**122** *0.099*	**129** *0.044*	**134** *0.023*	**140** *0.0093*	**144** *0.0047*
	12	**125** *0.189*	**132** *0.100*	**139** *0.047*	**145** *0.023*	**151** *0.0097*	**156** *0.0044*
	13	**134** *0.199*	**143** *0.092*	**149** *0.050*	**156** *0.022*	**163** *0.0087*	**167** *0.0048*
	14	**144** *0.193*	**153** *0.093*	**160** *0.047*	**166** *0.025*	**174** *0.0091*	**179** *0.0045*
	15	**154** *0.188*	**163** *0.093*	**170** *0.049*	**177** *0.024*	**185** *0.0093*	**190** *0.0048*
	16	**163** *0.196*	**173** *0.094*	**181** *0.047*	**188** *0.023*	**196** *0.0096*	**202** *0.0045*
17	2	**28** *0.187*	**31** *0.070*	**32** *0.047*	**33** *0.023*		
	3	**39** *0.179*	**42** *0.093*	**45** *0.040*	**47** *0.019*	**49** *0.0070*	**50** *0.0035*
	4	**50** *0.172*	**53** *0.099*	**57** *0.040*	**59** *0.024*	**62** *0.0090*	**64** *0.0040*
	5	**60** *0.189*	**65** *0.085*	**68** *0.048*	**71** *0.025*	**75** *0.0086*	**77** *0.0046*
	6	**71** *0.177*	**76** *0.087*	**80** *0.044*	**83** *0.024*	**87** *0.0099*	**90** *0.0045*
	7	**81** *0.187*	**86** *0.100*	**91** *0.047*	**95** *0.024*	**100** *0.0085*	**103** *0.0042*
	8	**91** *0.194*	**97** *0.098*	**102** *0.050*	**107** *0.023*	**112** *0.0090*	**115** *0.0048*
	9	**101** *0.200*	**108** *0.095*	**114** *0.045*	**118** *0.025*	**124** *0.0092*	**128** *0.0043*
	10	**112** *0.187*	**119** *0.093*	**125** *0.046*	**130** *0.024*	**136** *0.0093*	**140** *0.0047*
	11	**122** *0.191*	**130** *0.091*	**136** *0.047*	**142** *0.022*	**136** *0.0093*	**152** *0.0049*
	12	**132** *0.195*	**140** *0.097*	**147** *0.048*	**153** *0.024*	**160** *0.0093*	**165** *0.0043*
	13	**142** *0.198*	**151** *0.095*	**158** *0.048*	**164** *0.025*	**172** *0.0091*	**177** *0.0045*
	14	**153** *0.186*	**161** *0.100*	**169** *0.048*	**176** *0.023*	**184** *0.0090*	**189** *0.0046*
	15	**163** *0.189*	**172** *0.097*	**180** *0.049*	**187** *0.024*	**195** *0.0100*	**201** *0.0047*
	16	**173** *0.191*	**183** *0.094*	**191** *0.049*	**199** *0.023*	**207** *0.0097*	**213** *0.0048*
	17	**183** *0.193*	**193** *0.099*	**202** *0.049*	**210** *0.024*	**219** *0.0095*	**225** *0.0048*
18	2	**30** *0.168*	**32** *0.095*	**34** *0.042*	**35** *0.021*		
	3	**41** *0.185*	**45** *0.080*	**47** *0.047*	**49** *0.024*	**52** *0.0060*	**53** *0.0030*
	4	**52** *0.195*	**56** *0.098*	**60** *0.042*	**63** *0.019*	**66** *0.0074*	**67** *0.0049*
	5	**63** *0.200*	**68** *0.094*	**72** *0.046*	**75** *0.024*	**79** *0.0089*	**81** *0.0049*
	6	**74** *0.199*	**80** *0.090*	**84** *0.047*	**88** *0.022*	**92** *0.0094*	**95** *0.0044*
	7	**85** *0.198*	**91** *0.097*	**96** *0.047*	**100** *0.025*	**105** *0.0094*	**108** *0.0049*
	8	**96** *0.196*	**103** *0.091*	**108** *0.047*	**113** *0.022*	**118** *0.0092*	**122** *0.0042*

TABLE 6 Critical values and *P*-values of U_s for the Wilcoxon-Mann-Whitney test *(continued)*

n	*n′*	0.20	0.10	0.05	0.025	0.01	0.005
	9	**107** *0.194*	**114** *0.095*	**120** *0.046*	**125** *0.023*	**131** *0.0089*	**135** *0.0043*
	10	**118** *0.191*	**125** *0.099*	**132** *0.045*	**137** *0.024*	**143** *0.0100*	**148** *0.0044*
	11	**129** *0.188*	**137** *0.092*	**143** *0.049*	**149** *0.024*	**156** *0.0094*	**161** *0.0043*
	12	**139** *0.200*	**148** *0.095*	**155** *0.048*	**161** *0.025*	**169** *0.0089*	**173** *0.0050*
	13	**150** *0.196*	**159** *0.097*	**167** *0.046*	**173** *0.025*	**181** *0.0095*	**186** *0.0049*
	14	**161** *0.193*	**170** *0.099*	**178** *0.049*	**185** *0.025*	**194** *0.0089*	**199** *0.0047*
	15	**172** *0.190*	**182** *0.093*	**190** *0.048*	**197** *0.025*	**206** *0.0094*	**212** *0.0046*
	16	**182** *0.199*	**193** *0.095*	**202** *0.046*	**209** *0.025*	**218** *0.0099*	**224** *0.0050*
	17	**193** *0.195*	**204** *0.096*	**213** *0.049*	**221** *0.025*	**231** *0.0093*	**237** *0.0048*
	18	**204** *0.192*	**215** *0.097*	**225** *0.047*	**233** *0.024*	**243** *0.0096*	**250** *0.0046*
19	2	**31** *0.191*	**34** *0.086*	**36** *0.038*	**37** *0.019*	**38** *0.0095*	
	3	**43** *0.191*	**47** *0.087*	**50** *0.040*	**52** *0.021*	**54** *0.0091*	**56** *0.0026*
	4	**55** *0.188*	**59** *0.097*	**63** *0.044*	**66** *0.021*	**69** *0.0086*	**71** *0.0041*
	5	**67** *0.183*	**72** *0.088*	**76** *0.044*	**79** *0.024*	**83** *0.0093*	**86** *0.0039*
	6	**78** *0.198*	**84** *0.092*	**89** *0.043*	**93** *0.021*	**97** *0.0090*	**100** *0.0044*
	7	**90** *0.188*	**96** *0.094*	**101** *0.048*	**106** *0.022*	**111** *0.0085*	**114** *0.0045*
	8	**101** *0.198*	**108** *0.095*	**114** *0.045*	**119** *0.022*	**124** *0.0094*	**128** *0.0044*
	9	**113** *0.188*	**120** *0.095*	**126** *0.048*	**131** *0.025*	**138** *0.0086*	**142** *0.0043*
	10	**124** *0.195*	**132** *0.094*	**138** *0.050*	**144** *0.024*	**151** *0.0091*	**155** *0.0048*
	11	**136** *0.185*	**144** *0.094*	**151** *0.047*	**157** *0.023*	**164** *0.0094*	**169** *0.0045*
	12	**147** *0.191*	**156** *0.093*	**163** *0.048*	**170** *0.023*	**177** *0.0097*	**182** *0.0049*
	13	**158** *0.195*	**167** *0.100*	**175** *0.049*	**182** *0.025*	**190** *0.0098*	**196** *0.0045*
	14	**169** *0.199*	**179** *0.098*	**188** *0.046*	**195** *0.024*	**203** *0.0099*	**209** *0.0048*
	15	**181** *0.190*	**191** *0.096*	**200** *0.047*	**208** *0.023*	**216** *0.0100*	**223** *0.0045*
	16	**192** *0.194*	**203** *0.095*	**212** *0.048*	**220** *0.024*	**230** *0.0090*	**236** *0.0047*
	17	**203** *0.196*	**214** *0.100*	**224** *0.049*	**233** *0.023*	**242** *0.0100*	**249** *0.0048*
	18	**214** *0.199*	**226** *0.098*	**236** *0.049*	**245** *0.024*	**255** *0.0100*	**262** *0.0050*
	19	**226** *0.191*	**238** *0.096*	**248** *0.050*	**258** *0.023*	**268** *0.0099*	**276** *0.0046*
20	2	**33** *0.173*	**36** *0.078*	**38** *0.035*	**39** *0.017*	**40** *0.0087*	
	3	**45** *0.197*	**49** *0.094*	**52** *0.046*	**55** *0.018*	**57** *0.0079*	**58** *0.0045*
	4	**58** *0.183*	**62** *0.097*	**66** *0.045*	**69** *0.023*	**72** *0.0100*	**75** *0.0034*
	5	**70** *0.192*	**75** *0.097*	**80** *0.042*	**83** *0.024*	**87** *0.0096*	**90** *0.0043*
	6	**82** *0.196*	**88** *0.095*	**93** *0.046*	**97** *0.023*	**102** *0.0087*	**105** *0.0043*
	7	**94** *0.198*	**101** *0.092*	**106** *0.048*	**111** *0.022*	**116** *0.0093*	**120** *0.0041*
	8	**106** *0.199*	**113** *0.099*	**119** *0.049*	**124** *0.025*	**130** *0.0096*	**134** *0.0047*
	9	**118** *0.199*	**126** *0.095*	**132** *0.049*	**138** *0.023*	**144** *0.0097*	**149** *0.0043*
	10	**130** *0.198*	**138** *0.100*	**145** *0.049*	**151** *0.024*	**158** *0.0096*	**163** *0.0045*
	11	**142** *0.197*	**151** *0.095*	**158** *0.049*	**165** *0.023*	**172** *0.0095*	**177** *0.0047*
	12	**154** *0.195*	**163** *0.099*	**171** *0.048*	**178** *0.024*	**186** *0.0092*	**191** *0.0048*
	13	**166** *0.194*	**176** *0.094*	**184** *0.048*	**191** *0.024*	**200** *0.0090*	**205** *0.0049*
	14	**178** *0.192*	**188** *0.097*	**197** *0.047*	**204** *0.025*	**213** *0.0098*	**219** *0.0049*
	15	**190** *0.191*	**200** *0.099*	**210** *0.046*	**218** *0.023*	**227** *0.0095*	**233** *0.0049*
	16	**201** *0.200*	**213** *0.095*	**222** *0.049*	**231** *0.024*	**241** *0.0091*	**247** *0.0049*
	17	**213** *0.198*	**225** *0.097*	**235** *0.049*	**244** *0.024*	**254** *0.0097*	**261** *0.0048*
	18	**225** *0.196*	**237** *0.099*	**248** *0.048*	**257** *0.024*	**268** *0.0094*	**275** *0.0048*
	19	**237** *0.194*	**250** *0.095*	**261** *0.047*	**270** *0.024*	**281** *0.0099*	**289** *0.0047*
	20	**249** *0.192*	**262** *0.097*	**273** *0.049*	**283** *0.025*	**295** *0.0095*	**303** *0.0047*

TABLE 7 Critical Values and *P*-Values of B_s for the Sign Test

Note: Because the Sign test null distribution is discrete, this table provides selected values of the test statistic B_s **in bold type** and corresponding *P*-values for a non-directional alternative *in italics*. Directional *P*-values are found by dividing the numbers in italics in half.

n_d	0.20	0.10	0.05	0.02	0.01	0.002	0.001
1							
2							
3							
4							
5	**5** *0.063*	**5** *0.063*					
6	**6** *0.031*	**6** *0.031*	**6** *0.031*				
7	**6** *0.125*	**7** *0.016*	**7** *0.016*	**7** *0.016*			
8	**7** *0.070*	**7** *0.070*	**8** *0.008*	**8** *0.008*	**8** *0.008*		
9	**7** *0.180*	**8** *0.039*	**8** *0.039*	**9** *0.004*	**9** *0.004*		
10	**8** *0.109*	**9** *0.021*	**9** *0.021*	**10** *0.002*	**10** *0.002*	**10** *0.0020*	
11	**9** *0.065*	**9** *0.065*	**10** *0.012*	**10** *0.012*	**11** *0.001*	**11** *0.0010*	**11** *0.0010*
12	**9** *0.146*	**10** *0.039*	**10** *0.039*	**11** *0.006*	**11** *0.006*	**12** *0.0005*	**12** *0.0005*
13	**10** *0.092*	**10** *0.093*	**11** *0.023*	**12** *0.003*	**12** *0.003*	**13** *0.0002*	**13** *0.0002*
14	**10** *0.180*	**11** *0.057*	**12** *0.013*	**12** *0.013*	**13** *0.0018*	**13** *0.0018*	**14** *0.0001*
15	**11** *0.118*	**12** *0.035*	**12** *0.035*	**13** *0.007*	**13** *0.007*	**14** *0.0010*	**14** *0.0010*
16	**12** *0.077*	**12** *0.077*	**13** *0.021*	**14** *0.004*	**14** *0.004*	**15** *0.0005*	**15** *0.0005*
17	**12** *0.143*	**13** *0.049*	**13** *0.049*	**14** *0.013*	**15** *0.002*	**16** *0.0003*	**16** *0.0003*
18	**13** *0.096*	**13** *0.096*	**14** *0.031*	**15** *0.008*	**15** *0.008*	**16** *0.0013*	**17** *0.0001*
19	**13** *0.167*	**14** *0.064*	**15** *0.019*	**15** *0.019*	**16** *0.004*	**17** *0.0007*	**17** *0.0007*
20	**14** *0.115*	**15** *0.041*	**15** *0.041*	**16** *0.012*	**17** *0.003*	**18** *0.0004*	**18** *0.0004*
21	**14** *0.189*	**15** *0.078*	**16** *0.027*	**17** *0.007*	**17** *0.007*	**18** *0.0015*	**19** *0.0002*
22	**15** *0.134*	**16** *0.052*	**17** *0.017*	**17** *0.017*	**18** *0.004*	**19** *0.0009*	**19** *0.0009*
23	**16** *0.093*	**16** *0.093*	**17** *0.037*	**18** *0.011*	**19** *0.003*	**20** *0.0005*	**20** *0.0005*
24	**16** *0.152*	**17** *0.064*	**18** *0.023*	**19** *0.007*	**19** *0.007*	**20** *0.0015*	**21** *0.0003*
25	**17** *0.108*	**18** *0.043*	**18** *0.043*	**19** *0.015*	**20** *0.004*	**21** *0.0009*	**21** *0.0009*
26	**17** *0.168*	**18** *0.076*	**19** *0.029*	**20** *0.009*	**20** *0.009*	**22** *0.0005*	**22** *0.0005*
27	**18** *0.122*	**19** *0.052*	**20** *0.019*	**20** *0.019*	**21** *0.006*	**22** *0.0015*	**23** *0.0003*
28	**18** *0.185*	**19** *0.087*	**20** *0.036*	**21** *0.013*	**22** *0.004*	**23** *0.0009*	**23** *0.0009*
29	**19** *0.136*	**20** *0.061*	**21** *0.024*	**22** *0.008*	**22** *0.008*	**24** *0.0005*	**24** *0.0005*
30	**20** *0.099*	**20** *0.099*	**21** *0.043*	**22** *0.016*	**23** *0.005*	**24** *0.0014*	**25** *0.0003*
31	**20** *0.152*	**21** *0.071*	**22** *0.029*	**23** *0.011*	**24** *0.003*	**25** *0.0009*	**25** *0.0009*

TABLE 8 Critical Values and *P*-Values of W_s for the Wilcoxon Signed-Rank Test

Note: Because the Wilcoxon Signed-Rank test null distribution is discrete, this table provides selected values of the test statistic W_s **in bold type** and corresponding *P*-values for a non-directional alternative *in italics*. Directional *P*-values are found by dividing the numbers in italics in half.

n	0.20	0.10	0.05	0.02	0.01	0.002	0.001
1							
2							
3							
4	**10** *0.125*						
5	**13** *0.188*	**15** *0.063*					
6	**18** *0.156*	**19** *0.093*	**21** *0.031*				
7	**23** *0.156*	**25** *0.078*	**26** *0.047*	**28** *0.016*			
8	**28** *0.195*	**31** *0.078*	**33** *0.039*	**35** *0.016*	**36** *0.0078*		
9	**35** *0.164*	**37** *0.098*	**40** *0.039*	**42** *0.020*	**44** *0.0078*		
10	**41** *0.193*	**45** *0.084*	**47** *0.049*	**50** *0.020*	**52** *0.0098*	**55** *0.0020*	
11	**49** *0.175*	**53** *0.083*	**56** *0.042*	**59** *0.019*	**61** *0.0098*	**65** *0.0020*	**66** *0.0010*
12	**57** *0.176*	**61** *0.092*	**65** *0.042*	**69** *0.016*	**71** *0.0093*	**76** *0.0015*	**77** *0.0010*
13	**65** *0.191*	**70** *0.094*	**74** *0.048*	**79** *0.017*	**82** *0.0081*	**87** *0.0017*	**89** *0.0007*
14	**74** *0.194*	**80** *0.091*	**84** *0.049*	**90** *0.017*	**93** *0.0085*	**99** *0.0017*	**101** *0.0009*
15	**84** *0.188*	**90** *0.095*	**95** *0.048*	**101** *0.018*	**105** *0.0084*	**112** *0.0015*	**114** *0.0009*
16	**94** *0.193*	**101** *0.093*	**107** *0.044*	**113** *0.018*	**117** *0.0092*	**125** *0.0017*	**128** *0.0008*
17	**105** *0.190*	**112** *0.098*	**119** *0.045*	**126** *0.017*	**130** *0.0093*	**139** *0.0017*	**142** *0.0008*
18	**116** *0.196*	**124** *0.099*	**131** *0.048*	**139** *0.018*	**144** *0.0090*	**153** *0.0019*	**157** *0.0008*
19	**128** *0.196*	**137** *0.096*	**144** *0.049*	**153** *0.018*	**158** *0.0094*	**169** *0.0017*	**172** *0.0010*
20	**141** *0.189*	**150** *0.097*	**158** *0.048*	**167** *0.019*	**173** *0.0094*	**184** *0.0020*	**189** *0.0009*
21	**154** *0.191*	**164** *0.096*	**173** *0.046*	**182** *0.019*	**189** *0.0090*	**201** *0.0019*	**206** *0.0009*
22	**167** *0.198*	**178** *0.094*	**188** *0.046*	**198** *0.019*	**205** *0.0093*	**218** *0.0019*	**223** *0.0009*
23	**182** *0.190*	**193** *0.098*	**203** *0.048*	**214** *0.020*	**222** *0.0091*	**236** *0.0019*	**241** *0.0010*
24	**196** *0.197*	**209** *0.095*	**219** *0.049*	**231** *0.019*	**239** *0.0096*	**255** *0.0018*	**260** *0.0010*
25	**212** *0.191*	**225** *0.096*	**236** *0.048*	**249** *0.019*	**257** *0.0096*	**274** *0.0018*	**280** *0.0009*
26	**227** *0.199*	**241** *0.099*	**253** *0.049*	**267** *0.019*	**276** *0.0094*	**293** *0.0020*	**300** *0.0009*
27	**244** *0.194*	**259** *0.095*	**271** *0.049*	**286** *0.019*	**295** *0.0096*	**314** *0.0019*	**321** *0.0009*
28	**261** *0.194*	**276** *0.099*	**290** *0.048*	**305** *0.019*	**315** *0.0095*	**335** *0.0019*	**342** *0.0010*
29	**278** *0.198*	**295** *0.096*	**309** *0.048*	**325** *0.019*	**335** *0.0099*	**256** *0.0020*	**364** *0.0010*
30	**296** *0.198*	**314** *0.096*	**328** *0.050*	**345** *0.020*	**356** *0.0099*	**379** *0.0019*	**387** *0.0010*
31	**315** *0.195*	**333** *0.098*	**349** *0.048*	**366** *0.020*	**378** *0.0097*	**402** *0.0019*	**410** *0.0010*

TABLE 9 Critical Values of the Chi-Square Distribution

Note: Column headings are non-directional (omni-directional) P-values. If H_A is directional (which is only possible when df = 1), the directional P-values are found by dividing the column headings in half.

	TAIL PROBABILITY						
df	0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	1.64	2.71	3.84	5.41	6.63	10.83	15.14
2	3.22	4.61	5.99	7.82	9.21	13.82	18.42
3	4.64	6.25	7.81	9.84	11.34	16.27	21.11
4	5.99	7.78	9.49	11.67	13.28	18.47	23.51
5	7.29	9.24	11.07	13.39	15.09	20.51	25.74
6	8.56	10.64	12.59	15.03	16.81	22.46	27.86
7	9.80	12.02	14.07	16.62	18.48	24.32	29.88
8	11.03	13.36	15.51	18.17	20.09	26.12	31.83
9	12.24	14.68	16.92	19.68	21.67	27.88	33.72
10	13.44	15.99	18.31	21.16	23.21	29.59	35.56
11	14.63	17.28	19.68	22.62	24.72	31.26	37.37
12	15.81	18.55	21.03	24.05	26.22	32.91	39.13
13	16.98	19.81	22.36	25.47	27.69	34.53	40.87
14	18.15	21.06	23.68	26.87	29.14	36.12	42.58
15	19.31	22.31	25.00	28.26	30.58	37.70	44.26
16	20.47	23.54	26.30	29.63	32.00	39.25	45.92
17	21.61	24.77	27.59	31.00	33.41	40.79	47.57
18	22.76	25.99	28.87	32.35	34.81	42.31	49.19
19	23.90	27.20	30.14	33.69	36.19	43.82	50.80
20	25.04	28.41	31.41	35.02	37.57	45.31	52.39
21	26.17	29.62	32.67	36.34	38.93	46.80	53.96
22	27.30	30.81	33.92	37.66	40.29	48.27	55.52
23	28.43	32.01	35.17	38.97	41.64	49.73	57.08
24	29.55	33.20	36.42	40.27	42.98	51.18	58.61
25	30.68	34.38	37.65	41.57	44.31	52.62	60.14
26	31.79	35.56	38.89	42.86	45.64	54.05	61.66
27	32.91	36.74	40.11	44.14	46.96	55.48	63.16
28	34.03	37.92	41.34	45.42	48.28	56.89	64.66
29	35.14	39.09	42.56	46.69	49.59	58.30	66.15
30	36.25	40.26	43.77	47.96	50.89	59.70	67.63

TABLE 10 Critical Values of the *F* Distribution

Numerator df = 1

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	9.47	39.86	161	101^1	405^1	406^3	405^5
2	3.56	8.53	18.51	48.51	98.50	998	100^2
3	2.68	5.54	10.13	20.62	34.12	167	784
4	2.35	4.54	7.71	14.04	21.20	74.14	242
5	2.18	4.06	6.61	11.32	16.26	47.18	125
6	2.07	3.78	5.99	9.88	13.75	35.51	82.49
7	2.00	3.59	5.59	8.99	12.25	29.25	62.17
8	1.95	3.46	5.32	8.39	11.26	25.41	50.69
9	1.91	3.36	5.12	7.96	10.56	22.86	43.48
10	1.88	3.29	4.96	7.64	10.04	21.04	38.58
11	1.86	3.23	4.84	7.39	9.65	19.69	35.06
12	1.84	3.18	4.75	7.19	9.33	18.64	32.43
13	1.82	3.14	4.67	7.02	9.07	17.82	30.39
14	1.81	3.10	4.60	6.89	8.86	17.14	28.77
15	1.80	3.07	4.54	6.77	8.68	16.59	27.45
16	1.79	3.05	4.49	6.67	8.53	16.12	26.36
17	1.78	3.03	4.45	6.59	8.40	15.72	25.44
18	1.77	3.01	4.41	6.51	8.29	15.38	24.66
19	1.76	2.99	4.38	6.45	8.18	15.08	23.99
20	1.76	2.97	4.35	6.39	8.10	14.82	23.40
21	1.75	2.96	4.32	6.34	8.02	14.59	22.89
22	1.75	2.95	4.30	6.29	7.95	14.38	22.43
23	1.74	2.94	4.28	6.25	7.88	14.20	22.03
24	1.74	2.93	4.26	6.21	7.82	14.03	21.66
25	1.73	2.92	4.24	6.18	7.77	13.88	21.34
26	1.73	2.91	4.23	6.14	7.72	13.74	21.04
27	1.73	2.90	4.21	6.11	7.68	13.61	20.77
28	1.72	2.89	4.20	6.09	7.64	13.50	20.53
29	1.72	2.89	4.18	6.06	7.60	13.39	20.30
30	1.72	2.88	4.17	6.04	7.56	13.29	20.09
40	1.70	2.84	4.08	5.87	7.31	12.61	18.67
60	1.68	2.79	4.00	5.71	7.08	11.97	17.38
100	1.66	2.76	3.94	5.59	6.90	11.50	16.43
140	1.66	2.74	3.91	5.54	6.82	11.30	16.05
∞	1.64	2.71	3.84	5.41	6.63	10.83	15.14

Notation: 406^3 means 406×10^3.

Continued

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 2

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	12.00	49.50	200	125^{1}	500^{1}	500^{3}	500^{5}
2	4.00	9.00	19.00	49.00	99.00	999	100^{2}
3	2.89	5.46	9.55	18.86	30.82	149	695
4	2.47	4.32	6.94	12.14	18.00	61.25	198
5	2.26	3.78	5.79	9.45	13.27	37.12	97.03
6	2.13	3.46	5.14	8.05	10.92	27.00	61.63
7	2.04	3.26	4.74	7.20	9.55	21.69	45.13
8	1.98	3.11	4.46	6.64	8.65	18.49	36.00
9	1.93	3.01	4.26	6.23	8.02	16.39	30.34
10	1.90	2.92	4.10	5.93	7.56	14.91	26.55
11	1.87	2.86	3.98	5.70	7.21	13.81	23.85
12	1.85	2.81	3.89	5.52	6.93	12.97	21.85
13	1.83	2.76	3.81	5.37	6.70	12.31	20.31
14	1.81	2.73	3.74	5.24	6.51	11.78	19.09
15	1.80	2.70	3.68	5.14	6.36	11.34	18.11
16	1.78	2.67	3.63	5.05	6.23	10.97	17.30
17	1.77	2.64	3.59	4.97	6.11	10.66	16.62
18	1.76	2.62	3.55	4.90	6.01	10.39	16.04
19	1.75	2.61	3.52	4.84	5.93	10.16	15.55
20	1.75	2.59	3.49	4.79	5.85	9.95	15.12
21	1.74	2.57	3.47	4.74	5.78	9.77	14.74
22	1.73	2.56	3.44	4.70	5.72	9.61	14.41
23	1.73	2.55	3.42	4.66	5.66	9.47	14.12
24	1.72	2.54	3.40	4.63	5.61	9.34	13.85
25	1.72	2.53	3.39	4.59	5.57	9.22	13.62
26	1.71	2.52	3.37	4.56	5.53	9.12	13.40
27	1.71	2.51	3.35	4.54	5.49	9.02	13.21
28	1.71	2.50	3.34	4.51	5.45	8.93	13.03
29	1.70	2.50	3.33	4.49	5.42	8.85	12.87
30	1.70	2.49	3.32	4.47	5.39	8.77	12.72
40	1.68	2.44	3.23	4.32	5.18	8.25	11.70
60	1.65	2.39	3.15	4.18	4.98	7.77	10.78
100	1.64	2.36	3.09	4.07	4.82	7.41	10.11
140	1.63	2.34	3.06	4.02	4.76	7.26	9.84
∞	1.61	2.30	3.00	3.91	4.61	6.91	9.21

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 3

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	13.06	53.59	216	135^1	540^1	540^3	540^5
2	4.16	9.16	19.16	49.17	99.17	999	100^2
3	2.94	5.39	9.28	18.11	29.46	141	659
4	2.48	4.19	6.59	11.34	16.69	56.18	181
5	2.25	3.62	5.41	8.67	12.06	33.20	86.29
6	2.11	3.29	4.76	7.29	9.78	23.70	53.68
7	2.02	3.07	4.35	6.45	8.45	18.77	38.68
8	1.95	2.92	4.07	5.90	7.59	15.83	30.46
9	1.90	2.81	3.86	5.51	6.99	13.90	25.40
10	1.86	2.73	3.71	5.22	6.55	12.55	22.04
11	1.83	2.66	3.59	4.99	6.22	11.56	19.66
12	1.80	2.61	3.49	4.81	5.95	10.80	17.90
13	1.78	2.56	3.41	4.67	5.74	10.21	16.55
14	1.76	2.52	3.34	4.55	5.56	9.73	15.49
15	1.75	2.49	3.29	4.45	5.42	9.34	14.64
16	1.74	2.46	3.24	4.36	5.29	9.01	13.93
17	1.72	2.44	3.20	4.29	5.18	8.73	13.34
18	1.71	2.42	3.16	4.22	5.09	8.49	12.85
19	1.70	2.40	3.13	4.16	5.01	8.28	12.42
20	1.70	2.38	3.10	4.11	4.94	8.10	12.05
21	1.69	2.36	3.07	4.07	4.87	7.94	11.73
22	1.68	2.35	3.05	4.03	4.82	7.80	11.44
23	1.68	2.34	3.03	3.99	4.76	7.67	11.19
24	1.67	2.33	3.01	3.96	4.72	7.55	10.96
25	1.66	2.32	2.99	3.93	4.68	7.45	10.76
26	1.66	2.31	2.98	3.90	4.64	7.36	10.58
27	1.65	2.30	2.96	3.87	4.60	7.27	10.41
28	1.65	2.29	2.95	3.85	4.57	7.19	10.26
29	1.65	2.28	2.93	3.83	4.54	7.12	10.12
30	1.64	2.28	2.92	3.81	4.51	7.05	9.99
40	1.62	2.23	2.84	3.67	4.31	6.59	9.13
60	1.60	2.18	2.76	3.53	4.13	6.17	8.35
100	1.58	2.14	2.70	3.43	3.98	5.86	7.79
140	1.57	2.12	2.67	3.38	3.92	5.73	7.57
∞	1.55	2.08	2.60	3.28	3.78	5.42	7.04

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 4

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	13.64	55.83	225	141^{1}	562^{1}	562^{3}	562^{5}
2	4.24	9.24	19.25	49.25	99.25	999	100^{2}
3	2.96	5.34	9.12	17.69	28.71	137	640
4	2.48	4.11	6.39	10.90	15.98	53.44	172
5	2.24	3.52	5.19	8.23	11.39	31.09	80.53
6	2.09	3.18	4.53	6.86	9.15	21.92	49.42
7	1.99	2.96	4.12	6.03	7.85	17.20	35.22
8	1.92	2.81	3.84	5.49	7.01	14.39	27.49
9	1.87	2.69	3.63	5.10	6.42	12.56	22.77
10	1.83	2.61	3.48	4.82	5.99	11.28	19.63
11	1.80	2.54	3.36	4.59	5.67	10.35	17.42
12	1.77	2.48	3.26	4.42	5.41	9.63	15.79
13	1.75	2.43	3.18	4.28	5.21	9.07	14.55
14	1.73	2.39	3.11	4.16	5.04	8.62	13.57
15	1.71	2.36	3.06	4.06	4.89	8.25	12.78
16	1.70	2.33	3.01	3.97	4.77	7.94	12.14
17	1.68	2.31	2.96	3.90	4.67	7.68	11.60
18	1.67	2.29	2.93	3.84	4.58	7.46	11.14
19	1.66	2.27	2.90	3.78	4.50	7.27	10.75
20	1.65	2.25	2.87	3.73	4.43	7.10	10.41
21	1.65	2.23	2.84	3.69	4.37	6.95	10.12
22	1.64	2.22	2.82	3.65	4.31	6.81	9.86
23	1.63	2.21	2.80	3.61	4.26	6.70	9.63
24	1.63	2.19	2.78	3.58	4.22	6.59	9.42
25	1.62	2.18	2.76	3.55	4.18	6.49	9.24
26	1.62	2.17	2.74	3.52	4.14	6.41	9.07
27	1.61	2.17	2.73	3.50	4.11	6.33	8.92
28	1.61	2.16	2.71	3.47	4.07	6.25	8.79
29	1.60	2.15	2.70	3.45	4.04	6.19	8.66
30	1.60	2.14	2.69	3.43	4.02	6.12	8.54
40	1.57	2.09	2.61	3.30	3.83	5.70	7.76
60	1.55	2.04	2.53	3.16	3.65	5.31	7.06
100	1.53	2.00	2.46	3.06	3.51	5.02	6.55
140	1.52	1.99	2.44	3.02	3.46	4.90	6.35
∞	1.50	1.94	2.37	2.92	3.32	4.62	5.88

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 5

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	14.01	57.24	230	144^1	576^1	576^3	576^5
2	4.28	9.29	19.30	49.30	99.30	999	100^2
3	2.97	5.31	9.01	17.43	28.24	135	628
4	2.48	4.05	6.26	10.62	15.52	51.71	166
5	2.23	3.45	5.05	7.95	10.97	29.75	76.91
6	2.08	3.11	4.39	6.58	8.75	20.80	46.75
7	1.97	2.88	3.97	5.76	7.46	16.21	33.06
8	1.90	2.73	3.69	5.22	6.63	13.48	25.63
9	1.85	2.61	3.48	4.84	6.06	11.71	21.11
10	1.80	2.52	3.33	4.55	5.64	10.48	18.12
11	1.77	2.45	3.20	4.34	5.32	9.58	16.02
12	1.74	2.39	3.11	4.16	5.06	8.89	14.47
13	1.72	2.35	3.03	4.02	4.86	8.35	13.29
14	1.70	2.31	2.96	3.90	4.69	7.92	12.37
15	1.68	2.27	2.90	3.81	4.56	7.57	11.62
16	1.67	2.24	2.85	3.72	4.44	7.27	11.01
17	1.65	2.22	2.81	3.65	4.34	7.02	10.50
18	1.64	2.20	2.77	3.59	4.25	6.81	10.07
19	1.63	2.18	2.74	3.53	4.17	6.62	9.71
20	1.62	2.16	2.71	3.48	4.10	6.46	9.39
21	1.61	2.14	2.68	3.44	4.04	6.32	9.11
22	1.61	2.13	2.66	3.40	3.99	6.19	8.87
23	1.60	2.11	2.64	3.36	3.94	6.08	8.65
24	1.59	2.10	2.62	3.33	3.90	5.98	8.46
25	1.59	2.09	2.60	3.30	3.85	5.89	8.28
26	1.58	2.08	2.59	3.28	3.82	5.80	8.13
27	1.58	2.07	2.57	3.25	3.78	5.73	7.99
28	1.57	2.06	2.56	3.23	3.75	5.66	7.86
29	1.57	2.06	2.55	3.21	3.73	5.59	7.74
30	1.57	2.05	2.53	3.19	3.70	5.53	7.63
40	1.54	2.00	2.45	3.05	3.51	5.13	6.90
60	1.51	1.95	2.37	2.92	3.34	4.76	6.25
100	1.49	1.91	2.31	2.82	3.21	4.48	5.78
140	1.48	1.89	2.28	2.78	3.15	4.37	5.59
∞	1.46	1.85	2.21	2.68	3.02	4.10	5.15

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 6

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	14.26	58.20	234	146^{1}	586^{1}	586^{3}	586^{5}
2	4.32	9.33	19.33	49.33	99.33	999	100^{2}
3	2.97	5.28	8.94	17.25	27.91	133	620
4	2.47	4.01	6.16	10.42	15.21	50.53	162
5	2.22	3.40	4.95	7.76	10.67	28.83	74.43
6	2.06	3.05	4.28	6.39	8.47	20.03	44.91
7	1.96	2.83	3.87	5.58	7.19	15.52	31.57
8	1.88	2.67	3.58	5.04	6.37	12.86	24.36
9	1.83	2.55	3.37	4.65	5.80	11.13	19.97
10	1.78	2.46	3.22	4.37	5.39	9.93	17.08
11	1.75	2.39	3.09	4.15	5.07	9.05	15.05
12	1.72	2.33	3.00	3.98	4.82	8.38	13.56
13	1.69	2.28	2.92	3.84	4.62	7.86	12.42
14	1.67	2.24	2.85	3.72	4.46	7.44	11.53
15	1.66	2.21	2.79	3.63	4.32	7.09	10.82
16	1.64	2.18	2.74	3.54	4.20	6.80	10.23
17	1.63	2.15	2.70	3.47	4.10	6.56	9.75
18	1.62	2.13	2.66	3.41	4.01	6.35	9.33
19	1.61	2.11	2.63	3.35	3.94	6.18	8.98
20	1.60	2.09	2.60	3.30	3.87	6.02	8.68
21	1.59	2.08	2.57	3.26	3.81	5.88	8.41
22	1.58	2.06	2.55	3.22	3.76	5.76	8.18
23	1.57	2.05	2.53	3.19	3.71	5.65	7.97
24	1.57	2.04	2.51	3.15	3.67	5.55	7.79
25	1.56	2.02	2.49	3.13	3.63	5.46	7.62
26	1.56	2.01	2.47	3.10	3.59	5.38	7.48
27	1.55	2.00	2.46	3.07	3.56	5.31	7.34
28	1.55	2.00	2.45	3.05	3.53	5.24	7.22
29	1.54	1.99	2.43	3.03	3.50	5.18	7.10
30	1.54	1.98	2.42	3.01	3.47	5.12	7.00
40	1.51	1.93	2.34	2.88	3.29	4.73	6.30
60	1.48	1.87	2.25	2.75	3.12	4.37	5.68
100	1.46	1.83	2.19	2.65	2.99	4.11	5.24
140	1.45	1.82	2.16	2.61	2.93	4.00	5.06
∞	1.43	1.77	2.10	2.51	2.80	3.74	4.64

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 7

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	14.44	58.91	237	148^1	593^1	593^3	593^5
2	4.34	9.35	19.35	49.36	99.36	999	100^2
3	2.97	5.27	8.89	17.11	27.67	132	614
4	2.47	3.98	6.09	10.27	14.98	49.66	159
5	2.21	3.37	4.88	7.61	10.46	28.16	72.61
6	2.05	3.01	4.21	6.25	8.26	19.46	43.57
7	1.94	2.78	3.79	5.44	6.99	15.02	30.48
8	1.87	2.62	3.50	4.90	6.18	12.40	23.42
9	1.81	2.51	3.29	4.52	5.61	10.70	19.14
10	1.77	2.41	3.14	4.23	5.20	9.52	16.32
11	1.73	2.34	3.01	4.02	4.89	8.66	14.34
12	1.70	2.28	2.91	3.85	4.64	8.00	12.89
13	1.68	2.23	2.83	3.71	4.44	7.49	11.79
14	1.65	2.19	2.76	3.59	4.28	7.08	10.92
15	1.64	2.16	2.71	3.49	4.14	6.74	10.23
16	1.62	2.13	2.66	3.41	4.03	6.46	9.66
17	1.61	2.10	2.61	3.34	3.93	6.22	9.19
18	1.60	2.08	2.58	3.27	3.84	6.02	8.79
19	1.58	2.06	2.54	3.22	3.77	5.85	8.45
20	1.58	2.04	2.51	3.17	3.70	5.69	8.16
21	1.57	2.02	2.49	3.13	3.64	5.56	7.90
22	1.56	2.01	2.46	3.09	3.59	5.44	7.68
23	1.55	1.99	2.44	3.05	3.54	5.33	7.48
24	1.55	1.98	2.42	3.02	3.50	5.23	7.30
25	1.54	1.97	2.40	2.99	3.46	5.15	7.14
26	1.53	1.96	2.39	2.97	3.42	5.07	6.99
27	1.53	1.95	2.37	2.94	3.39	5.00	6.86
28	1.52	1.94	2.36	2.92	3.36	4.93	6.75
29	1.52	1.93	2.35	2.90	3.33	4.87	6.64
30	1.52	1.93	2.33	2.88	3.30	4.82	6.54
40	1.49	1.87	2.25	2.74	3.12	4.44	5.86
60	1.46	1.82	2.17	2.62	2.95	4.09	5.27
100	1.43	1.78	2.10	2.52	2.82	3.83	4.84
140	1.42	1.76	2.08	2.48	2.77	3.72	4.67
∞	1.40	1.72	2.01	2.37	2.64	3.47	4.27

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 8

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	14.58	59.44	239	149^1	598^1	598^3	598^5
2	4.36	9.37	19.37	49.37	99.37	999	100^2
3	2.98	5.25	8.85	17.01	27.49	131	609
4	2.47	3.95	6.04	10.16	14.80	49.00	157
5	2.20	3.34	4.82	7.50	10.29	27.65	71.23
6	2.04	2.98	4.15	6.14	8.10	19.03	42.54
7	1.93	2.75	3.73	5.33	6.84	14.63	29.64
8	1.86	2.59	3.44	4.79	6.03	12.05	22.71
9	1.80	2.47	3.23	4.41	5.47	10.37	18.50
10	1.75	2.38	3.07	4.13	5.06	9.20	15.74
11	1.72	2.30	2.95	3.91	4.74	8.35	13.80
12	1.69	2.24	2.85	3.74	4.50	7.71	12.38
13	1.66	2.20	2.77	3.60	4.30	7.21	11.30
14	1.64	2.15	2.70	3.48	4.14	6.80	10.46
15	1.62	2.12	2.64	3.39	4.00	6.47	9.78
16	1.61	2.09	2.59	3.30	3.89	6.19	9.23
17	1.59	2.06	2.55	3.23	3.79	5.96	8.76
18	1.58	2.04	2.51	3.17	3.71	5.76	8.38
19	1.57	2.02	2.48	3.12	3.63	5.59	8.04
20	1.56	2.00	2.45	3.07	3.56	5.44	7.76
21	1.55	1.98	2.42	3.02	3.51	5.31	7.51
22	1.54	1.97	2.40	2.99	3.45	5.19	7.29
23	1.53	1.95	2.37	2.95	3.41	5.09	7.09
24	1.53	1.94	2.36	2.92	3.36	4.99	6.92
25	1.52	1.93	2.34	2.89	3.32	4.91	6.76
26	1.52	1.92	2.32	2.86	3.29	4.83	6.62
27	1.51	1.91	2.31	2.84	3.26	4.76	6.50
28	1.51	1.90	2.29	2.82	3.23	4.69	6.38
29	1.50	1.89	2.28	2.80	3.20	4.64	6.28
30	1.50	1.88	2.27	2.78	3.17	4.58	6.18
40	1.47	1.83	2.18	2.64	2.99	4.21	5.53
60	1.44	1.77	2.10	2.51	2.82	3.86	4.95
100	1.41	1.73	2.03	2.41	2.69	3.61	4.53
140	1.40	1.71	2.01	2.37	2.64	3.51	4.36
∞	1.38	1.67	1.94	2.27	2.51	3.27	3.98

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 9

Denom. df	TAIL PROBABILITY 0.20	0.10	0.05	0.02	0.01	0.001	0.0001
1	14.68	59.86	241	151^{1}	602^{1}	602^{3}	602^{5}
2	4.37	9.38	19.38	49.39	99.39	999	100^{2}
3	2.98	5.24	8.81	16.93	27.35	130	606
4	2.46	3.94	6.00	10.07	14.66	48.47	155
5	2.20	3.32	4.77	7.42	10.16	27.24	70.13
6	2.03	2.96	4.10	6.05	7.98	18.69	41.73
7	1.93	2.72	3.68	5.24	6.72	14.33	28.99
8	1.85	2.56	3.39	4.70	5.91	11.77	22.14
9	1.79	2.44	3.18	4.33	5.35	10.11	18.00
10	1.74	2.35	3.02	4.04	4.94	8.96	15.27
11	1.70	2.27	2.90	3.83	4.63	8.12	13.37
12	1.67	2.21	2.80	3.66	4.39	7.48	11.98
13	1.65	2.16	2.71	3.52	4.19	6.98	10.92
14	1.63	2.12	2.65	3.40	4.03	6.58	10.09
15	1.61	2.09	2.59	3.30	3.89	6.26	9.42
16	1.59	2.06	2.54	3.22	3.78	5.98	8.88
17	1.58	2.03	2.49	3.15	3.68	5.75	8.43
18	1.56	2.00	2.46	3.09	3.60	5.56	8.05
19	1.55	1.98	2.42	3.03	3.52	5.39	7.72
20	1.54	1.96	2.39	2.98	3.46	5.24	7.44
21	1.53	1.95	2.37	2.94	3.40	5.11	7.19
22	1.53	1.93	2.34	2.90	3.35	4.99	6.98
23	1.52	1.92	2.32	2.87	3.30	4.89	6.79
24	1.51	1.91	2.30	2.83	3.26	4.80	6.62
25	1.51	1.89	2.28	2.81	3.22	4.71	6.47
26	1.50	1.88	2.27	2.78	3.18	4.64	6.33
27	1.49	1.87	2.25	2.76	3.15	4.57	6.21
28	1.49	1.87	2.24	2.73	3.12	4.50	6.09
29	1.49	1.86	2.22	2.71	3.09	4.45	5.99
30	1.48	1.85	2.21	2.69	3.07	4.39	5.90
40	1.45	1.79	2.12	2.56	2.89	4.02	5.26
60	1.42	1.74	2.04	2.43	2.72	3.69	4.69
100	1.40	1.69	1.97	2.33	2.59	3.44	4.29
140	1.39	1.68	1.95	2.29	2.54	3.34	4.12
∞	1.36	1.63	1.88	2.19	2.41	3.10	3.75

TABLE 10 Critical Values of the *F* Distribution *(continued)*

Numerator df = 10

Denom. df	0.20	0.10	0.05	0.02	0.01	0.001	0.0001
	TAIL PROBABILITY						
1	14.77	60.19	242	151^1	606^1	606^3	606^5
2	4.38	9.39	19.40	49.40	99.40	999	100^2
3	2.98	5.23	8.79	16.86	27.23	129	603
4	2.46	3.92	5.96	10.00	14.55	48.05	154
5	2.19	3.30	4.74	7.34	10.05	26.92	69.25
6	2.03	2.94	4.06	5.98	7.87	18.41	41.08
7	1.92	2.70	3.64	5.17	6.62	14.08	28.45
8	1.84	2.54	3.35	4.63	5.81	11.54	21.68
9	1.78	2.42	3.14	4.26	5.26	9.89	17.59
10	1.73	2.32	2.98	3.97	4.85	8.75	14.90
11	1.69	2.25	2.85	3.76	4.54	7.92	13.02
12	1.66	2.19	2.75	3.59	4.30	7.29	11.65
13	1.64	2.14	2.67	3.45	4.10	6.80	10.60
14	1.62	2.10	2.60	3.33	3.94	6.40	9.79
15	1.60	2.06	2.54	3.23	3.80	6.08	9.13
16	1.58	2.03	2.49	3.15	3.69	5.81	8.60
17	1.57	2.00	2.45	3.08	3.59	5.58	8.15
18	1.55	1.98	2.41	3.02	3.51	5.39	7.78
19	1.54	1.96	2.38	2.96	3.43	5.22	7.46
20	1.53	1.94	2.35	2.91	3.37	5.08	7.18
21	1.52	1.92	2.32	2.87	3.31	4.95	6.94
22	1.51	1.90	2.30	2.83	3.26	4.83	6.73
23	1.51	1.89	2.27	2.80	3.21	4.73	6.54
24	1.50	1.88	2.25	2.77	3.17	4.64	6.37
25	1.49	1.87	2.24	2.74	3.13	4.56	6.23
26	1.49	1.86	2.22	2.71	3.09	4.48	6.09
27	1.48	1.85	2.20	2.69	3.06	4.41	5.97
28	1.48	1.84	2.19	2.66	3.03	4.35	5.86
29	1.47	1.83	2.18	2.64	3.00	4.29	5.76
30	1.47	1.82	2.16	2.62	2.98	4.24	5.66
40	1.44	1.76	2.08	2.49	2.80	3.87	5.04
60	1.41	1.71	1.99	2.36	2.63	3.54	4.48
100	1.38	1.66	1.93	2.26	2.50	3.30	4.08
140	1.37	1.64	1.90	2.22	2.45	3.20	3.93
∞	1.34	1.60	1.83	2.12	2.32	2.96	3.56

TABLE 11 Bonferroni Multipliers for 95% Confidence Intervals

The values given in the table are $t_{df,0.025/k}$ where k is the number of tests.

	NUMBER OF TESTS									
df	1	2	3	4	5	6	8	10	15	20
1	12.706	25.452	38.185	50.923	63.657	76.384	101.856	127.321	190.946	254.647
2	4.303	6.205	7.648	8.860	9.925	10.885	12.590	14.089	17.275	19.963
3	3.182	4.177	4.857	5.392	5.841	6.231	6.895	7.453	8.575	9.465
4	2.776	3.495	3.961	4.315	4.604	4.851	5.261	5.598	6.254	6.758
5	2.571	3.163	3.534	3.810	4.032	4.219	4.526	4.773	5.247	5.604
6	2.447	2.969	3.287	3.521	3.707	3.863	4.115	4.317	4.698	4.981
7	2.365	2.841	3.128	3.335	3.499	3.636	3.855	4.029	4.355	4.595
8	2.306	2.752	3.016	3.206	3.355	3.479	3.677	3.833	4.122	4.334
9	2.262	2.685	2.933	3.111	3.250	3.364	3.547	3.690	3.954	4.146
10	2.228	2.634	2.870	3.038	3.169	3.277	3.448	3.581	3.827	4.005
11	2.201	2.593	2.820	2.981	3.106	3.208	3.370	3.497	3.728	3.895
12	2.179	2.560	2.779	2.934	3.055	3.153	3.308	3.428	3.649	3.807
13	2.160	2.533	2.746	2.896	3.012	3.107	3.256	3.372	3.584	3.735
14	2.145	2.510	2.718	2.864	2.977	3.069	3.214	3.326	3.529	3.675
15	2.131	2.490	2.694	2.837	2.947	3.036	3.177	3.286	3.484	3.624
16	2.120	2.473	2.673	2.813	2.921	3.008	3.146	3.252	3.444	3.581
17	2.110	2.458	2.655	2.793	2.898	2.984	3.119	3.222	3.410	3.543
18	2.101	2.445	2.639	2.775	2.878	2.963	3.095	3.197	3.380	3.510
19	2.093	2.433	2.625	2.759	2.861	2.944	3.074	3.174	3.354	3.481
20	2.086	2.423	2.613	2.744	2.845	2.927	3.055	3.153	3.331	3.455
25	2.060	2.385	2.566	2.692	2.787	2.865	2.986	3.078	3.244	3.361
30	2.042	2.360	2.536	2.657	2.750	2.825	2.941	3.030	3.189	3.300
40	2.021	2.329	2.499	2.616	2.704	2.776	2.887	2.971	3.122	3.227
50	2.009	2.311	2.477	2.591	2.678	2.747	2.855	2.937	3.083	3.184
60	2.000	2.299	2.463	2.575	2.660	2.729	2.834	2.915	3.057	3.156
70	1.994	2.291	2.453	2.564	2.648	2.715	2.820	2.899	3.039	3.137
80	1.990	2.284	2.445	2.555	2.639	2.705	2.809	2.887	3.026	3.122
100	1.984	2.276	2.435	2.544	2.626	2.692	2.793	2.871	3.007	3.102
140	1.977	2.266	2.423	2.530	2.611	2.676	2.776	2.852	2.986	3.079
1000	1.962	2.245	2.398	2.502	2.581	2.643	2.740	2.813	2.942	3.031
∞	1.960	2.241	2.394	2.498	2.576	2.638	2.734	2.807	2.935	3.023