

Elementary
STATISTICS

8TH EDITION



Neil A.
WEISS

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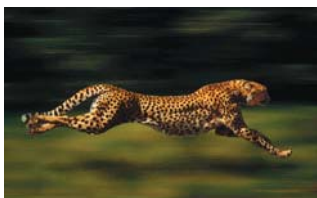
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School of Mathematical and Statistical Sciences
Arizona State University

Biographies by **Carol A. Weiss**

Addison-Wesley

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On the cover: The cheetah (*Acinonyx jubatus*) is the world's fastest land animal, capable of speeds between 70 and 75 mph. A cheetah can go from 0 to 60 mph in only 3 seconds. Adult cheetahs range in weight from about 80 to 140 lb, in total body length from about 3.5 to 4.5 ft, and in height at the shoulder from about 2 to 3 ft. They use their extraordinary eyesight, rather than scent, to spot prey, usually antelopes and hares. Hunting is done by first stalking and then chasing, with roughly half of chases resulting in capture.

Cover photograph: A cheetah at Masai Mara National Reserve, Kenya. Tom Brakefield/Corbis

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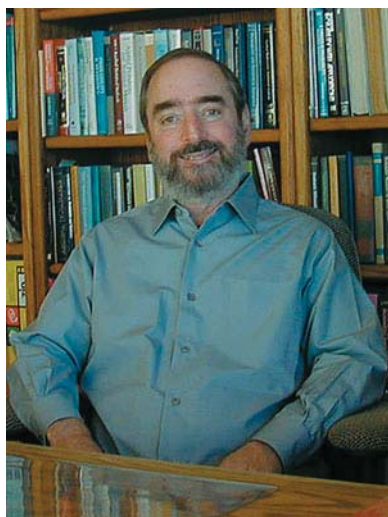


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To my father
and the memory
of my mother

About the Author



Neil A. Weiss received his Ph.D. from UCLA and subsequently accepted an assistant professor position at Arizona State University (ASU), where he was ultimately promoted to the rank of full professor. Dr. Weiss has taught statistics, probability, and mathematics—from the freshman level to the advanced graduate level—for more than 30 years. In recognition of his excellence in teaching, he received the *Dean's Quality Teaching Award* from the ASU College of Liberal Arts and Sciences. Dr. Weiss's comprehensive knowledge and experience ensures that his texts are mathematically and statistically accurate, as well as pedagogically sound.

In addition to his numerous research publications, Dr. Weiss is the author of *A Course in Probability* (Addison-Wesley, 2006). He has also authored or coauthored books in finite mathematics, statistics, and real analysis, and is currently working on a new book on applied regression analysis and the analysis of variance. His texts—well known for their precision, readability, and pedagogical excellence—are used worldwide.

Dr. Weiss is a pioneer of the integration of statistical software into textbooks and the classroom, first providing such integration in the book *Introductory Statistics* (Addison-Wesley, 1982). Weiss and Addison-Wesley continue that pioneering spirit to this day with the inclusion of some of the most comprehensive Web sites in the field.

In his spare time, Dr. Weiss enjoys walking, studying and practicing meditation, and playing hold'em poker. He is married and has two sons.

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WeissStats CD (brief contents)

Note: See the WeissStats CD ReadMe file for detailed contents.

- Applets
- Data Sets
- DDXL (Excel Add-In)
- Detailed *t* and Chi-square Tables
- Focus Database
- Formulas and Appendix A Tables
- Further Topics in Probability
- JMP Concept Discovery Modules
- Minitab_Macros
- Technology Basics
- TI Programs

Preface

Using and understanding statistics and statistical procedures have become required skills in virtually every profession and academic discipline. The purpose of this book is to help students master basic statistical concepts and techniques and to provide real-life opportunities for applying them.

Audience and Approach

Elementary Statistics is intended for a one-quarter or one-semester course. Instructors can easily fit the text to the pace and depth they prefer. Introductory high school algebra is a sufficient prerequisite.

Although mathematically and statistically sound (the author has also written books at the senior and graduate levels), the approach does not require students to examine complex concepts. Rather, the material is presented in a natural and intuitive way. Simply stated, students will find this book's presentation of introductory statistics easy to understand.

About This Book

Elementary Statistics presents the fundamentals of statistics, featuring data production and data analysis. Data exploration is emphasized as an integral prelude to inference.

This edition of *Elementary Statistics* continues the book's tradition of being on the cutting edge of statistical pedagogy, technology, and data analysis. It includes hundreds of new and updated exercises with real data from journals, magazines, newspapers, and Web sites.

The following Guidelines for Assessment and Instruction in Statistics Education (GAISE), funded and endorsed by the American Statistical Association are supported and adhered to in *Elementary Statistics*:

- Emphasize statistical literacy and develop statistical thinking.
- Use real data.
- Stress conceptual understanding rather than mere knowledge of procedures.
- Foster active learning in the classroom.
- Use technology for developing conceptual understanding and analyzing data.
- Use assessments to improve and evaluate student learning.

Changes in the Eighth Edition

The goal for this edition was to make the book even more flexible and user-friendly (especially in the treatment of hypothesis testing), to provide modern alternatives to some of the classic procedures, to expand the use of technology for developing understanding and analyzing data, and to refurbish the exercises. Several important revisions are as follows.

New! **New Case Studies.** More than half of the chapter-opening case studies have been replaced.

New! **New and Revised Exercises.** This edition contains more than **2000** high-quality exercises, which far exceeds what is found in typical introductory statistics books. Over **25%** of the exercises are new, updated, or modified. Wherever appropriate, routine exercises with simple data have been added to allow students to practice fundamentals.

Revised! **Reorganization of Introduction to Hypothesis Testing.** The introduction to hypothesis testing, found in Chapter 9, has been reworked, reorganized, and streamlined. *P*-values are introduced much earlier. Users now have the option to omit the material on critical values or omit the material on *P*-values, although doing the latter would impact the use of technology.

Revised! **Revision of Organizing Data Material.** The presentation of organizing data, found in Chapter 2, has been revised. The material on grouping and graphing qualitative data is now contained in one section and that for quantitative data in another section. In addition, the presentation and pedagogy in this chapter have been made consistent with the other chapters by providing step-by-step procedures for performing required statistical analyses.

New! **Density Curves.** A brief discussion of density curves has been included at the beginning of Chapter 6, thus providing a presentation of continuous distributions corresponding to that given in Chapter 5 for discrete distributions.

New! **Plus-Four Confidence Intervals for Proportions.** Plus-four confidence-interval procedures for one and two population proportions have been added, providing a more accurate alternative to the classic normal-approximation procedures.

New! **Chi-Square Homogeneity Test.** A new section incorporates the chi-square homogeneity test, in addition to the existing chi-square goodness-of-fit test and chi-square independence test.

New! **Course Management Notes.** New course management notes (CMN) have been produced to aid instructors in designing their courses and preparing their syllabi. The CMN are located directly after the preface in the Instructor's Edition of the book and can also be accessed from the Instructor Resource Center (IRC) located at www.pearsonhighered.com/irc.

Note: See the Technology section of this preface for a discussion of technology additions, revisions, and improvements.

Hallmark Features and Approach

Chapter-Opening Features. Each chapter begins with a general description of the chapter, an explanation of how the chapter relates to the text as a whole, and a chapter outline. A classic or contemporary case study highlights the real-world relevance of the material.

End-of-Chapter Features. Each chapter ends with features that are useful for review, summary, and further practice.

- *Chapter Reviews.* Each chapter review includes *chapter objectives*, a list of *key terms* with page references, and *review problems* to help students review and study the chapter. Items related to optional materials are marked with asterisks, unless the entire chapter is optional.

- *Focusing on Data Analysis.* This feature lets students work with large data sets, practice using technology, and discover the many methods of exploring and analyzing data. For details, refer to the Focusing on Data Analysis section on page 30 of Chapter 1.
- *Case Study Discussion.* At the end of each chapter, the chapter-opening case study is reviewed and discussed in light of the chapter's major points, and then problems are presented for students to solve.
- *Biographical Sketches.* Each chapter ends with a brief biography of a famous statistician. Besides being of general interest, these biographies teach students about the development of the science of statistics.

Formula/Table Card. The book's detachable formula/table card (FTC) contains most of the formulas and many of the tables that appear in the text. The FTC is helpful for quick-reference purposes; many instructors also find it convenient for use with examinations.

Procedure Boxes and Procedure Index. To help students learn statistical procedures, easy-to-follow, step-by-step methods for carrying them out have been developed. Each step is highlighted and presented again within the illustrating example. This approach shows how the procedure is applied and helps students master its steps. A *Procedure Index* (located near the front of the book) provides a quick and easy way to find the right procedure for performing any statistical analysis.

WeissStats CD. This PC- and Mac-compatible CD, included with every new copy of the book, contains a wealth of resources. Its ReadMe file presents a complete contents list. The contents in brief are presented at the end of the text Contents.

ASA/MAA—Guidelines Compliant. *Elementary Statistics* follows American Statistical Association (ASA) and Mathematical Association of America (MAA) guidelines, which stress the interpretation of statistical results, the contemporary applications of statistics, and the importance of critical thinking.

Populations, Variables, and Data. Through the book's consistent and proper use of the terms *population*, *variable*, and *data*, statistical concepts are made clearer and more unified. This strategy is essential for the proper understanding of statistics.

Data Analysis and Exploration. Data analysis is emphasized, both for exploratory purposes and to check assumptions required for inference. Recognizing that not all readers have access to technology, the book provides ample opportunity to analyze and explore data without the use of a computer or statistical calculator.

Parallel Critical-Value/ P -Value Approaches. Through a parallel presentation, the book offers complete flexibility in the coverage of the critical-value and P -value approaches to hypothesis testing. Instructors can concentrate on either approach, or they can cover and compare both approaches. The dual procedures, which provide both the critical-value and P -value approaches to a hypothesis-testing method, are combined in a side-by-side, easy-to-use format.

Interpretation

Interpretations. This feature presents the meaning and significance of statistical results in everyday language and highlights the importance of interpreting answers and results.



You Try It! This feature, which follows most examples, allows students to immediately check their understanding by asking them to work a similar exercise.



What Does It Mean? This margin feature states in “plain English” the meanings of definitions, formulas, key facts, and some discussions—thus facilitating students' understanding of the formal language of statistics.

Examples and Exercises

Real-World Examples. Every concept discussed in the text is illustrated by at least one detailed example. Based on real-life situations, these examples are interesting as well as illustrative.

Real-World Exercises. Constructed from an extensive variety of articles in newspapers, magazines, statistical abstracts, journals, and Web sites, the exercises provide current, real-world applications whose sources are explicitly cited. Section exercise sets are divided into the following three categories:

- *Understanding the Concepts and Skills* exercises help students master the concepts and skills explicitly discussed in the section. These exercises can be done with or without the use of a statistical technology, at the instructor's discretion. At the request of users, routine exercises on statistical inferences have been added that allow students to practice fundamentals.
- *Working with Large Data Sets* exercises are intended to be done with a statistical technology and let students apply and interpret the computing and statistical capabilities of Minitab[®], Excel[®], the TI-83/84 Plus[®], or any other statistical technology.
- *Extending the Concepts and Skills* exercises invite students to extend their skills by examining material not necessarily covered in the text. These exercises include many critical-thinking problems.

Notes: An exercise number set in cyan indicates that the exercise belongs to a group of exercises with common instructions. Also, exercises related to optional materials are marked with asterisks, unless the entire section is optional.

Data Sets. In most examples and many exercises, both raw data and summary statistics are presented. This practice gives a more realistic view of statistics and lets students solve problems by computer or statistical calculator. More than **700** data sets are included, many of which are new or updated. All data sets are available in multiple formats on the WeissStats CD, which accompanies new copies of the book. Data sets are also available online at www.pearsonhighered.com/neilweiss.

Technology

Parallel Presentation. The book's technology coverage is completely flexible and includes options for use of Minitab, Excel, and the TI-83/84 Plus. Instructors can concentrate on one technology or cover and compare two or more technologies.

Updated! **The Technology Center.** This in-text, statistical-technology presentation discusses three of the most popular applications—Minitab, Excel, and the TI-83/84 Plus graphing calculators—and includes step-by-step instructions for the implementation of each of these applications. The Technology Centers are integrated as optional material and reflect the latest software releases.

Updated! **Technology Appendixes.** The appendixes for Excel, Minitab, and the TI-83/84 Plus have been updated to correspond to the latest versions of these three statistical technologies. New to this edition is a technology appendix for SPSS[®], an IBM[®] Company.[†] These appendixes introduce the four statistical technologies, explain how to input data, and discuss how to perform other basic tasks. They are entitled *Getting Started with . . .* and are located in the Technology Basics folder on the WeissStats CD.

[†]SPSS was acquired by IBM in October 2009.

Computer Simulations. Computer simulations, appearing in both the text and the exercises, serve as pedagogical aids for understanding complex concepts such as sampling distributions.

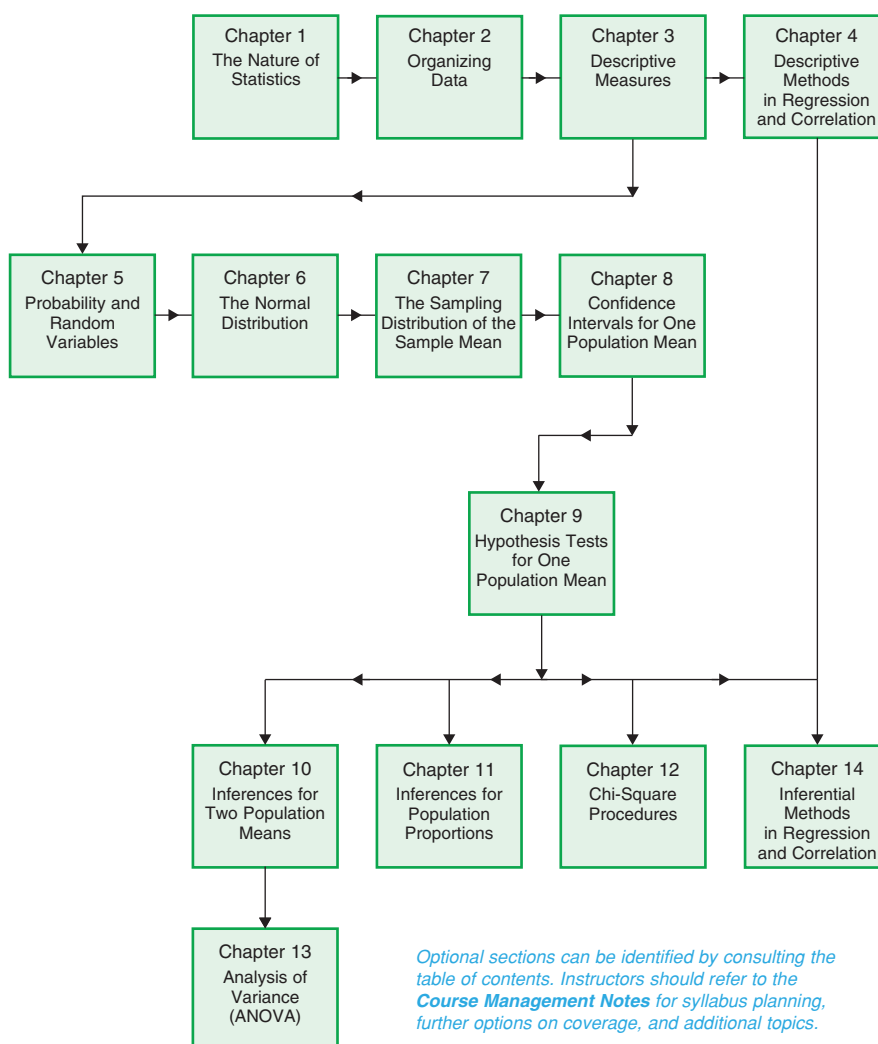
New! Interactive StatCrunch Reports. New to this edition are 54 StatCrunch Reports, each corresponding to a statistical analysis covered in the book. These interactive reports, keyed to the book with StatCrunch icons, explain how to use StatCrunch online statistical software to solve problems previously solved by hand in the book. Go to www.statcrunch.com, choose **Explore ▼ Groups**, and search “Weiss Elementary Statistics 8/e” to access the StatCrunch Reports. *Note:* Accessing these reports requires a MyStatLab or StatCrunch account.

New! Java Applets. New to this edition are 19 Java applets, custom written for *Elementary Statistics* and keyed to the book with applet icons. This new feature gives students additional interactive activities for the purpose of clarifying statistical concepts in an interesting and fun way. The applets are available on the WeissStats CD.



Organization

Elementary Statistics offers considerable flexibility in choosing material to cover. The following flowchart indicates different options by showing the interdependence among chapters; the prerequisites for a given chapter consist of all chapters that have a path that leads to that chapter.



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N.A.W.

Supplements

Student Supplements

Student's Edition

- This version of the text includes the answers to the odd-numbered Understanding the Concepts and Skills exercises. (The Instructor's Edition contains the answers to all of those exercises.)
- ISBN: 0-321-69123-7 / 978-0-321-69123-1

Technology Manuals

- *Excel Manual*, written by Mark Dummeldinger. ISBN: 0-321-69150-4 / 978-0-321-69150-7
- *Minitab Manual*, written by Dennis Young. ISBN: 0-321-69148-2 / 978-0-321-69148-4
- *TI-83/84 Plus Manual*, written by Susan Herring. ISBN: 0-321-69149-0 / 978-0-321-69149-1
- *SPSS Manual*, written by Susan Herring. Available for download within MyStatLab or at www.pearsonhighered.com/irc.

Student's Solutions Manual

- Written by Toni Garcia, this supplement contains detailed, worked-out solutions to the odd-numbered section exercises (Understanding the Concepts and Skills, Working with Large Data Sets, and Extending the Concepts and Skills) and all Review Problems.
- ISBN: 0-321-69141-5 / 978-0-321-69141-5

Weiss Web Site

- The Web site includes all data sets from the book in multiple file formats, the Formula/Table card, and more.
- URL: www.pearsonhighered.com/neilweiss.

Instructor Supplements

Instructor's Edition

- This version of the text includes the answers to all of the Understanding the Concepts and Skills exercises. (The Student's Edition contains the answers to only the odd-numbered ones.)
- ISBN: 0-321-69142-3 / 978-0-321-69142-2

Instructor's Solutions Manual

- Written by Toni Garcia, this supplement contains detailed, worked-out solutions to all of the section exercises (Understanding the Concepts and Skills, Working with Large Data Sets, and Extending the Concepts and Skills), the Review Problems, the Focusing on Data Analysis exercises, and the Case Study Discussion exercises.
- ISBN: 0-321-69144-X / 978-0-321-69144-6

Online Test Bank

- Written by Michael Butros, this supplement provides three examinations for each chapter of the text.
- Answer keys are included.
- Available for download within MyStatLab or at www.pearsonhighered.com/irc.

TestGen®

TestGen (www.pearsoned.com/testgen) enables instructors to build, edit, print, and administer tests using a computerized bank of questions developed to cover all the objectives of the text. TestGen is algorithmically based, allowing instructors to create multiple but equivalent versions of the same question or test with the click of a button. Instructors can also modify test bank questions or add new questions. The software and testbank are available for download from Pearson Education's online catalog.

PowerPoint Lecture Presentation

- Classroom presentation slides are geared specifically to the sequence of this textbook.
- These PowerPoint slides are available within MyStatLab or at www.pearsonhighered.com/irc.

Pearson Math Adjunct Support Center

The Pearson Math Adjunct Support Center, which is located at www.pearson tutorservices.com/math-adjunct.html, is staffed by qualified instructors with more than 100 years of combined experience at both the community college and university levels. Assistance is provided for faculty in the following areas:

- Suggested syllabus consultation
- Tips on using materials packed with your book
- Book-specific content assistance
- Teaching suggestions, including advice on classroom strategies

Technology Resources

The Student Edition of Minitab®

The Student Edition of Minitab is a condensed version of the Professional Release of Minitab statistical software. It offers the full range of statistical methods and graphical capabilities, along with worksheets that can include up to 10,000 data points. Individual copies of the software can be bundled with the text (ISBN: 978-0-321-11313-9 / 0-321-11313-6) (CD ONLY).

JMP® Student Edition

JMP Student Edition is an easy-to-use, streamlined version of JMP desktop statistical discovery software from SAS Institute Inc. and is available for bundling with the text (ISBN: 978-0-321-67212-4 / 0-321-67212-7).

IBM® SPSS® Statistics Student Version

SPSS, a statistical and data management software package, is also available for bundling with the text (ISBN: 978-0-321-67537-8 / 0-321-67537-1).

MathXL® for Statistics Online Course (access code required)

MathXL for Statistics is a powerful online homework, tutorial, and assessment system that accompanies Pearson textbooks in statistics. With MathXL for Statistics, instructors can:

- Create, edit, and assign online homework and tests using algorithmically generated exercises correlated at the objective level to the textbook.
- Create and assign their own online exercises and import TestGen tests for added flexibility.
- Maintain records of all student work, tracked in MathXL's online gradebook.

With MathXL for Statistics, students can:

- Take chapter tests in MathXL and receive personalized study plans and/or personalized homework assignments based on their test results.
- Use the study plan and/or the homework to link directly to tutorial exercises for the objectives they need to study.
- Access supplemental animations directly from selected exercises.

MathXL for Statistics is available to qualified adopters. For more information, visit the Web site www.mathxl.com or contact a Pearson representative.

MyStatLab™ Online Course (access code required)

MyStatLab (part of the MyMathLab® and MathXL product family) is a text-specific, easily customizable online course that integrates interactive multimedia instruction with textbook content. MyStatLab gives instructors the tools they need to deliver all or a portion of the course online, whether students are in a lab or working from home. MyStatLab provides a rich and flexible set of course materials, featuring free-response tutorial exercises for unlimited practice and mastery. Students can also use online tools, such as animations and a multimedia textbook, to independently improve their understanding and performance. Instructors can use MyStatLab's homework and test managers to select and assign online exercises correlated directly to the textbook, as well as media related to that textbook, and they can also create and assign their own online exercises and import TestGen® tests for added flexibility. MyStatLab's online gradebook—designed specifically for mathematics and statistics—automatically tracks students' homework and test results and gives instructors control over how to calculate final grades. Instructors can also add offline (paper-and-pencil) grades to the gradebook. MyStatLab includes access to **StatCrunch**, an online statistical software package that allows users to perform complex analyses, share data sets, and generate compelling reports of their data. MyStatLab also includes access to the **Pearson Tutor Center** (www.pearson tutorservices.com). The Tutor Center is staffed by qualified mathematics instructors who provide textbook-specific tutoring for students via toll-free phone, fax, email, and interactive Web sessions. MyStatLab is available to qualified adopters. For more information, visit the Web site www.mystatlab.com or contact a Pearson representative.

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StatCrunch®

StatCrunch is an online statistical software Web site that allows users to perform complex analyses, share data sets, and generate compelling reports of their data. Developed by Webster West, Texas A&M, StatCrunch already has more than 12,000 data sets available for students to analyze, covering almost any topic of interest. Interactive graphics are embedded to help users understand statistical concepts and are available for export to enrich reports with visual representations of data. Additional features include:

- A full range of numerical and graphical methods that allow users to analyze and gain insights from any data set.
- Flexible upload options that allow users to work with their .txt or Excel® files, both online and offline.
- Reporting options that help users create a wide variety of visually appealing representations of their data.

StatCrunch is available to qualified adopters. For more information, visit the Web site www.statcrunch.com or contact a Pearson representative.

ActivStats®

ActivStats, developed by Paul Velleman and Data Description, Inc., is an award-winning multimedia introduction to statistics and a comprehensive learning tool that works in conjunction with the book. It complements this text with interactive features such as videos of real-world stories, teaching applets, and animated expositions of major statistics topics. It also contains tutorials for learning a variety of statistics software, including Data Desk,® Excel, JMP, Minitab, and SPSS. *ActivStats*, ISBN: 978-0-321-50014-4 / 0-321-50014-8. For additional information, contact a Pearson representative or visit the Web site www.pearsonhighered.com/activstats.

Data Sources

- A Handbook of Small Data Sets*
A. C. Nielsen Company
AAA Daily Fuel Gauge Report
AAA Foundation for Traffic Safety
AAMC Faculty Roster
AAUP Annual Report on the Economic Status of the Profession
ABC Global Kids Study
ABCNEWS Poll
ABCNews.com
Academic Libraries
Accident Facts
ACT High School Profile Report
ACT, Inc.
Acta Ophthalmologica
Advances in Cancer Research
AHA Hospital Statistics
Air Travel Consumer Report
Alcohol Consumption and Related Problems: Alcohol and Health Monograph 1
All About Diabetes
Alzheimer's Care Quarterly
American Association of University Professors
American Automobile Manufacturers Association
American Bar Foundation
American Community Survey
American Council of Life Insurers
American Demographics
American Diabetes Association
American Elasmobranch Society
American Express Retail Index
American Film Institute
American Hospital Association
American Housing Survey for the United States
American Industrial Hygiene Association Journal
American Journal of Clinical Nutrition
American Journal of Obstetrics and Gynecology
American Journal of Political Science
American Laboratory
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American Scientist
American Statistical Association
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Auckland University of Technology
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Cellular Telecommunications & Internet Association
Census of Agriculture
Centers for Disease Control and Prevention
Central Intelligence Agency
Chance
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Chesapeake Biological Laboratory
Climates of the World
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CNNPolitics.com
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College Bound Seniors
College Entrance Examination Board
College of Public Programs at Arizona State University
Comerica Auto Affordability Index
Comerica Bank

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Compendium of Federal Justice Statistics
 Conde Nast Bridal Group
Congressional Directory
Conservation Biology
Consumer Expenditure Survey
Consumer Profile
Consumer Reports
Contributions to Boyce Thompson Institute
Controlling Road Rage: A Literature Review and Pilot Study
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Daily Racing Form
Dallas Mavericks Roster
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Dave Leip's Atlas of U.S. Presidential Elections
Deep Sea Research Part I: Oceanographic Research Papers
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 Department of Information Resources and Communications
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Digest of Education Statistics
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 Federal Bureau of Prisons
 Federal Communications Commission
 Federal Election Commission
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Introduction

CHAPTER 1

The Nature of Statistics 2