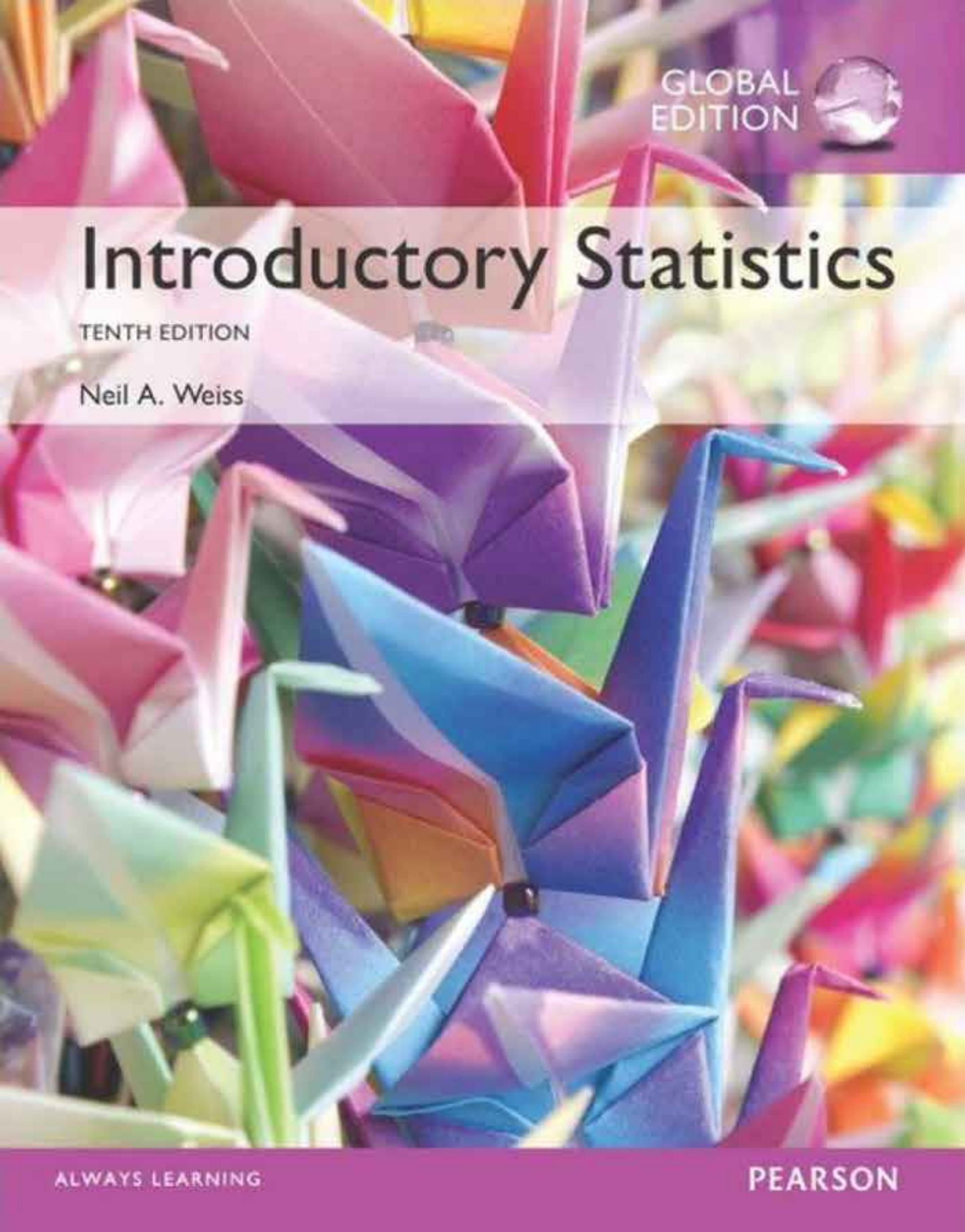
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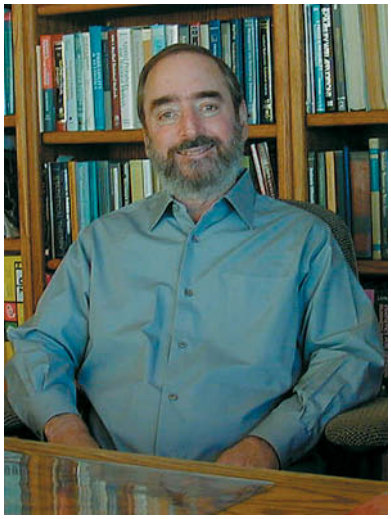

Neil A. Weiss received his Ph.D. from UCLA and subsequently accepted an assistant professor position at Arizona State University (ASU), where he was ultimately promoted to the rank of full professor. Dr. Weiss has taught statistics, probability, and mathematics—from the freshman level to the advanced graduate level—for more than 30 years.

In recognition of his excellence in teaching, Dr. Weiss received the *Dean's Quality Teaching Award* from the ASU College of Liberal Arts and Sciences. He has also been runner-up twice for the *Charles Wexler Teaching Award* in the ASU School of Mathematical and Statistical 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). He and Pearson Education continue that spirit to this day.

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

Dedicated to Aaron and Greg

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Data Sets

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Formulas

JMP Concept Discovery Modules

Minitab Macros

Procedures Booklet

Regression-ANOVA Modules

StatCrunch Reports

Technology Basics

TI Programs

*indicates optional material

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

Introductory Statistics is intended for one- or two-semester courses or for quarter-system courses. 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

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

This edition of *Introductory 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 websites.

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 *Introductory 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 Tenth Edition

The goal for this edition was to create an even more flexible and user-friendly book, to provide several new step-by-step procedures for making statistical analyses easier to apply, to add a fourth category of exercises, to expand the use of technology for developing understanding and analyzing data, and to refurbish the exercises. Several important revisions are presented as follows.

New! **New Case Studies.** Fifty percent of the chapter-opening case studies have been replaced.

New! **New and Revised Exercises.** This edition contains more than **3000** high-quality exercises, which far exceeds what is found in typical introductory statistics books. Over 35% of the exercises are new, updated, or modified.

New! **WeissStats Resource Site.** The WeissStats Resource Site (aka WeissStats site) provides an extensive array of resources for both instructors and students, including additional topics, applets, all data sets from the book in multiple formats, a procedures booklet, and technology appendixes. In addition to several new items, the site offers universal access to those items formerly included on the WeissStats CD. Refer to the table of contents for a brief list of the contents of the WeissStats site or visit the site at www.pearsonglobaleditions.com/weiss. *Note:* Resources for instructors only are available on the Instructor Resource Center at www.pearsonglobaleditions.com/weiss.

New! **Chebyshev's Rule and the Empirical Rule.** A new (optional) section of Chapter 3 has been added that is dedicated to an examination of Chebyshev's rule and the empirical rule. The empirical rule is further examined in Chapter 6 when the normal distribution is discussed.

New! **Quartiles.** The method for calculating quartiles has been modified to make it more easily accessible to students. Furthermore, a dedicated procedure that provides a step-by-step method for finding the quartiles of a data set has been included.

Revised! **Distribution Shapes.** The material on distribution shapes in Section 2.4 has been significantly modified

and clarified. Students will find this revised approach easier to understand and apply.

Revised! **Regression Analysis.** Major improvements have been made to the chapter on Descriptive Methods in Regression and Correlation. These improvements include a comprehensive discussion of scatterplots, a simpler introduction to the least-squares criterion, and easier introductory examples for the regression equation, the sums of squares and coefficient of determination, and the linear correlation coefficient.

Expanded! **Warm-up Exercises.** In this edition, hundreds of "warm-up" exercises have been added. These exercises provide context-free problems that allow students to concentrate solely on the relevant concepts before moving on to applied exercises.

Expanded! **Density Curves.** The discussion of density curves has been significantly expanded and now includes several examples and many more exercises.

Expanded! **Type II Error Probabilities and Power.** Section 9.7, which covers Type II error probabilities and power, has undergone major revision, including increased visuals and the addition of procedures for calculating Type II error probabilities and for constructing power curves.

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 technology use, and discover the many methods of exploring and analyzing data. For details, see the introductory Focusing on Data Analysis section on page 56 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.

Procedure Boxes, Index, and Booklet. To help students learn how to perform statistical analyses, easy-to-follow, step-by-step procedures have been provided. 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. Additionally:

- A *Procedure Index* provides a quick and easy way to find the right procedure for performing any statistical analysis.
- A *Procedures Booklet* (available in the Procedures Booklet section of the WeissStats Resource Site) provides a convenient way to access any required procedure.

ASA/MAA–Guidelines Compliant. *Introductory 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.

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 working 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 websites, the exercises provide current, real-world applications whose sources are explicitly cited.

New to this edition, a fourth category of exercises has been added, namely, Applying the Concepts and Skills. As a consequence, the exercise sets are now divided into the following four categories:

- *Understanding the Concepts and Skills* exercises help students master the basic concepts and skills explicitly discussed in the section. These exercises consist of two types: (1) Non-computational problems that test student understanding of definitions, formulas, and key facts; (2) "warm-up" exercises, which require only simple computations and provide context-free problems that allow students to concentrate solely on the relevant concepts before moving on to applied exercises. For pedagogical reasons, it is recommended that warm-up exercises be done without the use of a statistical technology.
- *Applying the Concepts and Skills* exercises provide students with an extensive variety of applied problems that hone student skills with real-life data. These exercises can be done with or without the use of a statistical technology, at the instructor's discretion.
- *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 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 **1000** data sets are included, many of which are new or updated. All data sets are available in multiple formats in the Data Sets section of the WeissStats Resource Site, www.pearsonglobaleditions.com/weiss.

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. These appendixes introduce the three 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 section of the WeissStats Resource Site, www.pearsonglobaleditions.com/weiss.

Expanded! **Built-in Technology Manuals.** The Technology Center features (in the book) and the technology appendixes (on the WeissStats site) make it unnecessary for students to purchase technology manuals. Students who will be using Minitab, Excel, or the TI-83/84 Plus to solve exercises should study the appropriate technology appendix(es) before commencing with The Technology Center sections.

Expanded! **TI Programs.** The TI-83/84 Plus does not have built-in applications for a number of the statistical analyses discussed in the book. So that users of the TI-83/84 Plus can do such analyses with their calculators, the author has made available TI programs. Those programs are obtainable from the TI Programs section of the WeissStats site.

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

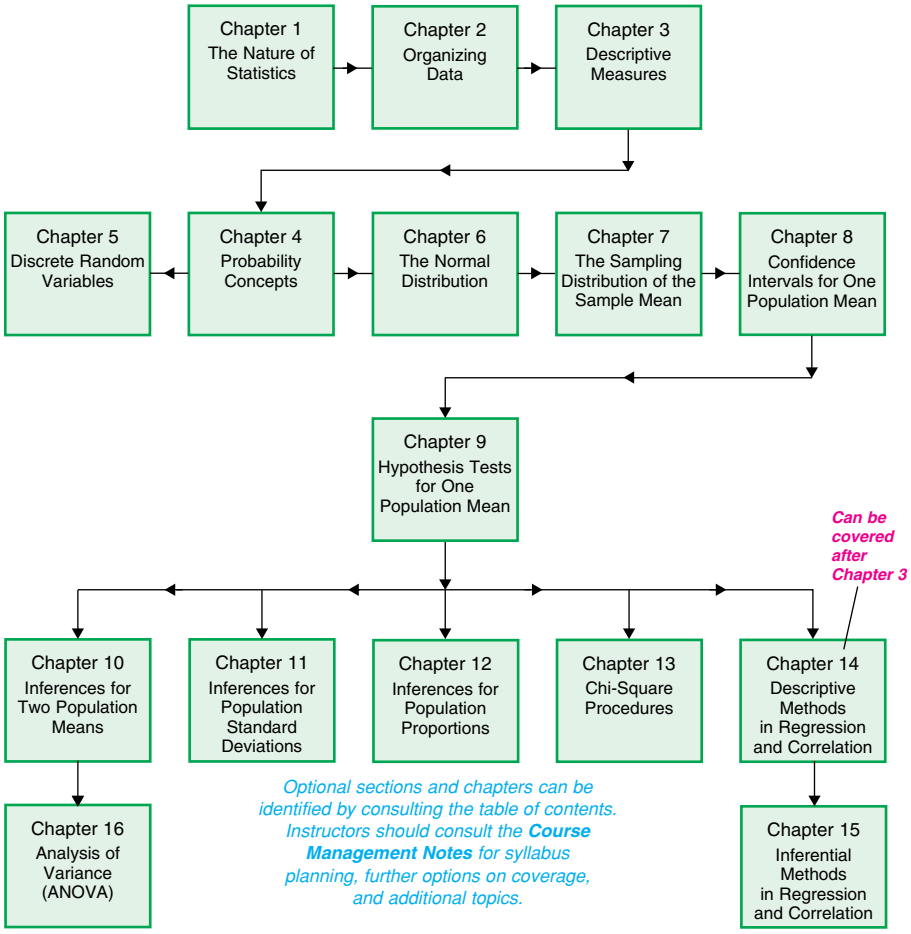
StatCrunch **Interactive StatCrunch Reports.** Sixty-four StatCrunch reports have been written specifically for *Introductory Statistics*. Each report corresponds to a statistical analysis covered in the book. These interactive reports, keyed to the book with a StatCrunch icon, explain how to use StatCrunch online statistical software to solve problems previously solved by hand in the book. Go to www.statcrunch.com, choose **Explore ▼ Groups**, and search "Weiss Introductory Statistics 10/e" to access the

StatCrunch Reports. Alternatively, you can access these reports from the document Access to StatCrunch Reports.pdf, which is in the StatCrunch section of the WeissStats Resource Site. *Note:* Analyzing data in StatCrunch requires a MyStatLab or StatCrunch account.

APPLET **Java Applets.** Twenty-one Java applets have been custom written for *Introductory Statistics*. These applets, keyed to the book with an applet icon, give students additional interactive activities for the purpose of clarifying statistical concepts in an interesting and fun way. The applets are available from the Applets section of the WeissStats Resource Site.

Organization

Introductory 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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Supplements

WeissStats Resource Site

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- URL: www.pearsonglobaleditions.com/weiss.

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- Written by Toni Garcia, this supplement contains detailed, worked-out solutions to all of the section exercises (Understanding the Concepts and Skills, Applying 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.
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Data Sources

1stock1
A Handbook of Small Data Sets
A. C. Nielsen Company
AAA Foundation for Traffic Safety
AAMC Faculty Roster
AAUP Annual Report on the Economic Status of the Profession
ABC Global Kids Study
ABCNews.com
About.com Pediatrics
Accident Facts
ACT High School Profile Report
Acta Opthalmologica
Agricultural Marketing Service
Agricultural Research Service
AHA Hospital Statistics
Air Travel Consumer Report
Alcohol Consumption and Related Problems: Alcohol and Health Monograph 1
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Alzheimer's Care Quarterly
American Association of University Professors
American Community Survey
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American Express Retail Index
American Film Institute
American Hospital Association
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American Housing Survey for the United States
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Arizona State University
Arizona State University Enrollment Summary
Arthritis Today
Asian Import
Associated Newspapers Ltd
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Avis Rent-A-Car
Baltimore Ravens
BARRON'S
Baseball Almanac
BBC News Magazine
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Beer Institute Annual Report
Behavior Research Center
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Behavioural Pharmacology
Bell Systems Technical Journal
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ESPN
ESPN MLB Scoreboard
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Everyday Health Network
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Footwear News
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Harris Poll
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Heredity
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Hilton Hotels Corporation
Hirslanden Clinic
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Information Please Almanac
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National Agricultural Statistics Service
National Anti-Vivisection Society
National Association of Colleges and Employers
National Association of Realtors
National Association of State Racing Commissioners
National Basketball Association
National Cancer Institute
National Center for Education Statistics
National Center for Health Statistics
National Center on Addiction and Substance Abuse at Columbia University
National Collegiate Athletic Association
National Corrections Reporting Program
National Education Association
National Football League
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Year-End Industry Shipment and Revenue Statistics
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CHAPTER 1

The Nature of Statistics

CHAPTER OBJECTIVES

What does the word *statistics* bring to mind? To most people, it suggests numerical facts or data, such as unemployment figures, farm prices, or the number of marriages and divorces. Two common definitions of the word *statistics* are as follows:

1. [used with a plural verb] facts or data, either numerical or nonnumerical, organized and summarized so as to provide useful and accessible information about a particular subject.
2. [used with a singular verb] the science of organizing and summarizing numerical or nonnumerical information.

Statisticians also analyze data for the purpose of making generalizations and decisions. For example, a political analyst can use data from a portion of the voting population to predict the political preferences of the entire voting population, or a city council can decide where to build a new airport runway based on environmental impact statements and demographic reports that include a variety of statistical data.

In this chapter, we introduce some basic terminology so that the various meanings of the word *statistics* will become clear to you. We also examine two primary ways of producing data, namely, through sampling and experimentation. We discuss sampling designs in Sections 1.2 and 1.3 and experimental designs in Section 1.4.

CASE STUDY

Top Films of All Time

Honoring the 10th anniversary of its award-winning series, the American Film Institute (AFI) again conducted a poll of 1500 film artists, critics, and historians, asking them to pick their 100 favorite films from a list of 400. The films on the list were made between 1915 and 2005.

After tallying the responses, AFI compiled a list representing the top 100 films. *Citizen Kane,* made in 1941, again finished in first place, followed by *The Godfather,* which was made in 1972. The following table shows the top 40 finishers in the poll. [SOURCE: Data from *AFI's 100 Years... 100 Movies — 10th Anniversary Edition*. Published by the American Film Institute.]

CHAPTER OUTLINE

1.1 Statistics Basics

1.2 Simple Random Sampling

1.3 Other Sampling Designs*

1.4 Experimental Designs*

Rank	Film	Year	Rank	Film	Year
1	Citizen Kane	1941	21	Chinatown	1974
2	The Godfather	1972	22	Some Like It Hot	1959
3	Casablanca	1942	23	The Grapes of Wrath	1940
4	Raging Bull	1980	24	E.T. The Extra-Terrestrial	1982
5	Singin' in the Rain	1952	25	To Kill a Mockingbird	1962
6	Gone with the Wind	1939	26	Mr. Smith Goes to Washington	1939
7	Lawrence of Arabia	1962	27	High Noon	1952
8	Schindler's List	1993	28	All About Eve	1950
9	Vertigo	1958	29	Double Indemnity	1944
10	The Wizard of Oz	1939	30	Apocalypse Now	1979
11	City Lights	1931	31	The Maltese Falcon	1941
12	The Searchers	1956	32	The Godfather Part II	1974
13	Star Wars	1977	33	One Flew Over the Cuckoo's Nest	1975
14	Psycho	1960	34	Snow White and the Seven Dwarfs	1937
15	2001: A Space Odyssey	1968	35	Annie Hall	1977
16	Sunset Blvd.	1950	36	The Bridge on the River Kwai	1957
17	The Graduate	1967	37	The Best Years of Our Lives	1946
18	The General	1927	38	The Treasure of the Sierra Madre	1948
19	On the Waterfront	1954	39	Dr. Strangelove	1964
20	It's a Wonderful Life	1946	40	The Sound of Music	1965

Armed with the knowledge that you gain in this chapter, you will be asked to further analyze this AFI poll at the end of the chapter.

1.1 Statistics Basics

You probably already know something about statistics. If you read newspapers, surf the Web, watch the news on television, or follow sports, you see and hear the word *statistics* frequently. In this section, we use familiar examples such as baseball statistics and voter polls to introduce the two major types of statistics: **descriptive statistics** and **inferential statistics.** We also introduce terminology that helps differentiate among various types of statistical studies.

Descriptive Statistics

Each spring in the late 1940s, President Harry Truman officially opened the major league baseball season by throwing out the "first ball" at the opening game of the Washington Senators. We use the 1948 baseball season to illustrate the first major type of statistics, descriptive statistics.

EXAMPLE 1.1 Descriptive Statistics

The 1948 Baseball Season In 1948, the Washington Senators (Nationals) played 153 games, winning 56 and losing 97. They finished seventh in the American League and were led in hitting by Bud Stewart, whose batting average was .279. Baseball statisticians compiled these and many other statistics by organizing the complete records for each game of the season.

Although fans take baseball statistics for granted, much time and effort is required to gather and organize them. Moreover, without such statistics, baseball would be much harder to follow. For instance, imagine trying to select the best hitter in the American League given only the official score sheets for each game. (More than 600 games were played in 1948; the best hitter was Ted Williams, who led the league with a batting average of .369.)

The work of baseball statisticians is an illustration of *descriptive statistics*.

DEFINITION 1.1

Descriptive Statistics

Descriptive statistics consists of methods for organizing and summarizing information.

Descriptive statistics includes the construction of graphs, charts, and tables and the calculation of various descriptive measures such as averages, measures of variation, and percentiles. We discuss descriptive statistics in detail in Chapters 2 and 3.

Inferential Statistics

We use the 1948 presidential election to introduce the other major type of statistics, inferential statistics.

EXAMPLE 1.2 **Inferential Statistics**

The 1948 Presidential Election In the fall of 1948, President Truman was concerned about statistics. The Gallup Poll taken just prior to the election predicted that he would win only 44.5% of the vote and be defeated by the Republican nominee, Thomas E. Dewey. But the statisticians had predicted incorrectly. Truman won more than 49% of the vote and, with it, the presidency. The Gallup Organization modified some of its procedures and has correctly predicted the winner ever since.

Political polling provides an example of inferential statistics. Interviewing everyone of voting age in the United States on their voting preferences would be expensive and unrealistic. Statisticians who want to gauge the sentiment of the entire **population** of U.S. voters can afford to interview only a carefully chosen group of a few thousand voters. This group is called a **sample** of the population. Statisticians analyze the information obtained from a sample of the voting population to make inferences (draw conclusions) about the preferences of the entire voting population. Inferential statistics provides methods for drawing such conclusions.

The terminology just introduced in the context of political polling is used in general in statistics.

DEFINITION 1.2

Population and Sample

Population: The collection of all individuals or items under consideration in a statistical study.

Sample: That part of the population from which information is obtained.

Figure 1.1 on the following page depicts the relationship between a population and a sample from the population.

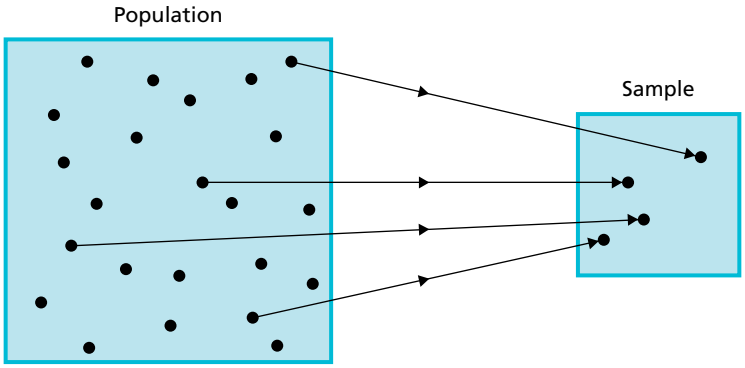
Now that we have discussed the terms *population* and *sample,* we can define *inferential statistics.*

DEFINITION 1.3

Inferential Statistics

Inferential statistics consists of methods for drawing and measuring the reliability of conclusions about a population based on information obtained from a sample of the population.

FIGURE 1.1
Relationship between population and sample



Descriptive statistics and inferential statistics are interrelated. You must almost always use techniques of descriptive statistics to organize and summarize the information obtained from a sample before carrying out an inferential analysis. Furthermore, as you will see, the preliminary descriptive analysis of a sample often reveals features that lead you to the choice of (or to a reconsideration of the choice of) the appropriate inferential method.

Classifying Statistical Studies

As you proceed through this book, you will obtain a thorough understanding of the principles of descriptive and inferential statistics. In this section, you will classify statistical studies as either descriptive or inferential. In doing so, you should consider the purpose of the statistical study.

If the purpose of the study is to examine and explore information for its own intrinsic interest only, the study is descriptive. However, if the information is obtained from a sample of a population and the purpose of the study is to use that information to draw conclusions about the population, the study is inferential.

Thus, a descriptive study may be performed either on a sample or on a population. Only when an inference is made about the population, based on information obtained from the sample, does the study become inferential.

Examples 1.3 and 1.4 further illustrate the distinction between descriptive and inferential studies. In each example, we present the result of a statistical study and classify the study as either descriptive or inferential. Classify each study yourself before reading our explanation.

EXAMPLE 1.3 Classifying Statistical Studies

The 1948 Presidential Election Table 1.1 displays the voting results for the 1948 presidential election.

TABLE 1.1
Final results of the 1948 presidential election

Ticket	Votes	Percentage
Truman–Barkley (Democratic)	24,179,345	49.7
Dewey–Warren (Republican)	21,991,291	45.2
Thurmond–Wright (States Rights)	1,176,125	2.4
Wallace–Taylor (Progressive)	1,157,326	2.4
Thomas–Smith (Socialist)	139,572	0.3

Exercise 1.7 on page 29

Classification This study is descriptive. It is a summary of the votes cast by U.S. voters in the 1948 presidential election. No inferences are made.

EXAMPLE 1.4 Classifying Statistical Studies

Testing Baseballs For the 101 years preceding 1977, the major leagues purchased baseballs from the Spalding Company. In 1977, that company stopped manufacturing major league baseballs, and the major leagues then bought their baseballs from the Rawlings Company.

Early in the 1977 season, pitchers began to complain that the Rawlings ball was "livelier" than the Spalding ball. They claimed it was harder, bounced farther and faster, and gave hitters an unfair advantage. Indeed, in the first 616 games of 1977, 1033 home runs were hit, compared to only 762 home runs hit in the first 616 games of 1976.

Sports Illustrated magazine sponsored a study of the liveliness question and published the results in the article "They're Knocking the Stuffing Out of It" (*Sports Illustrated*, June 13, 1977, pp. 23–27) by L. Keith. In this study, an independent testing company randomly selected 85 baseballs from the current (1977) supplies of various major league teams. It measured the bounce, weight, and hardness of the chosen baseballs and compared these measurements with measurements obtained from similar tests on baseballs used in 1952, 1953, 1961, 1963, 1970, and 1973.

The conclusion was that "…the 1977 Rawlings ball is livelier than the 1976 Spalding, but not as lively as it could be under big league rules, or as the ball has been in the past."

Classification This study is inferential. The independent testing company used a sample of 85 baseballs from the 1977 supplies of major league teams to make an inference about the population of all such baseballs. (An estimated 360,000 baseballs were used by the major leagues in 1977.)

You try it!

Exercise 1.9 on page 29

The *Sports Illustrated* study also shows that it is often not feasible to obtain information for the entire population. Indeed, after the bounce and hardness tests, all of the baseballs sampled were taken to a butcher in Plainfield, New Jersey, to be sliced in half so that researchers could look inside them. Clearly, testing every baseball in this way would not have been practical.

The Development of Statistics

Historically, descriptive statistics appeared before inferential statistics. Censuses were taken as long ago as Roman times. Over the centuries, records of such things as births, deaths, marriages, and taxes led naturally to the development of descriptive statistics.

Inferential statistics is a newer arrival. Major developments began to occur with the research of Karl Pearson (1857–1936) and Ronald Fisher (1890–1962), who published their findings in the early years of the twentieth century. Since the work of Pearson and Fisher, inferential statistics has evolved rapidly and is now applied in a myriad of fields.

What Does It Mean?

An understanding of statistical reasoning and of the basic concepts of descriptive and inferential statistics has become mandatory for virtually everyone, in both their private and professional lives.

Familiarity with statistics will help you make sense of many things you read in newspapers and magazines and on the Internet. For instance, could the *Sports Illustrated* baseball test (Example 1.4), which used a sample of only 85 baseballs, legitimately draw a conclusion about 360,000 baseballs? After working through Chapter 9, you will understand why such inferences are reasonable.

Observational Studies and Designed Experiments

Besides classifying statistical studies as either descriptive or inferential, we often need to classify them as either *observational studies* or *designed experiments*. In an **observational study,** researchers simply observe characteristics and take measurements, as in a sample survey. In a **designed experiment,** researchers impose

treatments and controls (discussed in Section 1.4) and then observe characteristics and take measurements. Observational studies can reveal only *association,* whereas designed experiments can help establish *causation.*

Note that, in an observational study, someone is observing data that already exist (i.e., the data were there and would be there whether someone was interested in them or not). In a designed experiment, however, the data do not exist until someone does something (the experiment) that produces the data. Examples 1.5 and 1.6 illustrate some major differences between observational studies and designed experiments.

EXAMPLE 1.5 An Observational Study

Vasectomies and Prostate Cancer Approximately 450,000 vasectomies are performed each year in the United States. In this surgical procedure for contraception, the tube carrying sperm from the testicles is cut and tied.

Several studies have been conducted to analyze the relationship between vasectomies and prostate cancer. The results of one such study by E. Giovannucci et al. appeared in the paper "A Retrospective Cohort Study of Vasectomy and Prostate Cancer in U.S. Men" (*Journal of the American Medical Association*, Vol. 269(7), pp. 878–882).

Dr. Giovannucci, study leader and epidemiologist at Harvard-affiliated Brigham and Women's Hospital, said that "…we found 113 cases of prostate cancer among 22,000 men who had a vasectomy. This compares to a rate of 70 cases per 22,000 among men who didn't have a vasectomy."

The study shows about a 60% elevated risk of prostate cancer for men who have had a vasectomy, thereby revealing an association between vasectomy and prostate cancer. But does it establish causation: that having a vasectomy causes an increased risk of prostate cancer?

Exercise 1.19
on page 30

The answer is no, because the study was observational. The researchers simply observed two groups of men, one with vasectomies and the other without. Thus, although an association was established between vasectomy and prostate cancer, the association might be due to other factors (e.g., temperament) that make some men more likely to have vasectomies and also put them at greater risk of prostate cancer.

EXAMPLE 1.6 A Designed Experiment

Folic Acid and Birth Defects For several years, evidence had been mounting that folic acid reduces major birth defects. Drs. A. E. Czeizel and I. Dudas of the National Institute of Hygiene in Budapest directed a study that provided the strongest evidence to date. Their results were published in the paper "Prevention of the First Occurrence of Neural-Tube Defects by Periconceptional Vitamin Supplementation" (*New England Journal of Medicine*, Vol. 327(26), p. 1832).

For the study, the doctors enrolled 4753 women prior to conception and divided them randomly into two groups. One group took daily multivitamins containing 0.8 mg of folic acid, whereas the other group received only trace elements (minute amounts of copper, manganese, zinc, and vitamin C). A drastic reduction in the rate of major birth defects occurred among the women who took folic acid: 13 per 1000, as compared to 23 per 1000 for those women who did not take folic acid.

Exercise 1.21
on page 30

In contrast to the observational study considered in Example 1.5, this is a designed experiment and does help establish causation. The researchers did not simply observe two groups of women but, instead, randomly assigned one group to take daily doses of folic acid and the other group to take only trace elements.

Exercises 1.1

Understanding the Concepts and Skills

1.1 Define the following terms:
a. Population
b. Sample

1.2 What are the two major types of statistics? Describe them in detail.

1.3 Identify some methods used in descriptive statistics.

1.4 Explain two ways in which descriptive statistics and inferential statistics are interrelated.

1.5 Define the following terms:
a. Observational study
b. Designed experiment

1.6 Fill in the following blank: Observational studies can reveal only association, whereas designed experiments can help establish _____.

Applying the Concepts and Skills

*In Exercises **1.7–1.12**, classify each of the studies as either descriptive or inferential. Explain your answers.*

1.7 TV Viewing Times. Data from a sample of Americans yielded the following estimates of average TV viewing time per month for all Americans 2 years old and older. The times are in hours and minutes; Q1 stands for first quarter. [SOURCE: *The Cross-Platform Report*, Quarter 1, 2011. Published by The Nielsen Company, © 2011.]

Viewing method	Q1 2011	Q1 2010	Change (%)
Watching TV in the home	158:47	158:25	0.2
Watching timeshifted TV	10:46	9:36	12.2
DVR playback	26:14	25:48	1.7
Using the Internet on a computer	25:33	25:54	−1.4
Watching video on the Internet	4:33	3:23	34.5
Mobile subscribers watching video on a mobile phone	4:20	3:37	20.0

1.8 Professional Athlete Salaries. From the *Statistical Abstract of the United States* and the article "Average Salaries in the NBA, NFL, MLB and NHL" by J. Dorish, published on the Yahoo! Contributor Network, we obtained the following data on average professional athletes' salaries for the years 2005 and 2011.

Sport	Average salary ($millions)	
	2005	2011
Baseball (MLB)	2.48	3.31
Basketball (NBA)	4.04	5.15
Football (NFL)	1.40	1.90

1.9 Home Sales. Zillow.com is an online database that provides real estate information for U.S. homes that are for rent or sale. It also presents statistics on recently sold homes. The following table gives various information on all homes sold in several different cities across the United States for the month of September 2012.

City	Price per square foot	Sale to list price ratio	% foreclosure re-sales
Scottsdale, AZ	$167	0.973	12.43%
Washington, DC	$436	0.990	2.88%
San Francisco, CA	$636	1.026	6.55%
Las Vegas, NV	$ 74	1.000	19.45%
Nashville, TN	$106	0.973	18.09%

1.10 Drug Use. The U.S. Substance Abuse and Mental Health Services Administration collects and publishes data on nonmedical drug use, by type of drug and age group, in *National Survey on Drug Use and Health*. The following table provides data for the years 2003 and 2008. The percentages shown are estimates for the entire nation based on information obtained from a sample (NA, not available).

Type of drug	Percentage, 18–25 years old			
	Ever used		Current user	
	2003	2008	2003	2008
Any illicit drug	60.5	56.6	20.3	19.6
Marijuana and hashish	53.9	50.4	17.0	16.5
Cocaine	15.0	14.4	2.2	1.5
Hallucinogens	23.3	17.7	1.7	1.7
Inhalants	14.9	10.4	0.4	0.3
Any psychotherapeutic	29.0	29.2	6.0	5.9
Alcohol	87.1	85.6	61.4	61.2
"Binge" alcohol use	NA	NA	41.6	41.8
Cigarettes	70.2	64.2	40.2	35.7
Smokeless tobacco	22.0	20.3	4.7	5.4
Cigars	45.2	41.4	11.4	11.3

1.11 Dow Jones Industrial Averages. From the *Stock Performance Guide*, published online by 1stock1 on the website 1Stock1.com, we found the closing values of the Dow Jones Industrial Averages as of the end of December for the years 2004 through 2013.

Year	Closing
2004	10,783.01
2005	10,717.50
2006	12,463.15
2007	13,264.82
2008	8,776.39
2009	10,428.05
2010	11,577.51
2011	12,217.56
2012	13,104.14
2013	16,576.66

1.12 In-Demand College Majors. In a June 2013 article, published online by The Street, B. O'Connell discussed the results of a survey on opportunities for graduating college students. In one aspect of the survey, the following percentage estimates were reported on which college majors were in demand among U.S. firms. [SOURCE: "The Most In-Demand College Majors This Year." Published by CareerBuilder, LLC, © 2013.]

Major	Percentage of U.S. firms
Business studies	31%
Computer sciences	24%
Engineering	17%
Health care sciences	10%
Engineering technologies	9%
Math and statistics	9%
Communications	7%
Education	7%
Science technology	6%
Liberal arts	6%

1.13 Thoughts on Evolution. In an article titled "Who has designs on your student's minds?" (*Nature*, Vol. 434, pp. 1062–1065), author G. Brumfiel postulated that support for Darwinism increases with level of education. The following table provides percentages of U.S. adults, by educational level, who believe that evolution is a scientific theory well supported by evidence.

Education	Percentage
Postgraduate education	65%
College graduate	52%
Some college education	32%
High school or less	20%

a. Do you think that this study is descriptive or inferential? Explain your answer.
b. If, in fact, the study is inferential, identify the sample and population.

1.14 Judgment of Faces. In a psychological study linking a person's attitude with his or her perception of human faces, 165 subjects were asked to judge the attributes of each of two unknown faces. It was proven that manipulated attitude significantly influences the judgment of facial dimensions that are evaluatively loaded (e.g., smiling or frowning mouth).
a. Do you think this study is descriptive or inferential? Explain your answer.
b. If, in fact, the study is inferential, identify the sample and population.

1.15 Genocide. The document "American Attitudes about Genocide" provided highlights of a nationwide poll with 1000 participants. The survey, conducted by Penn Schoen Berland between June 30 and July 10, 2012, revealed that "66% of respondents believe that genocide is preventable."
a. Is the statement in quotes an inferential or a descriptive statement? Explain your answer.
b. Based on the same information, what if the statement had been "66% of Americans believe that genocide is preventable"?

1.16 Vasectomies and Prostate Cancer. Refer to the vasectomy/prostate cancer study discussed in Example 1.5 on page 28.
a. How could the study be modified to make it a designed experiment?
b. Comment on the feasibility of the designed experiment that you described in part (a).

*In Exercises **1.17–1.22**, state whether the investigation in question is an observational study or a designed experiment. Justify your answer in each case.*

1.17 The Salk Vaccine. In the 1940s and early 1950s, the public was greatly concerned about polio. In an attempt to prevent this disease, Jonas Salk of the University of Pittsburgh developed a polio vaccine. In a test of the vaccine's efficacy, involving nearly 2 million grade-school children, half of the children received the Salk vaccine; the other half received a placebo, in this case an injection of salt dissolved in water. Neither the children nor the doctors performing the diagnoses knew which children belonged to which group, but an evaluation center did. The center found that the incidence of polio was far less among the children inoculated with the Salk vaccine. From that information, the researchers concluded that the vaccine would be effective in preventing polio for all U.S. school children; consequently, it was made available for general use.

1.18 Do Left-Handers Die Earlier? According to a study published in the *Journal of the American Public Health Association*, left-handed people do not die at an earlier age than right-handed people, contrary to the conclusion of a highly publicized report done 2 years earlier. The investigation involved a 6-year study of 3800 people in East Boston older than age 65. Researchers at Harvard University and the National Institute of Aging found that the "lefties" and "righties" died at exactly the same rate. "There was no difference, period," said Dr. J. Guralnik, an epidemiologist at the institute and one of the coauthors of the report.

1.19 Sex, Sleep, and PTSD. In the article, "One's Sex, Sleep, and Posttraumatic Stress Disorder" (*Biology of Sex Differences*, Vol. 3, No. 29, pp. 1–7), I. Kobayashi et al. study the relationship between one's sex, sleep patterns, and posttraumatic stress disorder (PTSD) after trauma exposure. The authors report that women have a higher lifetime prevalence of PTSD as well as a greater risk of developing PTSD following trauma exposure. Relationships between sleep and physical health have been documented in a number of studies, and the authors explore the possibility that disruptive sleep habits are common among people with PTSD and also a possible risk factor for the development of PTSD. A questionnaire of men and women with and without PTSD produced data on their sleep habits.

1.20 Aspirin and Cardiovascular Disease. In the article by P. Ridker et al. titled "A Randomized Trial of Low-dose Aspirin in the Primary Prevention of Cardiovascular Disease in Women" (*New England Journal of Medicine*, Vol. 352, pp. 1293–1304), the researchers noted that "We randomly assigned 39,876 initially healthy women 45 years of age or older to receive 100 mg of aspirin or placebo on alternate days and then monitored them for 10 years for a first major cardiovascular event (i.e., nonfatal myocardial infarction, nonfatal stroke, or death from cardiovascular causes)."

1.21 Heart Failure. In the paper "Cardiac-Resynchronization Therapy with or without an Implantable Defibrillator in Advanced Chronic Heart Failure" (*New England Journal of Medicine*, Vol. 350, pp. 2140–2150), M. Bristow et al. reported the results of a study of methods for treating patients who had advanced heart failure due to ischemic or nonischemic cardiomyopathies. A total of 1520 patients were randomly assigned in a 1:2:2 ratio to receive optimal pharmacologic therapy alone or in combination with either a pacemaker or a pacemaker–defibrillator combination. The patients were then observed until they died or were hospitalized for any cause.

1.22 Starting Salaries. The National Association of Colleges and Employers (NACE) compiles information on salary offers to new college graduates and publishes the results in *Salary Survey*.