FIFTH EDITION

BENNETT | BRIGGS | TRIOLA

STATISTICAL REASONING

FOR EVERYDAY LIFE

Pearson

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FOR EVERYDAY LIFE

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Pearson

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This book is dedicated to everyone
who will try to make the world
a better place. We hope that your
study of statistics will be useful
to your efforts.

And it is dedicated to those who
make our own lives brighter,
especially Lisa, Grant, Brooke, Julie,
Katie, Ginny, Marc, and Scott.

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PREFACE

"Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write."

—H. G. Wells

Why Study Statistics?

The future imagined by fiction writer H. G. Wells in the quotation above is no longer the future; it is now. Statistical reasoning is a part of everyday life, unavoidable whether you are starting a new business, deciding how to plan for your financial future, or simply following the news. Statistics comes up in everything from opinion polls to economic reports to the latest research in a wide variety of fields. Understanding the core ideas behind statistics is therefore crucial to your success in the modern world.

What Kind of Statistics Will You Learn in This Book?

Statistics is a rich field of study—so rich that it is possible to study it for a lifetime and still have much left to learn. Nevertheless, you can understand the core ideas of statistics with just a quarter or semester of academic study. This book is designed to help you learn these core ideas. The ideas you'll study in this book represent the statistics that you'll *need* in your everyday life—and that you can reasonably learn in one course of study. In particular, we've designed this book to fulfill three specific purposes:

1. To provide you with the understanding of statistics you'll need for **college** courses, particularly those in social sciences such as economics, psychology, sociology, and political science.
2. To help you develop the ability to reason using statistical information—an ability that is crucial to almost any **career** in the modern world.
3. To provide you with the power to evaluate the many news reports of statistical studies that you encounter in your daily **life**, thereby helping you to form opinions about their conclusions and to decide whether the conclusions should influence the way you live.

Who Should Read This Book?

We hope this book will be useful to everyone, but it is designed primarily for students who are *not* planning to pursue advanced course work in statistics. In particular, this book should provide a suitable introduction to statistics for students majoring in a broad range of fields that require statistical literacy, including most disciplines in the humanities and social sciences. The level of this text should be appropriate to anyone who has completed two years of high school mathematics.

Approach

This book takes an approach designed to help you understand important statistical ideas qualitatively, using quantitative techniques only when they clarify those ideas. The following are a few of the key pedagogical strategies that guided the creation of this book.

Start with the Big Picture. Most people entering a statistics course have little prior knowledge of the subject, so it is important to keep sight of the overall purpose of statistics while learning individual ideas or methods. We therefore begin this book with a broad overview of statistics in Chapter 1, in which we explain the relationship between samples and populations, discuss sampling methods and the various types of statistical studies, and show numerous examples designed to help you decide whether to rely on the results of a statistical study. This "big picture" overview of statistics provides a solid foundation for the more in-depth study of statistical ideas in the rest of the book.

Build Ideas Step by Step. The goal of any course in statistics is to help students understand real statistical issues. However, it is often easier to begin by investigating simple examples in order to build step-by-step understanding that can then be applied to more complex studies. We apply this strategy within every section and every chapter, gradually building toward real examples and case studies.

Use Computations to Enhance Understanding. The primary goal of this book is to help you understand statistical concepts and ideas, but we firmly believe that this goal is best achieved by doing at least some computation. We therefore include computational techniques wherever they will enhance understanding of the underlying ideas. However, this is a book that emphasizes statistical *concepts* over arithmetic calculations.

Connect Probability to Statistics. Many statistics courses include coverage of probability, but to students the concept of probability often seems disconnected from the rest of the subject matter. This is unfortunate, since probability plays such an integral role in the science of statistics. We introduce this point in Chapter 1, in discussing the basic structure of statistical studies, and then revisit it throughout the book, especially in Chapter 6, where we present many ideas of probability.

Stay on Goal: Applying Statistical Reasoning to Everyday Life. Because statistics is such a rich subject, it can be difficult to decide how far to go with any particular statistical topic. In making such decisions for this book, we always turned back to the goal reflected in the title: This book is supposed to help you with the statistical reasoning needed in everyday life. If we felt that a topic was not often encountered in everyday life, we left it out. In the same spirit, we included a few topics—such as a discussion of percentages in Chapter 2 and an in-depth study of graphics in Chapter 3—that are not often covered in statistics courses but are major features of the statistics encountered in daily life.

Modular Structure

Although we have written this book so that it can be read as a narrative from beginning to end, we recognize that many instructors might wish to teach material in a different order than we have chosen or to cover only selected portions of the text as time allows for classes of different length or with students at different levels. We have therefore organized the book with a modular structure that allows instructors to create a customized course. The 10 chapters are organized broadly by conceptual areas. Each chapter, in turn, is divided into a set of self-contained sections, each devoted to a particular topic or application. In most cases, you may cover the sections or chapters in any order or skip sections that do not fit well into your course. Please note the following specific structure within each chapter:

Learning Goals. Each chapter begins with a one-page overview of its subject matter, including a list that maps each section to learning goals.

Numbered Sections. Each chapter is subdivided into numbered sections (e.g., Sections 1.1, 1.2, …). To facilitate use of these sections in any order, each section begins with a short introduction and includes the following key features:

- **Headings to Identify Key Topics.** In keeping with the book's modularity, each subtopic within a section is clearly identified so that students understand what they will be learning.
- **Summary Boxes.** Key definitions and concepts are highlighted in summary boxes for easy reference.
- **Examples and Case Studies.** Numbered examples within each section are designed to build understanding and to offer practice with the types of questions that appear in the exercises. Case studies, which always focus on real issues, go into more depth than the numbered examples.
- **Exercises.** Each section concludes with a set of exercises, subdivided into the following categories:
    - **Statistical Literacy and Critical Thinking.** These exercises consist of short answer questions that students should be able to answer from the reading alone.

- **Does It Make Sense?** For each of these short statements about statistical concepts, students are expected to think about the statement, determine whether it makes sense, and explain why or why not. These exercises are generally easy once students understand a particular concept, but difficult otherwise; they are therefore an excellent probe of comprehension.
- **Concepts and Applications.** These exercises ask students to put the chapter ideas to use in solving real or hypothetical problems. Students who have worked through the examples and read the case studies should be well prepared for these exercises.
- **Projects for the Internet & Beyond.** These exercises present topics that students may explore through more in-depth research or study.
- **In the News.** These exercises ask students to draw connections between the section's content and the use of statistics in articles and reports in the news media.

Chapter Review Exercises. A set of review exercises is included near the end of each chapter. These exercises are designed primarily for self-study, and answers to all of them appear in the back of the book.

Chapter Quiz. The main part of each chapter ends with a chapter quiz consisting of questions that require relatively short answers. These questions address topics found throughout the chapter, and all answers are included in the back of the book.

Focus Topics. Each chapter concludes with two sections that are titled "Focus on …" and go into depth on important statistical issues. The topics of these sections were chosen to demonstrate the great variety of fields in which statistics plays a role, including history, environmental studies, agriculture, and economics. Each of these Focus sections includes a set of questions for assignment or discussion.

Additional Pedagogical Features. In addition to the components of the standard structure of each chapter described above, several other pedagogical features are presented throughout the text:

- **Think about It.** These features pose short conceptual questions designed to help students reflect on important new ideas. They also serve as excellent starting points for classroom discussions and, in some cases, can be used as a basis for clicker questions.
- **Using Technology.** In places where we've introduced computational ideas for which many students will use technology, we have included these features to give students clear instructions in the use of Microsoft Excel, Statdisk, and TI-83/84 Plus calculators. The Statdisk statistics software program is free to users of this book and can be downloaded at www.statdisk.org.
- **By the Way.** These short features appear in the margin and introduce students to interesting asides relevant to the topic at hand.
- **Technical Note.** These features also appear in the margin and note details that are important mathematically, but generally do not affect students' understanding of the material.

About the Fifth Edition

We've developed this fifth edition of *Statistical Reasoning for Everyday Life* with the help of many users and reviewers. In addition to editing the entire book to make it even more student-friendly, we have made the following major changes for this edition:

- Because this book is intended to show the relevance of statistics to everyday life, it is critical that discussions and examples be up to date. We have therefore revised or replaced many dozens of in-text and numbered examples and case studies to be sure that they reflect the latest data and topics of interest.
- We have substantially rewritten most of the 20 in-depth Focus topics to bring them up to date.
- We have thoroughly reworked the section exercise sets, completely replacing nearly half of the exercises and revising or updating data in most of the others.
- While we have made substantial changes to all of the chapters, users of past editions will particularly note the major revisions to Chapters 9 and 10, where we have reorganized much of the material within each section to make it easier for students to follow these more advanced topics.

Acknowledgments

Writing a textbook requires the efforts of many people besides the authors. This book would not have been possible without the help of many people. We'd particularly like to thank our past and present editors at Pearson, including Bill Poole, Greg Tobin, Deirdre Lynch, Chris Cummings, and Suzy Bainbridge, whose faith allowed us to create this book. We'd also like to thank the rest of the team at Pearson who helped produce this book, including Ron Hampton, Justin Billing, Robert Carroll, Mary Durnwald, Aimee Thorne, Erin Kelly, Jennifer Myers, and Barbara Atkinson, as well as the production team of Jane Hoover and her colleagues at Lifland et al., Bookmakers.

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SUPPLEMENTS

Student Supplements

Student's Solutions Manual. This manual provides detailed, worked-out solutions to all odd-numbered text exercises and chapter quiz problems. ISBN-13: 978-0-13-445694-2; ISBN-10: 0-13-445694-7.

Companion Website. The companion website contains additional resources for students, including data sets and web links from the text. Go to www.pearsonhighered.com/mathstatsresources.

Instructor Supplements

Instructor's Edition. This version of the text includes the answers to all exercises and chapter quizzes. (The student edition contains answers to the odd-numbered section exercises as well as all of the chapter review exercises and all chapter quiz exercises.)

Instructor's Solutions Manual. This comprehensive manual contains solutions to all text exercises.

Online Test Bank. The test bank, available in Pearson Education's online catalog, contains four tests to accompany every chapter of the text.

TestGen®. TestGen (www.pearsonhighered.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. Tests can be printed or administered online. The software and test bank are available for download from Pearson Education's online catalog.

Learning Catalytics. Learning Catalytics is a web-based engagement and assessment tool. A "bring-your-own-device" direct-response system, Learning Catalytics offers a diverse library of dynamic questions that allow students to interact with and think critically about statistical concepts. Using this real-time resource, instructors can take advantage of critical teaching moments both in the classroom and through gradable homework assignments.

PowerPoint® Lecture Slides. These slides present key concepts and definitions from the text. Slides are available to download from within MyStatLab and from Pearson Education's online catalog.

Technology Resources

MyStatLab™ Online Course (access code required)
MyStatLab is a course management system that delivers **proven results** in helping individual students succeed.

- MyStatLab can be successfully implemented in any environment—lab-based, hybrid, fully online, traditional—and demonstrates the quantifiable difference that integrated usage has on student retention, subsequent success, and overall achievement.
- MyStatLab's comprehensive online gradebook automatically tracks students' results on tests, quizzes, and homework and in the study plan. Instructors can use the gradebook to provide positive feedback or intervene if students have trouble. Gradebook data can be easily exported to a variety of spreadsheet programs, such as Microsoft Excel. You can determine which points of data you want to export and then analyze the results to determine success.

MyStatLab provides **engaging experiences** that personalize, stimulate, and measure learning for each student. In addition to the resources below, each course includes a full interactive online version of the accompanying textbook.

- **Tutorial Exercises with Multimedia Learning Aids.** The homework and practice exercises in MyStatLab align with the exercises in the textbook, and they regenerate algorithmically to give students unlimited opportunity for practice and mastery. Exercises offer immediate helpful feedback, guided solutions, sample problems, animations, videos, and eText clips for extra help at point of use.
- **StatTalk Videos: *24 Conceptual Videos to Help You Actually Understand Statistics.*** Fun-loving statistician Andrew Vickers takes to the streets of Brooklyn, New York, to demonstrate important statistical concepts through interesting stories and real-life events. These fun and engaging videos will help students actually understand statistical concepts. Available with an instructor's user guide and assessment questions.
- **Getting Ready for Statistics.** A library of questions now appears within each MyStatLab course to offer the developmental math topics students need for the course. These can be assigned as a prerequisite to other assignments, if desired.
- **Conceptual Question Library.** In addition to algorithmically regenerated questions that are aligned with your

textbook, there is a library of 1000 Conceptual Questions available in the assessment manager that require students to apply their statistical understanding.

- **StatCrunch™.** MyStatLab integrates the web-based statistical software StatCrunch within the online assessment platform so that students can easily analyze data sets from exercises and the text. In addition, MyStatLab includes access to **www.StatCrunch.com**, a website where users can access more than 26,000 shared data sets, conduct online surveys, perform complex analyses using the powerful statistical software, and generate compelling reports.
- **Statistical Software Support.** Knowing that students often use external statistical software, we make it easy to copy our data sets, both from the ebook and the MyStatLab questions, into software such as StatCrunch, Minitab, Excel, and more. Students have access to a variety of support tools—Technology Tutorial Videos, Technology Study Cards, and Technology Manuals for select titles—to learn how to effectively use statistical software.
- **Expert Tutoring.** Although many students describe the whole of MyStatLab as "like having your own personal tutor," students also have access to live tutoring from Pearson. Qualified statistics instructors provide tutoring sessions for students via MyStatLab.

And MyStatLab comes from a **trusted partner** with educational expertise and an eye on the future. Knowing that you are using a Pearson product means knowing that you are using quality content. That means that our eTexts are accurate and our assessment tools work. Whether you are just getting started with MyStatLab or have a question along the way, we're here to help you learn about our technologies and how to incorporate them into your course.

To learn more about how MyStatLab combines proven learning applications with powerful assessment, visit the website at **www.mystatlab.com** or contact your Pearson representative.

MyStatLab™ Ready-to-Go Course (access code required)

These new Ready-to-Go courses provide students with all the same great MyStatLab features that you're used to, but make it easier for instructors to get started. Each course includes preassigned homework and quizzes to make creating your course even simpler. Ask your Pearson representative about the details for this particular course or to see a copy of this course.

StatCrunch™

StatCrunch is powerful web-based statistical software that allows users to perform complex analyses, share data sets, and generate compelling reports of their data. The vibrant online community offers more than 26,000 data sets for students to analyze.

- **Collect.** Users can upload their own data to StatCrunch or search a large library of publicly shared data sets, spanning almost any topic of interest. Also, an online survey tool allows users to quickly collect data via web-based surveys.
- **Crunch.** A full range of numerical and graphical methods allow users to analyze and gain insights from any data set. Interactive graphics help users understand statistical concepts and are available for export to enrich reports with visual representations of data.
- **Communicate.** Reporting options help users create a wide variety of visually appealing representations of their data.

Full access to StatCrunch is available with a MyStatLab kit, and StatCrunch is available by itself to qualified adopters. For more information, visit the website at **www.statcrunch.com** or contact your Pearson representative.

If your course is	Time for reading the assigned text (per week)	Time for homework assignments (per week)	Time for review and test preparation (average per week)	Total study time (per week)
3 credits	1 to 2 hours	3 to 5 hours	2 hours	6 to 9 hours
4 credits	2 to 3 hours	3 to 6 hours	3 hours	8 to 12 hours
5 credits	2 to 4 hours	4 to 7 hours	4 hours	10 to 15 hours

The Key to Success: Study Time

The single most important key to success in any college course is to spend enough time studying. A general rule of thumb for college classes is that you should expect to study about 2 to 3 hours per week outside of class for each unit of credit. For example, a student taking 15 credit hours should expect to spend 30 to 45 hours each week studying outside of class. Combined with time in class, this works out to a total of 45 to 60 hours spent on academic work—not much more than the time a typical job requires, and you get to choose your own hours. Of course, if you are working or have family obligations while you attend school, you will need to budget your time carefully.

As a rough guideline, your study time for a single course might be divided as shown in the table above. If you find that you are spending fewer hours than these guidelines suggest, you can probably improve your grade by studying longer. If you are spending more hours than these guidelines suggest, you may be studying inefficiently; in that case, you should talk to your instructor about how to study more effectively.

Using This Book

The chapters in this book are structured to help you to study effectively and efficiently. To get the most out of each chapter, you might wish to use the following study plan.

- Begin by reading the assigned material *twice*.
  - On the first pass, read straight through to gain a "feel" for the material and concepts presented.
  - On the second pass, read the material more carefully while using the wide margins to take notes that will help later with homework and exams. Be sure to take notes by hand (or typing if you have an e-book); avoid using a highlighting pen (or highlighting tool), which makes it too easy to highlight mindlessly.
- Next go back and *work through* the examples. That is, don't just read them, but instead try to work them yourself, looking at the solutions only if you get stuck. Even then, write out the solutions as you follow them through, checking all calculations for yourself.
- Now you are ready to try the end-of-chapter exercises. It is worth your while to try as many as possible (you can check your answers for odd-numbered exercises in the back of the book), even if your instructor has assigned only a few.
- If you have access to MyStatLab with this book, be sure to take advantage of the many additional study resources available on this website.

General Strategies for Studying

- Budget your time effectively. Studying 1 or 2 hours each day is more effective, and far less painful, than studying all night before homework is due or before an exam. *Note*: Research shows that it can be helpful to create a "personal contract" for your study time (or for any other personal commitment), in which you specify rewards you'll give yourself for success and penalties you'll assess for failings.

- Engage your brain. Learning is an active process, not a passive experience. Whether you are reading, listening to a lecture, or working on assignments, always make sure that your mind is actively engaged. If you find your mind drifting or find yourself falling asleep, make a conscious effort to revive yourself, or take a break if necessary.
- Don't miss class, and come prepared. Listening to lectures and participating in class activities and discussions is much more effective than reading someone else's notes or watching a video later. Active participation will help you retain what you are learning. Also, be sure to complete assigned reading *before* the class in which it will be discussed. This is crucial, because class lectures and discussions are designed to reinforce key ideas from the reading.
- Start your homework early. The more time you allow yourself, the easier it is to get help if you need it. If a concept gives you trouble, first try additional reading or studying beyond what has been assigned. If you still have trouble, ask for help: You surely can find friends, peers, or teachers who will be glad to help you learn.
- Working together with friends can be valuable in helping you understand difficult concepts. However, be sure that you learn *with* your friends and do not become dependent on them.
- Don't try to multitask. Research shows that human beings simply are not good at multitasking: When we attempt it, we do more poorly at all of the individual tasks. And in case you think you are an exception, research has also shown that those people who believe they are best at multitasking are often the worst! So when it is time to study, turn off your electronic devices, find a quiet spot, and concentrate on your work. (If you must use a device to study, as is the case with an e-book or online homework, turn off e-mail, text, and other alerts so that they will not interrupt your concentration.)

Preparing for Exams

- Rework exercises and other assignments; try additional questions to be sure you understand the concepts. Study your performance on assignments, quizzes, or exams from earlier in the term.
- Study your notes from classes, and reread relevant sections in your textbook. Pay attention to what your instructor expects you to know for an exam.
- Study individually *before* joining a study group with friends. Study groups are effective only if every individual comes prepared to contribute.
- Don't stay up too late before an exam. Don't eat a big meal within an hour of the exam (thinking is more difficult when blood is being diverted to the digestive system).
- Try to relax before and during the exam. If you have studied effectively, you are capable of doing well. Staying relaxed will help you think clearly.

Presenting Homework and Writing Assignments

All work that you turn in should be of *collegiate quality:* neat and easy to read, well organized, and demonstrating mastery of the subject matter. Future employers and teachers will expect this quality of work. Moreover, although submitting homework of collegiate quality requires "extra" effort, it serves two important purposes directly related to learning:

1. The effort you expend in clearly explaining your work solidifies your learning. In particular, research has shown that writing triggers different areas of your brain than reading, listening, or speaking. As a result, writing something down will reinforce your learning of a concept, even when you think you already understand it.
2. By making your work clear and self-contained (that is, making it a document that you can read without referring to the questions in the text), you will have a much more useful study guide when you review for a quiz or exam.

The following guidelines will help ensure that your assignments meet the standards of collegiate quality:

- Always use proper grammar, proper sentence and paragraph structure, and proper spelling. Do not use texting shorthand.

- All answers and other written assignments should be fully self-contained. A good test is to imagine that a friend is reading your work and to ask yourself whether the friend would understand exactly what you are trying to say. It is also helpful to read your work out loud to yourself, making sure that it sounds clear and coherent.
- For exercises that require calculation:
    - Be sure to *show your work* clearly. By doing so, both you and your instructor can follow the process you used to obtain an answer. Also, please use standard mathematical symbols, rather than "calculator-ese." For example, show multiplication with the $\times$ symbol (not with an asterisk), and write 10^5, not 10^5 or 10E5.
    - *Word problems should have word answers.* That is, after you have completed any necessary calculations, any problem stated in words should be answered with one or more *complete sentences* that describe the point of the problem and the meaning of your solution.
    - Express your word answers in a way that would be *meaningful* to most people. For example, most people would find it more meaningful if you express a result of 720 hours as 1 month. Similarly, if a precise calculation yields an answer of 9,745,600 years, it may be more meaningful in words as "nearly 10 million years."
- Include illustrations whenever they help explain your answer, and make sure your illustrations are neat and clear. For example, if you graph by hand, use a ruler to make straight lines. If you use software to make illustrations, be careful to avoid cluttering them up with unnecessary features.
- If you study with friends, be sure that you turn in your own work, stated in your own words—you should avoid anything that might even give the *appearance* of possible academic dishonesty.

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APPLICATIONS INDEX

CS = CASE STUDY; E = EXAMPLE; F = FOCUS FEATURE; IE = IN-TEXT EXAMPLE; P = PROBLEM (EXERCISE); PR = PROJECT

Arts and Literature

Biological and Health Sciences

Business and Economics

Education

Government and Politics

Physical and Environmental Sciences

Social Sciences

Sports and Games

Surveys and Opinion Polls

Miscellaneous

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1

Speaking of Statistics

Is your drinking water safe? How many people approve of the President's budget plan? Are we getting good value for our health care dollars? Questions like these can be addressed only through statistical studies. In this first chapter, we will discuss basic principles of statistical research and lay a foundation for the more detailed study of statistics that follows in the rest of this text. Along the way, we will consider a variety of examples that show how well-designed statistical studies can provide guidance for social policy and personal decisions, as well as a few cases in which statistics can be misleading.

"Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write."

—H. G. Wells

LEARNING GOALS

1.1 What Is/Are Statistics?

Understand the two meanings of the term *statistics* and the basic ideas behind any statistical study, including the relationships among the study's population, sample, sample statistics, and population parameters.

1.2 Sampling

Understand the importance of choosing a representative sample and become familiar with several common methods of sampling.

1.3 Types of Statistical Studies

Understand the differences between observational studies and experiments; recognize key issues in experiments, including the selection of treatment and control groups, the placebo effect, and blinding.

1.4 Should You Believe a Statistical Study?

Be able to evaluate statistical studies that you find in the media, so that you can decide whether the results are meaningful.

FOCUS TOPICS

1.1 WHAT IS/ARE STATISTICS?

The subject of statistics is often stereotyped as dry or technical, but it touches on almost everything in modern society. Statistics can tell us whether a new drug is effective in treating cancer, it can help agricultural inspectors ensure that our food is safe, and it is essential for conducting and interpreting opinion polls. Businesses use statistics in market research and advertising. We even use statistics in sports, often as a way of ranking teams and athletes. Indeed, you'll be hard-pressed to think of any topic that is not linked with statistics in some important way.

The primary goal of this text is to help you learn the core ideas behind statistical methods, so that you will have the power to understand the statistics you encounter in the news, in your classes or workplace, and in your everyday life. If you take additional courses in statistics, you'll learn more of the details and theory behind these ideas.

A good place to start is with the term *statistics* itself, which can be either singular or plural and has different meanings in the two cases. When it is singular, *statistics* is the *science* that helps us understand how to collect, organize, and interpret numbers or other information about some topic; we refer to the numbers or other pieces of information as *data*. When the term is plural, *statistics* are the actual data that describe some characteristic. For example, if there are 30 students in your class and they range in age from 17 to 64, the numbers "30 students," "17 years," and "64 years" are all statistics that describe your class in some way.

By the Way

You'll sometimes see the word *data* used as a singular synonym for *information*, but grammatically speaking, data are plural: One piece of information is a *datum*, and two or more pieces are *data*.

Two Definitions of Statistics

- Statistics is the *science* of collecting, organizing, and interpreting data.
- Statistics are the *data* (numbers or other pieces of information) that describe or summarize something.

How Statistics Works

According to news reports, 111.9 million Americans watched the Denver Broncos win Super Bowl 50, which explains why the networks can now ask advertisers to pay more than $5 million for a 30-second commercial. But you may wonder: Who counted all these 111.9 million people?

The answer is *no one*. The claim that 111.9 million people watched the Super Bowl came from statistical studies. The best-known studies of television viewing are summarized with the famous *Nielsen ratings*, compiled by a company called Nielsen Media Research. Nielsen gathers much of its data by monitoring the television viewing habits of people in only about 5000 homes (though it has recently begun supplementing these data with other statistical samples, including samples of posts about television watching on Twitter and Facebook).

If you are new to the study of statistics, these methods may seem like a stretch. How can anyone draw a conclusion about millions of people by studying just a few thousand? However, statistical science shows that such conclusions can be quite accurate, *if* the statistical studies are conducted properly. Let's take the Nielsen ratings of the Super Bowl as an example and ask a few key questions that will illustrate how statistics works in general.

By the Way

Statistics originated with the collection of census and tax data, which are affairs of state. That is why the word *state* is at the root of the word *statistics*.

What Is the Goal of the Research?

Nielsen's goal is to determine the total number of Americans who watched the Super Bowl. In the language of statistics, we say that Nielsen is interested in the **population** of all Americans. The number that Nielsen hopes to determine—the number of people who watched the Super Bowl—is a particular characteristic of the population. In statistics, characteristics of the population are called **population parameters**.

Although we usually think of a population as a group of people, in statistics a population can be any kind of group—people, animals, or things. For example, in a study of automobile safety, the population might be *all cars on the road,* and the population parameters might include the total number of cars on the road during a certain time period, the accident rate among cars on the road, or the range of weights of cars on the road.

Definitions

The **population** in a statistical study is the *complete* set of people or things being studied.

Population parameters are specific numbers describing characteristics of the population.

EXAMPLE 1 Populations and Population Parameters

For each of the following situations, describe the population being studied and identify some of the population parameters that would be of interest.

a. You work for Farmers Insurance and you've been asked to determine the average (mean) amount paid to accident victims in cars without side-impact air bags.

b. You've been hired by McDonald's to determine the weights of the potatoes delivered each week for making French fries.

c. You are a business reporter covering Genentech Corporation and you are investigating whether its new treatment is effective against childhood leukemia.

SOLUTION

a. The population consists of people who have received insurance payments for accidents in cars that lacked side-impact air bags. The relevant population parameter is the average (mean) amount paid to these people. (See Section 4.1 for discussion of the *mean* and other types of "average.")

b. The population consists of all the potatoes delivered each week for making French fries. Relevant population parameters include the average (mean) weight of the potatoes and the variation of the weights (for example, are most of them close to or far from the average?).

c. The population consists of all children with leukemia. Important population parameters are the percentage of children who recover *without* the new treatment and the percentage of children who recover with the new treatment.

What Actually Gets Studied?

If researchers were all-powerful, they might determine the number of people watching the Super Bowl by surveying every individual American. But no one can do that, so instead they try to estimate the number of Americans watching by studying a relatively small group of people. In Nielsen's case, a big part of its effort to learn about the population of all Americans involves carefully monitoring the television viewing habits of a much smaller **sample** of Americans. More specifically, Nielsen has installed (with the residents' consent) television-monitoring devices in about 5000 homes, so the people who live in these homes are the sample of Americans that Nielsen studies.

The individual measurements that Nielsen collects from the people in the 5000 homes constitute the **raw data**. Nielsen collects much raw data—for example, when and how long each TV in the household is on, what show it is tuned to, and who in the household is watching. Nielsen then consolidates these raw data into a set of numbers that characterize the sample, such as the percentage of viewers in the sample who watched each individual television show or the total number of people in the sample who watched the Super Bowl. These numbers are called **sample statistics**.

Definitions

A **sample** is a subset of the population from which data are actually obtained.

The actual measurements or observations collected from the sample constitute the **raw data**.

Sample statistics are numbers describing characteristics of the sample found by consolidating or summarizing the raw data.

By the Way

Arthur C. Nielsen founded his company and invented market research in 1923. He introduced the Nielsen Radio Index to rate radio programs in 1942 and extended his methods to television programming in the 1960s. The company now also tracks other media (Internet, smartphones, etc.) and must constantly adapt its methodology to new media technologies.

By the Way

By the Labor Department definition, someone who is not working is not necessarily unemployed. For example, stay-at-home moms and dads are not counted among the unemployed unless they are actively trying to find a job, and people who tried to find work but gave up in frustration are not counted as unemployed.

EXAMPLE 2 Unemployment Survey

The U.S. Labor Department defines the *civilian labor force* as all those people who are either employed or actively seeking employment. Each month, the Labor Department reports the unemployment rate, which is the percentage of people actively seeking employment within the entire civilian labor force. To determine the unemployment rate, the Labor Department surveys 60,000 households. For the unemployment reports, describe each of the following.

a. population

b. sample

c. raw data

d. sample statistics

e. population parameters

SOLUTION

a. The *population* is the group that the Labor Department wants to learn about, which is all the people who make up the civilian labor force.

b. The *sample* consists of all the people among the 60,000 households surveyed.

c. The *raw data* consist of all the information collected in the survey.

d. The *sample statistics* summarize the raw data for the sample. In this case, the relevant sample statistic is the percentage of people in the sample who are actively seeking employment. (The Labor Department also calculates similar sample statistics for subgroups in the population, such as the percentages of teenagers, men, women, and veterans who are unemployed.)

e. The *population parameters* are the characteristics of the entire population that correspond to the sample statistics. In this case, the relevant population parameter is the actual unemployment rate. Note that the Labor Department does *not* actually measure this population parameter, because data are collected only for the sample and then are used to estimate the population parameter.

How Do Sample Statistics Relate to Population Parameters?

Suppose Nielsen finds that 31% of the people in the 5000 homes in its sample watched the Super Bowl. This "31%" is a sample statistic, because it characterizes the sample. But what Nielsen really wants to know is the corresponding population parameter, which is the percentage of all Americans who watched the Super Bowl.

There is no way for Nielsen researchers to know the exact value of the population parameter, because they've studied only a sample. However, Nielsen researchers hope that they've done their work correctly so that the sample statistic is a good estimate of the population parameter. In other words, they would like to conclude that because 31% of the sample watched the Super Bowl, approximately 31% of the population also watched the Super Bowl. One of the primary purposes of statistics is to help researchers assess the validity of this type of conclusion.

By the Way

Statisticians often simply say "statistic" instead of "sample statistic" and "parameter" instead of "population parameter." The alliterations (that is, the same starting letters in each case) will help you remember this shorthand.

THINK ABOUT IT Suppose Nielsen concludes that 31% of Americans watched the Super Bowl. About how many people does this represent? (Assume the population of the United States is approximately 325 million.)

Statistical science provides methods that enable researchers to determine how well a sample statistic estimates a population parameter. For example, results from surveys or opinion polls are usually quoted along with a value called the **margin of error**. By adding and subtracting the margin of error from the sample statistic, we find a range of values, or **confidence interval**, that is *likely* to contain the population parameter. In most cases, the margin of error is

defined so that we can have 95% confidence that this range contains the population parameter. We'll discuss more precise meanings for "likely" and "95% confidence" in Chapter 8, but for now you can think of it as follows: If a study were repeated 20 times with 20 different samples, 19 of the 20 studies (that is, 95% of the studies) would have a confidence interval that contains the true population parameter. In the case of the Nielsen ratings, the margin of error is calculated to be about 1 percentage point. In that case, if 31% of the sample was watching the Super Bowl, then we can be 95% confident that the range from 30% to 32% contains the actual percentage of the population watching the Super Bowl.

One of the most remarkable findings of statistical science is that it is possible to get meaningful results from surprisingly small samples. Nevertheless, larger sample sizes are better (when they are feasible), because the margin of error is generally smaller for larger samples. For example, the margin of error for a 95% confidence interval in a well-conducted poll is typically about 5 percentage points for a sample size of 400, but drops to 3 percentage points for a sample size of 1,000 and to 1 percentage point for a sample of 10,000. (See Chapter 8 to understand how margins of error are calculated.)

Definition

The **margin of error** in a statistical study is used to describe the range of values, or **confidence interval**, likely to contain the population parameter. We find the confidence interval by adding and subtracting the margin of error from the sample statistic obtained in the study. That is, the range of values likely to contain the population parameter is

$$\begin{aligned} \text{from} \quad & (\text{sample statistic} - \text{margin of error}) \\ \text{to} \quad & (\text{sample statistic} + \text{margin of error}) \end{aligned}$$

The margin of error is usually defined to give a 95% confidence interval, meaning that 95% of samples of the size used in the study would result in confidence intervals that contain the actual population parameter (and 5% would not).

EXAMPLE 3 Sex and Politics

The Pew Research Center for People and the Press interviewed 1002 adult Americans and asked about the reason for a recent increase in sex scandals among elected officials. About 57% of the respondents claimed that the increase was due to greater scrutiny by the media, while 19% felt that the increase was due to declining moral standards. The margin of error for the poll was 3 percentage points. Describe the population and the sample for this survey, and explain the meaning of the sample statistic of 57%. What can we conclude about the percentage of the population that believes the increase in political sex scandals is due to greater media scrutiny?

SOLUTION The population is all adult Americans and the sample consists of the 1002 people who were interviewed. The sample statistic of 57% is the actual percentage of people in the sample who answered that greater media scrutiny was responsible for the increase in political sex scandals. The 57% sample statistic and the margin of error of 3 percentage points tell us that the range of values

$$\begin{aligned} \text{from} \quad & 57\% - 3\% = 54\% \\ \text{to} \quad & 57\% + 3\% = 60\% \end{aligned}$$

is likely (with 95% confidence) to contain the population parameter, which in this case is the true percentage of all adult Americans who believe that greater media scrutiny is responsible for the increase in political sex scandals.

THINK ABOUT IT In the poll described in Example 3, the respondents were given the two possible explanations, greater media scrutiny and lower moral standards. Do you think the results might have been different if respondents were asked to provide their own explanations? Explain.

Putting It All Together: The Process of a Statistical Study

The process used by Nielsen Media Research is similar to that used in many statistical studies. Figure 1.1 and the box below summarize the basic steps in a statistical study. Keep in mind that these steps are somewhat idealized, and the actual steps may differ from one study to another. Moreover, the details hidden in the basic steps are critically important. For example, in step 2, a poorly chosen sample can render the entire study meaningless, and great care must be taken in inferring conclusions about a population from results found for the much smaller sample of that population.

By the Way

Statisticians often divide their subject into two major branches: **descriptive statistics**, which deals with *describing* raw data in the form of graphics and sample statistics, and **inferential statistics**, which deals with *inferring* (or estimating) population parameters from sample data. In this text, Chapters 2 through 5 primarily cover descriptive statistics, while Chapters 6 through 10 focus on inferential statistics.

Basic Steps in a Statistical Study

Step 1. State the goals of your study precisely. That is, determine the population you want to study and exactly what you'd like to learn about it.

Step 2. Choose a representative sample from the population.

Step 3. Collect raw data from the sample and summarize these data by finding sample statistics of interest.

Step 4. Use the sample statistics to make inferences about the population.

Step 5. Draw conclusions: Determine what you learned and whether you achieved your goal.

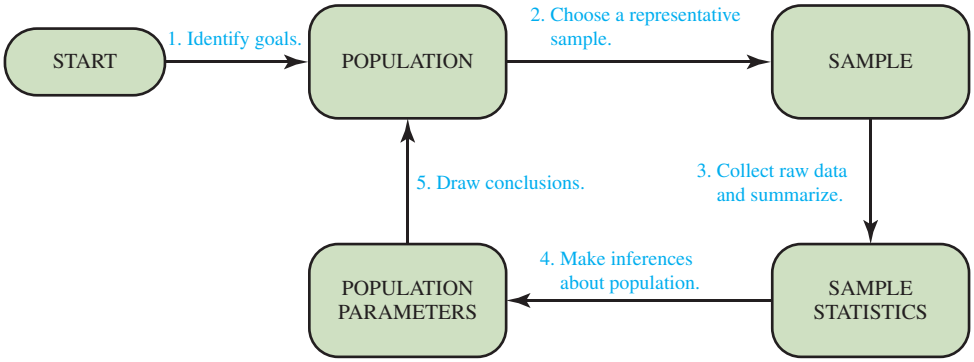

Figure 1.1 The process of a statistical study.

EXAMPLE 4 Identifying the Steps

Identify how researchers applied the five basic steps in the survey from Example 3.

SOLUTION The steps apply as follows.

1. The researchers had the goal of learning what Americans think about the causes of recent political scandals. They chose adult Americans as the population, deliberately leaving out children.
2. They chose 1002 adult Americans for their sample. Although we are not told how the sample was drawn, we will assume that it was drawn so that the 1002 adult Americans were typical of the entire adult American population.
3. They collected the raw data by asking a simple question of the people in the sample. The raw data are the individual responses to the question. They summarized these data with sample statistics, such as the overall percentages of people in the sample who chose each answer.
4. Techniques of statistical science allowed the researchers to infer population characteristics. In this case, the inference consisted of estimating the relevant population parameter and calculating the margin of error.
5. By making sure that the study was conducted properly and interpreting the estimates of the population parameters, the researchers drew overall conclusions about Americans' attitudes concerning recent political scandals.

Statistics: Decisions for an Uncertain World

Most of the examples we've discussed so far involve surveys or polls, but the subject of statistics encompasses much more, including experiments designed to test new medical treatments, analyses of the dangers of global warming, and assessments of the value of a college education. Indeed, it is fair to say that the primary purpose of statistics is to help us make good decisions whenever we are confronted with a variety of possible options.

The Purpose of Statistics

Statistics has many uses, but perhaps its most important purpose is to help us make good decisions about issues that involve uncertainty.

This purpose will be clear in most of the case studies and examples we consider in this text, but occasionally we'll have to discuss a bit of theory that may seem somewhat abstract at first. If you keep the overall purpose of statistics in mind, you'll be rewarded in the end when you see how the theory helps us understand our world. The following case study will give you a taste of what lies ahead. It involves several important theoretical ideas that led to one of the 20th century's greatest accomplishments in public health.

CASE STUDY The Salk Polio Vaccine

If you had been a parent in the 1940s or 1950s, one of your greatest fears would have been the disease known as polio. Each year during this long polio epidemic, thousands of young children were paralyzed by the disease. In 1954, a large experiment was conducted to test the effectiveness of a new vaccine created by Dr. Jonas Salk (1914–1995). The experiment involved a sample of 400,000 children chosen from the population of all children in the United States. Half of these 400,000 children received an injection of the Salk vaccine. The other half received an injection that contained only salt water. (The salt water injection was a *placebo*; see Section 1.3.) Among the children receiving the Salk vaccine, only 33 contracted polio. In contrast, there were 115 cases of polio among the children who did not get the Salk vaccine. Using techniques of statistical science that we'll study later, the researchers concluded that the vaccine was effective at preventing polio. They therefore decided to launch a major effort to improve the Salk vaccine and distribute it to the population of *all* children. Thanks to this vaccine (and improved ones developed later), the horror of polio is now largely a memory of the past. □

By the Way

Polio quickly became rare in the United States after the development of the Salk vaccine, but it remained common in less-developed countries. A global effort to vaccinate children against polio began in 1998 and has achieved great success, though it has not yet reached its goal of completely eradicating the disease.

The greatest reward for doing is the opportunity to do more.

—Jonas Salk

Section 1.1 Exercises

Statistical Literacy and Critical Thinking

1. **Dual Meaning**. State the two different meanings of the term *statistics*.
2. **Basic Definitions**. Define the terms *population*, *population parameter*, *sample*, *raw data*, and *sample statistic* as they apply to statistical studies.
3. **Confidence Interval**. What is a *margin of error*, and how is it used to establish a *confidence interval*? What is the confidence interval used for?
4. **Statistical Process**. Describe the five basic steps in a statistical study, and give an example of their application.

Does It Make Sense? ***For Exercises 5–10, determine whether the statement makes sense (or is clearly true) or does not make sense (or is clearly false). Explain your choice clearly; not all of these have definitive answers, so your explanation is more important than your chosen answer.***

5. **Statistics and Parameters.** After randomly selecting 1009 adults and surveying each of them, a pollster was able to

determine that precisely 54% of all American adults are not comfortable having drones make deliveries to them.

6. **Good Survey, Bad Result.** A poll conducted two months before a presidential election predicted that the Republican candidate would win with 55% of the vote; the survey had a margin of error of 3 percentage points. The Republican candidate lost the election.

7. **Improving Survey Results.** A pollster plans to improve survey results by only conducting polls in which the margin of error is zero.

8. **Confidence Interval.** The 95% confidence interval for a poll suggested that support for Governor Garcia is between 55% and 60%. Therefore, we can be certain that a majority of the population supports the governor.

9. **Sample of Males.** One study of heart disease involved treating male physicians with daily doses of aspirin. Because the study concluded that aspirin helps males avoid heart disease, it follows that females can also avoid heart disease by taking aspirin.

10. **New Product.** The producer of a new song surveys 1000 consumers and finds that most of them are very enthusiastic about it, so she convinces the Sony recording company to promote the song.

Concepts and Applications

Population, Sample, Statistic, and Parameter. ***Exercises 11–14 each describe a statistical study. In each case, identify the sample, the population, the sample statistic, and the population parameter.***

11. **Smoking Poll.** In a Gallup poll of 1018 adults, it was found that 22% smoked cigarettes in the past week.

12. **Birth Weights.** For 186 randomly selected babies, the average (mean) of their birth weights is 3103 grams (based on data from "Cognitive Outcomes of Preschool Children with Prenatal Cocaine Exposure," by Singer et al., *Journal of the American Medical Association,* Vol. 291, No. 20).

13. **Garlic and Cholesterol.** In a test of the effectiveness of garlic for lowering cholesterol, 47 adult subjects were treated with Garlicin, which is garlic in a processed tablet form. Cholesterol levels were measured before and after the treatment. The changes in the subjects' levels of LDL cholesterol (in mg/dL) had an average (mean) of 3.2 (based on data from "Effect of Raw Garlic vs Commercial Garlic Supplements on Plasma Lipid Concentrations in Adults With Moderate Hypercholesterolemia," by Gardner et al., *Archives of Internal Medicine*, Vol. 167).

14. **Job Interview Mistakes.** In an Accountemps survey of 150 senior executives, 47% said that the most common job interview mistake is to have little or no knowledge of the company where the applicant is being interviewed.

Identifying the Confidence Interval. ***In Exercises 15–20, use the given statistics and margin of error to identify the range of values (confidence interval) likely to contain the true value of the population parameter.***

15. **Global Warming.** In a Pew Research Center poll of 1501 randomly selected adults in Latin America, 77% said that global warming is already harming people around the world. The margin of error is 2 percentage points.

16. **Wash Up.** *USA Today* reported that among 6028 adults *observed* in restrooms, 85% washed their hands. The margin of error is 1 percentage point.

17. **Claim to Wash Up.** In a Harris Interactive survey of 1006 adults, 96% *say* that they wash their hands when in a public restroom. The margin of error is 3 percentage points.

18. **Body Temperatures.** 106 adults are randomly selected and tested for their body temperatures. Based on that sample, it is estimated that the average (mean) body temperature is 98.2°F with a margin of error of 0.1°F.

19. **Gun Laws.** In a CBS News/New York Times poll of 1289 adults nationwide, asking whether they favor or oppose teachers and school officials carrying guns in school, 57% were opposed. The margin of error is 4 percentage point.

20. **Cell Phones.** A study of 420,095 Danish cell phone users found that 0.032% of them developed cancer of the brain or nervous system. The margin of error is 0.006 percentage point.

Forming Conclusions. ***For each of Exercises 21–24, use the information about the confidence interval to answer the given question.***

21. **Do People Lie about Voting?** In a survey of 1002 people, 701 (or 70%) said that they voted in the last presidential election (based on data from ICR Research Group). The margin of error for this survey was 3 percentage points. However, actual voting records show that only 61% of all eligible voters actually did vote. Does this imply that people lied when they responded in the survey? Explain.

22. **Why the Discrepancy?** In an Eagleton Institute poll, surveyed men were asked if they agreed with this statement: "Abortion is a private matter that should be left to women to decide without government intervention." Among the men who were interviewed by women, 77% agreed with the statement. Among the men who were interviewed by men, 70% agreed with the statement. Assuming that the discrepancy is significant, how might that discrepancy be explained?

23. **Feeling Tired.** A *USA Today* report stated a survey of 22,000 high school students found that 39% of them reported being tired on most school days. The margin of error is less than 0.1 percentage point. Can we safely conclude that fewer than half of all students say they are tired on most days?

24. **Mendelian Genetics.** When Mendel conducted his famous genetics experiments with peas, one sample of offspring

consisted of 580 peas, and 26% of them were yellow. The margin of error is 4 percentage points. Based on his theory of genetics, Mendel expected that 25% of the offspring peas would be yellow. Given that the percentage of offspring yellow peas is not 25%, do the results contradict Mendel's theory? Why or why not?

Interpreting Real Studies. ***For each of Exercises 25–28, do the following:***

a. ***Based on the given information, state what you think was the goal of the study. Identify a possible population and the population parameter of interest.***

b. ***Briefly describe the sample, raw data, and sample statistic for the study.***

c. ***Based on the sample statistic and the margin of error, identify the range of values (confidence interval) likely to contain the population parameter of interest.***

25. Want Boss's Job. In a *USA Today* survey, 21% of 144 respondents said that they aspired to have their boss's job. The margin of error is 7 percentage points.

26. Prescription Drugs. A study of 3005 adults aged 57 to 85 showed that 82% of them use at least one prescription drug. The margin of error is 2 percentage points (based on data from "Use of Prescription and Over-the-Counter Medications and Dietary Supplements Among Older Adults in the United States," by Qato et al., *Journal of the American Medical Association*, Vol. 300, No. 24).

27. Underpaid. In a Gallup poll of 557 randomly selected adults, 51% said that they were underpaid. The margin of error is 4 percentage points.

28. Piercings and Tattoos. A Harris Interactive survey of 514 human resources professionals showed that 46% of them say that piercings or tattoos are big grooming red flags. The margin of error for the survey was 4 percentage points.

Five Steps in a Study. ***Describe how you would apply the five basic steps in a statistical study (as listed in the box on page 6) to the issues in Exercises 29–32.***

29. Texting and Driving. You want to determine the percentage of drivers who text while they are driving.

30. Credit Scores. FICO (Fair Isaac Corporation) scores are routinely used to rate the quality of consumer credit. You want to determine the average (mean) FICO score of all adults in the United States.

31. Passenger Weight. Recognizing that overloading commercial aircraft would lead to unsafe flights, you want to determine the average (mean) weight of airline passengers.

32. Pacemaker Batteries. Because the batteries used in heart pacemakers are so critically important, you want to determine the average (mean) length of time that such batteries last before failure.

PROJECTS FOR THE INTERNET & BEYOND

33. Current Nielsen Ratings. Search for Nielsen ratings for the past week and identify the three most popular television shows. Explain the meaning of the "rating" and the "share" for each show.

34. Nielsen Methods. Nielsen Media Research frequently revises the details of its data collection methods. Visit the organization's website and read about its current strategies for rating television shows. Summarize the method in a bulleted list format.

35. Comparing Airlines. The U.S. Department of Transportation routinely publishes on-time performance, lost baggage rates, and other statistics for different airline companies. Find a recent example of such statistics. Based on what you find, is it fair to say that any particular airline stands out as better or worse than others? Explain.

36. Labor Statistics. Use the Bureau of Labor Statistics website to find monthly unemployment rates over the past 12 months. If you assume that the monthly survey has a margin of error of about 0.2 percentage point, has there been a noticeable change in the unemployment rate over the past year? Explain.

37. Statistics and Safety. Identify a study that has been done (or should be done) to improve the safety of car drivers and passengers. Briefly describe the importance of statistics to the study.

38. Pew Research Center. The Pew Research Center for the People and the Press studies public attitudes toward the press, politics, and public policy issues. Go to its website and find the latest surveys about attitudes. Select a particular recent survey; write a summary of what was surveyed, how the survey was conducted, and what was found.

IN THE NEWS

39. Statistics in the News. Identify three news stories from the past week that involve statistics in some way. In each case, write a brief statement describing the role of statistics in the story.

40. Statistics in Your Major. Write a brief description of some ways in which you think that the science of statistics can be used in your major field of study. If you have not yet selected a major, answer the question for a major that you are considering.

41. Statistics and Entertainment. The Nielsen ratings are well known for their role in gauging television viewing. Identify another way that statistics are used in the entertainment industry. Briefly describe the role of statistics in this application.

42. Statistics in Sports. Choose a sport and describe at least three different statistics commonly tracked by players of the sport. In each case, briefly describe the importance of the statistic to the sport.