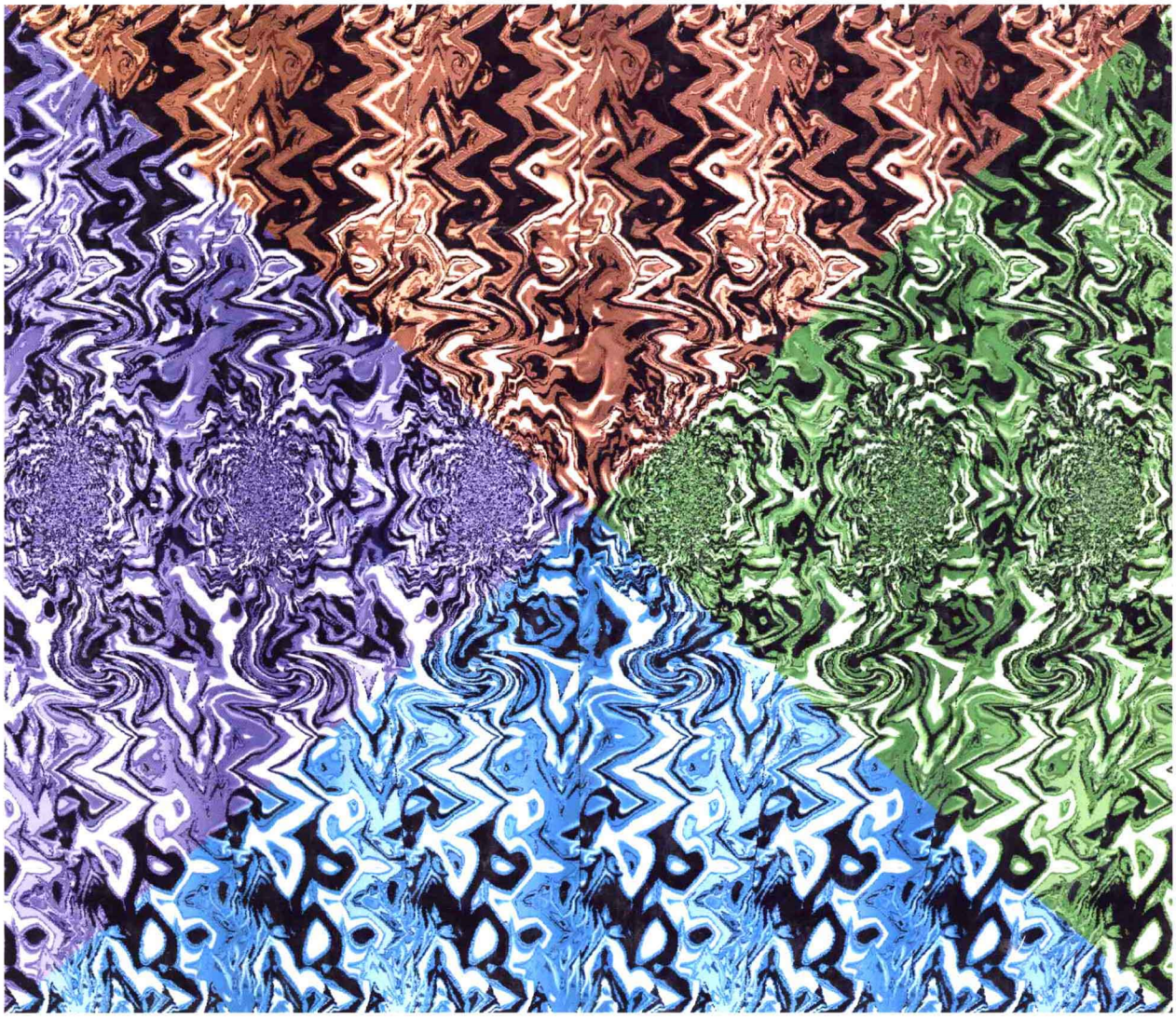

Mind on Statistics

Utts and Heckard

Mind on Statistics

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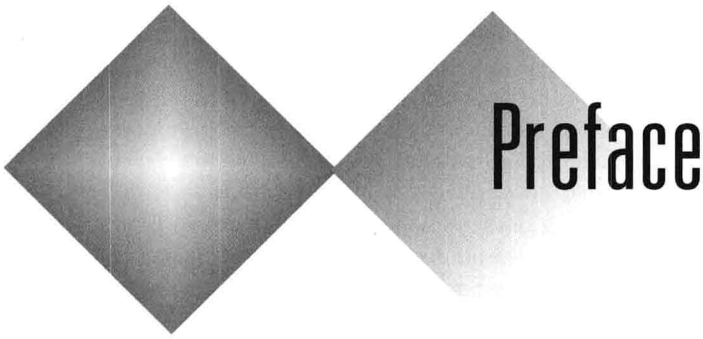
To Bill Harkness—energetic, generous, and innovative educator, guide, and friend—who launched our careers in statistics and continues to share his vision.



Preface

A CHALLENGE

Before you continue, think about how you would answer the question in the first bullet, and read the statement in the second bullet. We will return to them a little later in this Preface.

- What do you *really know* is true, and how do you know it?
- The diameter of the moon is about 2160 miles.

WHAT IS STATISTICS AND WHO SHOULD CARE?

Because people are curious about many things, chances are that your interests include topics to which the science of statistics has made a useful contribution. As written in Chapter 17, "information developed through the use of statistics has enhanced our understanding of how life works, helped us learn about each other, allowed control over some societal issues, and helped individuals make informed decisions. There is almost no area of knowledge that has not been advanced by statistical studies."

Statistical methods have contributed to our understanding of health, psychology, ecology, politics, music, lifestyle choices, and dozens of other topics. A quick look through this book, especially Chapters 1 and 17, should convince you of this. Watch for the influences of statistics in your daily life as you learn this material.

Although statistics courses are often offered through mathematics departments, statistics is not a branch of mathematics. Mathematics is to statistics as wood, hammer, and nails are to a house: a partial set of materials and tools. In addition to mathematics, statistics also draws materials and tools from philosophy, graphics, computing, psychology, and language.

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HOW IS THIS BOOK DIFFERENT? TWO BASIC PREMISES OF LEARNING

We wrote this book because we were tired of being told that what statisticians do is boring and difficult. We think statistics is useful and not difficult to learn, and yet the majority of college graduates we've met seem to have had a negative experience with a statistics class in college. We hope this book will help to overcome these misguided stereotypes.

Let's return to the two bullets at the beginning of this Preface. Without looking, do you remember the diameter of the moon? Unless you already had a pretty good idea, or have an excellent memory for numbers, you probably don't remember. One premise of this book is that **new material is much easier to learn and remember if it is related to something interesting or previously known**. The diameter of the moon is about the same as the air distance between Atlanta and Los Angeles, San Francisco and Chicago, London and Cairo, or Moscow and Madrid. Picture the moon sitting between any of those pairs of cities, and you are not likely to forget the size of the moon again. Throughout this book, new material is presented in the context of interesting and useful examples. The first and last chapters (1 and 17) are exclusively devoted to examples and case studies, which illustrate the wisdom that can be generated through statistical studies.

Now answer the question asked in the first bullet: What do you *really know* is true, and how do you know it? If you're like most people, you know because it's something you have experienced or verified for yourself. It's not likely to be something you were told or heard in a lecture. The second premise of this book is that **new material is easier to learn if you actively ask questions and answer them for yourself**. *Mind On Statistics* is designed to help you learn statistical ideas by actively thinking about them.

TOOLS FOR EXPANDED LEARNING

There are a number of tools provided in this book and beyond to enhance your learning of statistics.

Throughout most of the chapters there are boxes entitled *Turn on Your Mind*. Thinking about the questions in these boxes will help you discover and verify important ideas for yourself. We encourage you to think and question, rather than simply read and listen.

Explain in your own words what it means to say that we have 95% confidence in the interval estimate. Then give an example of something you do in your life that illustrates the same concept—you follow the same procedure each time, and it either works (most of the time) or does not work to produce the desired result. What confidence level would you assign to the procedure in your example; i.e., what percent of the time do you think it produces your desired result?

Special *Tech Note* boxes provide additional technical discussion as well as details about using MINITAB™ statistical software and Microsoft® Excel.

Additional Notes on Creating Histograms

- Consider using intervals that make the range and width of each interval convenient. For instance, to create a histogram of ages at death for First Ladies, it would be convenient to use ten-year periods—died in her 30s, died in her 40s, and so on, up to 90s. This would create seven intervals.
- To show relative frequency, you can use either the proportion or the percent that are in an interval. ◆

Case Studies present real-world stories and articles about current topics followed by further discussion, so that you can see how to apply statistical thinking to issues you might encounter while reading the newspaper or talking with friends.

CASE STUDY 10.2

Nicotine Patches versus Zyban®

Some of you may know from personal experience that quitting smoking is difficult. Many people trying to quit use nicotine replacement methods like nicotine patches or nicotine gum to ease nicotine withdrawal symptoms. Recently, medical researchers have begun investigating whether the use of an antidepressant medication might be a more effective aid to those attempting to give up cigarettes. In a study reported in the March 4, 1999 *New England Journal of Medicine*, Dr. Douglas Jorenby and colleagues compared the effectiveness of nicotine patches to the effectiveness of the antidepressant buproprion, which is marketed with the brand name Zyban.

The 893 participants were randomly allocated to four treatment groups: placebo, nicotine patch only, Zyban only, and Zyban plus nicotine patch. To keep participants blind as to their treatments, they all used a patch (nicotine or placebo) and took a pill (Zyban or placebo). For instance, in the placebo-only group, participants used both a placebo patch and took placebo pills. The Zyban group also used placebo patches, and so on. The treatments were used for nine weeks.

Table 10.4 displays, for each treatment group, an approximate 95% confidence interval for the proportion not smoking six months after the start of the experiment. Each interval is a range of estimates of the proportion that would not be smoking after six months in a population of individuals using that particular method. The results shown in the table indicate that Zyban improves the success rate.

TABLE 10.4 95% Confidence Intervals for Proportion Not Smoking after Six Months

Treatment	Subjects	Proportion Not Smoking	Approx. 95% CI
Placebo only	160	.188	.13 to .25
Nicotine patch	244	.213	.16 to .26
Zyban	244	.348	.29 to .41
Zyban and nicotine patch	245	.388	.33 to .44

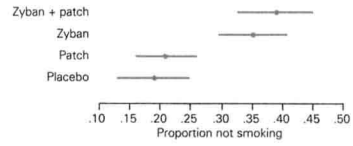


FIGURE 10.4 **95% Confidence intervals for proportion not smoking after six months**

The display in Figure 10.4 compares the 95% confidence intervals graphically, clearly showing an appropriate conclusion for this experiment.

Based on the graph, we can make the following generalizations:

- Zyban is effective. The Zyban groups had higher success rates and the confidence intervals for the two groups that used Zyban do not overlap the intervals for the two groups not using Zyban.
- The nicotine patch is not particularly effective. There is substantial overlap in the range of estimates in the intervals for the nicotine patch and placebo groups, so we can't conclude that the patch is better than the placebo. Similarly, there is substantial overlap between the intervals for the Zyban-only group and the Zyban-plus-patch group, so these two treatments do not significantly differ.

Key Terms at the end of each chapter, organized by section, function as a "quick-finder" and as a review tool.

KEY TERMS

Section 9.1
statistic, 260
parameter, 260
sampling distribution, 260

Section 9.2
sample proportion, 261
normal curve approximation rule for sample proportions, 262, 264
sampling distribution of $\hat{p}$, 264
standard deviation of $\hat{p}$, 265
standard error of $\hat{p}$, 265

Section 9.3
normal curve approximation rule for sample means, 268
sampling distribution of $\bar{x}$, 268
sampling distribution of the mean, 268
standard deviation of the mean, 268
standard error of the mean, 268
law of large numbers, 270

Section 9.4
central limit theorem, 270, 271

Section 9.6
standardized statistic, 275
standardized z-statistic, 275

Section 9.7
student's t-distribution, 276
t-distribution, 276
degrees of freedom, 276

Section 9.8
statistical inference, 278
confidence intervals, 278
hypothesis testing, 278
significance testing, 278
statistical significance, 278

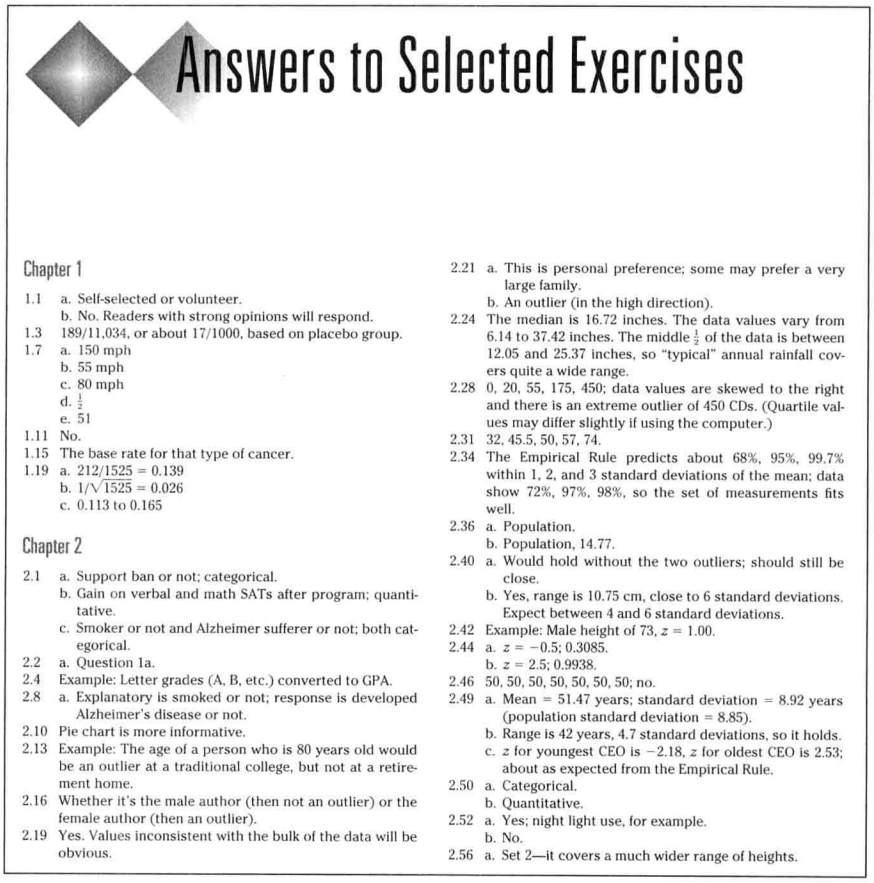
A CD provided in the back of the book includes many of the data sets used in this book, allowing you to explore ideas and play with the data.

Dataset Exercises

2.64 The data for this exercise are in the **GSS-93** dataset. The variable ***gunlaw*** is whether a respondent favors or opposes stronger gun control laws.
   a. Determine the percent of respondents who favor stronger gun control laws and the percent of respondents who oppose stronger gun control laws. (*Note:* Not all survey participants were asked the question about gun laws so the sample size for ***gunlaw*** is smaller than the overall sample size.)
   b. Draw a graphical summary of the ***gunlaw*** variable.
   c. Create a two-way table of counts that shows the relationship between gender and opinion about stronger gun control laws. From looking at this table of counts, can you judge whether the two variables are related? Briefly explain.
   d. What percent of females favors stronger gun control laws? What percent of males favors stronger gun control laws?
   e. Do you think that gender and opinion about gun control are related? Briefly explain.
   b. Create a table that displays the relationship between political party and opinion about the death penalty. Calculate an appropriate set of conditional percentages for describing the relationship.
   c. Are the variables ***polparty*** and ***cappun*** related? Explain.

2.68 Use the **cholest** dataset for this exercise. The data set contains cholesterol levels for 30 "control" patients and 28 heart attack patients at a medical facility. For the heart attack patients, cholesterol levels were measured 2 days, 4 days, and 14 days after the heart attack.
   a. Calculate the mean, the standard deviation, and the five-number summary for the control patients.
   b. Calculate the mean, the standard deviation, and the five-number summary for the heart attack patients' cholesterol levels 2 days after their attacks.
   c. Generally, which group has the higher cholesterol levels? How much difference is there in the *location* of the cholesterol levels of the two groups?
   d. Which group of measurements has a larger *spread*? Compare the groups with regard to all three measures of spread introduced in Sections 2.6 and 2.7.

Answers to Selected Exercises, provided in the back of the book, allow you to check your answers on those exercises, and guide your thinking on similar exercises.



Answers to Selected Exercises

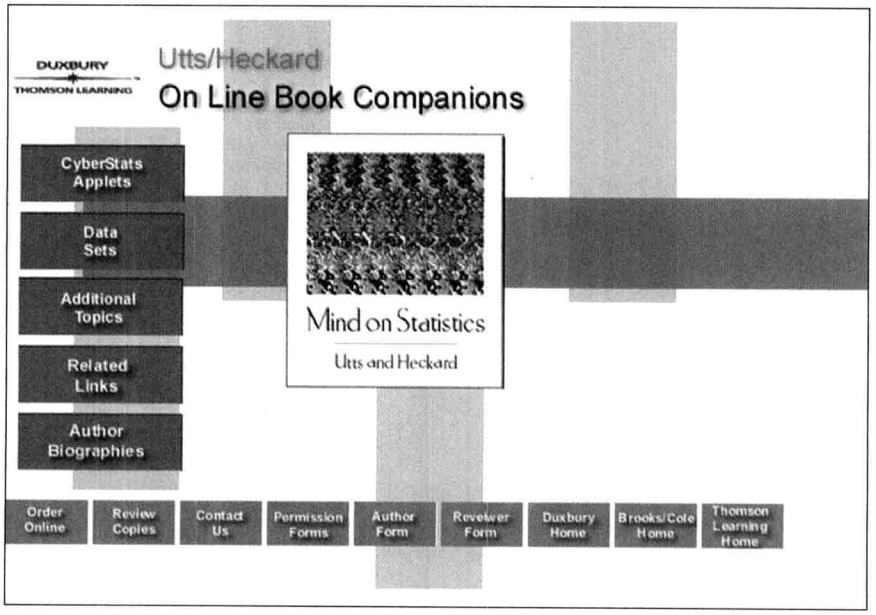
Chapter 1

1.1 a. Self-selected or volunteer.
b. No. Readers with strong opinions will respond.
1.3 189/11,034, or about 17/1000, based on placebo group.
1.7 a. 150 mph
b. 55 mph
c. 80 mph
d. $\frac{1}{2}$
e. 51
1.11 No.
1.15 The base rate for that type of cancer.
1.19 a. $212/1525 = 0.139$
b. $1/\sqrt{1525} = 0.026$
c. 0.113 to 0.165

Chapter 2

2.1 a. Support ban or not; categorical.
b. Gain on verbal and math SATs after program; quantitative.
c. Smoker or not and Alzheimer sufferer or not; both categorical.
2.2 a. Question 1a.
2.4 Example: Letter grades (A, B, etc.) converted to GPA.
2.8 a. Explanatory is smoked or not; response is developed Alzheimer's disease or not.
2.10 Pie chart is more informative.
2.13 Example: The age of a person who is 80 years old would be an outlier at a traditional college, but not at a retirement home.
2.16 Whether it's the male author (then not an outlier) or the female author (then an outlier).
2.19 Yes. Values inconsistent with the bulk of the data will be obvious.
2.21 a. This is personal preference; some may prefer a very large family.
b. An outlier (in the high direction).
2.24 The median is 16.72 inches. The data values vary from 6.14 to 37.42 inches. The middle $\frac{1}{2}$ of the data is between 12.05 and 25.37 inches, so "typical" annual rainfall covers quite a wide range.
2.28 0, 20, 55, 175, 450; data values are skewed to the right and there is an extreme outlier of 450 CDs. (Quartile values may differ slightly if using the computer.)
2.31 32, 45.5, 50, 57, 74.
2.34 The Empirical Rule predicts about 68%, 95%, 99.7% within 1, 2, and 3 standard deviations of the mean; data show 72%, 97%, 98%, so the set of measurements fits well.
2.36 a. Population.
b. Population, 14.77.
2.40 a. Would hold without the two outliers; should still be close.
b. Yes, range is 10.75 cm, close to 6 standard deviations. Expect between 4 and 6 standard deviations.
2.42 Example: Male height of 73, $z = 1.00$.
2.44 a. $z = -0.5$; 0.3085.
b. $z = 2.5$; 0.9938.
2.46 50, 50, 50, 50, 50, 50, 50; no.
2.49 a. Mean = 51.47 years; standard deviation = 8.92 years (population standard deviation = 8.85).
b. Range is 42 years, 4.7 standard deviations, so it holds.
c. z for youngest CEO is -2.18, z for oldest CEO is 2.53; about as expected from the Empirical Rule.
2.50 a. Categorical.
b. Quantitative.
2.52 a. Yes; night light use, for example.
b. No.
2.56 a. Set 2—it covers a much wider range of heights.

A website links you to useful resources and coverage of additional statistical topics, including multiple regression, computing Fisher's exact test, logistic regression, two-sample randomization tests, Kruskal-Wallis and other nonparametric methods, and the hypergeometric distribution. These resources can be found on the *Online Book Companion* site at www.duxbury.com. Instructors may contact us with suggestions for topics to be added to the website.



The *Instructor's Resource Manual* contains the complete solutions to all exercises, lecture suggestions and guidelines, additional examples, and other helpful ideas for teaching the course.

The *Student Solutions Manual* includes the complete solutions to all the end-of-book answers and offers many helpful hints and suggestions.

ACKNOWLEDGMENTS

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Jessica Utts
Robert Heckard

Contents

CHAPTER 3 Gathering Useful Data 52

CHAPTER 4 Sampling: Surveys and How To Ask Questions 80

CHAPTER 5 Relationships Between Quantitative Variables 108

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CHAPTER 6 Relationships Between Categorical Variables 144

CHAPTER 7 Probability 172

CHAPTER 8 Random Variables 216

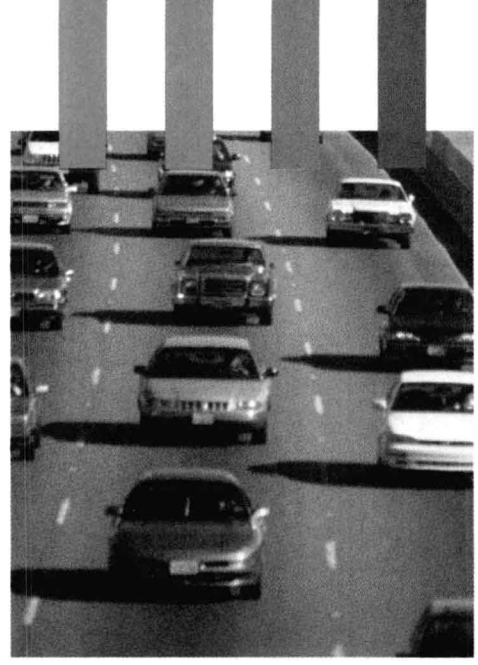
CHAPTER 14 More about Regression 424

CHAPTER 15 More about Categorical Variables 456

CHAPTER 16 Analysis of Variance 488

CHAPTER 17 Turning Information into Wisdom 518

The seven stories in this chapter are meant to bring life to the term *statistics*. When you are finished reading these stories, if you still think the subject of statistics is lifeless or gruesome, check your pulse!



Let's face it. You're a busy person. Why should you spend your time learning about a subject that sounds as dull as statistics? In this chapter we give seven examples of situations in which statistics either provided enlightenment or misinformation. With these examples, we hope to convince you that learning about this subject will be interesting and useful.

Each of the stories in this chapter illustrates one or more concepts that will be developed throughout the book. These concepts are given as "the moral of the story" after a case is presented. Definitions of some terms used in the story also are provided following each case. By the time you read all of these stories, you already will have an overview of what statistics is all about. ◆

1.1 WHAT IS STATISTICS?

When you hear the word *statistics* you probably think of lifeless or gruesome numbers, like the population of your state or the number of violent crimes committed in your city last year. The word *statistics,* however, actually is used to mean two different things. The better-known definition is that statistics are numbers measured for some purpose. A more complete definition, and the one that forms the substance of this book, is the following:

Statistics is a collection of procedures and principles for gathering data and analyzing information in order to help people make decisions when faced with uncertainty.

The stories in this chapter are meant to bring life to this definition. When you are finished reading them, if you still think the subject of statistics is lifeless or gruesome, check your pulse!

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