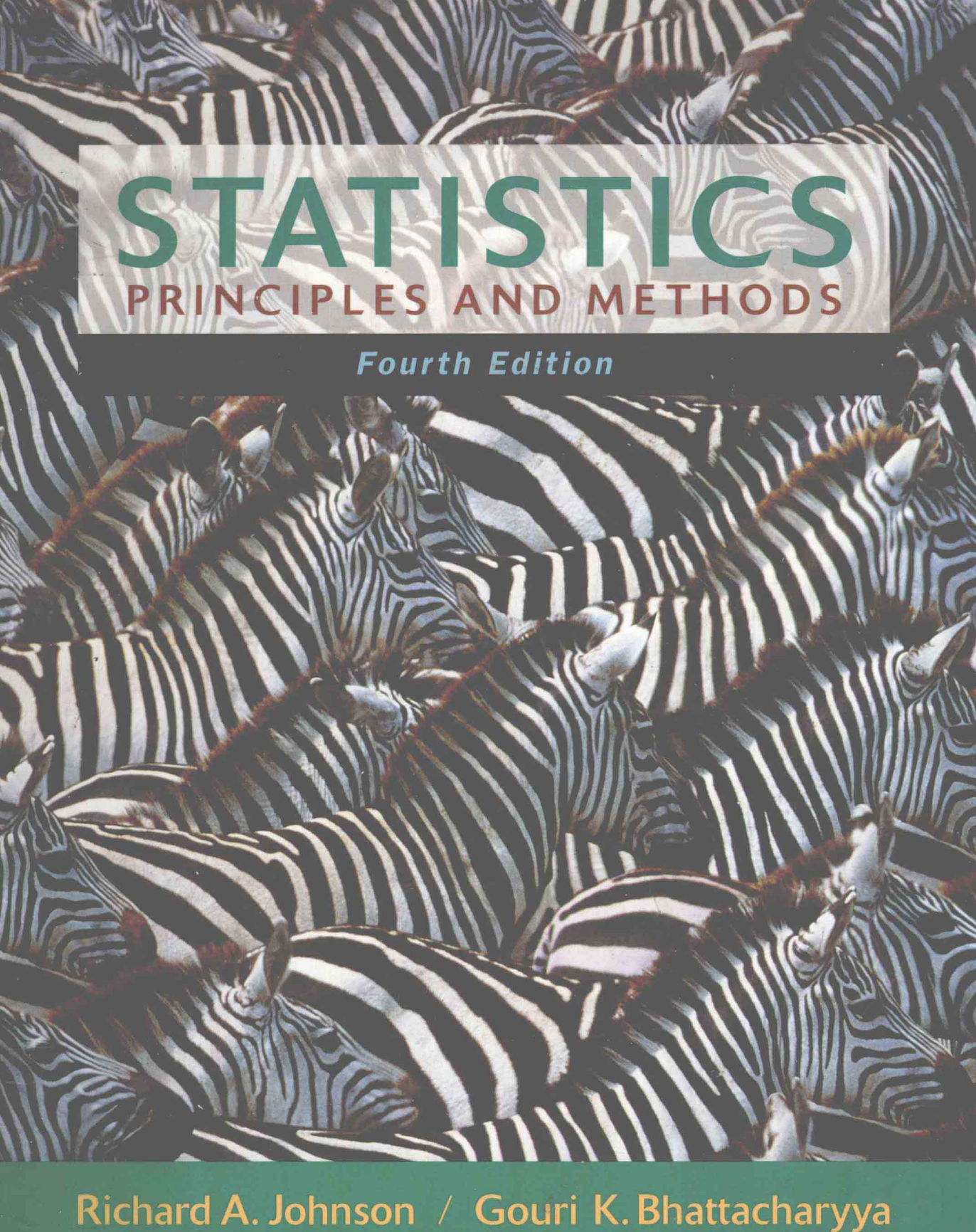
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PRINCIPLES AND METHODS
Fourth Edition
Richard A. Johnson / Gouri K. Bhattacharyya

Statistics

Principles and Methods

FOURTH EDITION

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University of Wisconsin at Madison

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Preface

THE NATURE OF THE BOOK

Statistics—the subject of data analysis and data-based reasoning—is playing an increasingly vital role in virtually all professions. Some familiarity with this subject is now an essential component of any college education. Yet, pressures to accommodate a growing list of academic requirements often necessitate that this exposure be brief. Keeping these conditions in mind, we have written this book to provide students with a first exposure to the powerful ideas of modern statistics. It presents the key statistical concepts and the most commonly applied methods of statistical analysis. Moreover, to keep it accessible to freshmen and sophomores from a wide range of disciplines, we have avoided mathematical derivations. They usually pose a stumbling block to learning the essentials in a short period of time.

This book is intended for students who do not have a strong background in mathematics but seek to learn the basic ideas of statistics and their application in a variety of practical settings. The core material of this book is common to almost all first courses in statistics and is designed to be covered well within a one-semester course in introductory statistics for freshmen–seniors. It is supplemented with some additional special-topics chapters.

ORIENTATION

The topics treated in this text are, by and large, the ones typically covered in an introductory statistics course. They span three major areas: (i) descriptive statistics, which deals with summarization and description of data; (ii) ideas of probability and an understanding of the manner in which sample-to-sample variation influences our conclusions; and (iii) a collection of statistical methods for analyzing the types of data that are of common occurrence. However, it is the treatment of these topics that makes the text distinctive. By means of good motivation, sound explanations, and an abundance of illustrations given in a real-world context, it emphasizes more than just a superficial understanding.

Each concept or technique is motivated by first setting out its goal and indicating its scope by an illustration of its application. The subsequent discussion is not only limited to showing how a method works but includes an explanation of the why. Even without recourse to mathematics, we are able to make the reader aware of possible pitfalls in the statistical analysis. Students can gain a proper appreciation of statistics only when they are provided with a careful explanation of the underlying logic. Without this understanding, a learning of elementary statistics is bound to be rote and transient.

When describing the various methods of statistical analysis, the reader is continually reminded that the validity of a statistical inference is contingent upon certain model assumptions. Misleading conclusions may result when these assumptions are violated. We feel that the teaching of statistics, even at an introductory level, should not be limited to the prescription of methods. Students should be encouraged to develop a critical attitude in applying the methods and to be cautious when interpreting the results. This attitude is especially important in the study of relationship among variables, which is perhaps the most widely used (and also abused) area of statistics. In addition to discussing inference procedures in this context, we have particularly stressed critical examination of the model assumptions and careful interpretation of the conclusions.

SPECIAL FEATURES

1. Crucial elements are boxed to highlight important concepts and methods. These boxes provide an ongoing summary of the important items essential for learning statistics. At the end of each chapter, all of its **key ideas and formulas** are summarized.
2. A rich collection of examples and exercises is included. These are drawn from a large variety of **real-life settings.** In fact, many data sets stem from genuine experiments, surveys, or reports.
3. Exercises are provided at the end of **each major section.** These provide the reader with the opportunity to practice the ideas just learned. Occasionally, they supplement some points raised in the text. A larger collection of exercises appears at the **end of a chapter.** The starred problems are relatively difficult and suited to the more mathematically competent student.
4. Statistics in Context sections, in four of the beginning chapters, each describe an important statistical application where a statistical approach to understanding variation is vital. These extended examples reveal, early on in the course, the value of understanding the subject of statistics.
5. *P*–values are emphasized in examples concerning tests of hypotheses. Graphs giving the relevant normal or t–density curve, rejection region, and *P*–value are presented.

6. **Regression analysis** is a primary statistical technique so we provide a more thorough coverage of the topic than is usual at this level. The basics of regression are introduced in Chapter 11, whereas Chapter 12 stretches the discussion to several issues of practical importance. These include methods of **model checking,** handling nonlinear relations, and multiple regression analysis. Complex formulas and calculations are judiciously replaced by computer output so the main ideas can be learned and appreciated with a minimum of stress.
7. **Computer Aided Statistical Analyses** use software packages that can remove much of the drudgery of hand calculation and plotting. They allow students to work with larger data sets where patterns are more pronounced and make complicated calculations. Besides discussion of some computer output in the text, computer exercises are included in all chapters where relevant.
8. **Convenient Electronic Data Bank** at the end of the book contains a substantial collection of data. These data sets, together with numerous others throughout the book, allow for considerable flexibility in the choice between concept-orientated and applications-orientated exercises. The Data Bank and the other larger data sets are available on floppy disk.
9. **Technical Appendix A** presents a few statistical facts of a mathematical nature. These are separated from the main text so that they can be left out if the instructor so desires.

ABOUT THIS FOURTH EDITION

The fourth edition of *STATISTICS—Principles and Methods* maintains the objectives and level of presentation of the earlier editions. The goals are the developing (i) of an understanding of the reasonings by which findings from sample data can be extended to general conclusions and (ii) a familiarity with some basic statistical methods. There are numerous data sets and computer outputs which give an appreciation of the role of the computer in modern data analysis.

Throughout, we have endeavored to give clear and concise explanations of the concepts and important statistical terminology and methods. Discussion of the statistical methods includes an explanation of their underlying assumptions and the dangers of ignoring them. Real-life settings are used to motivate the statistical ideas and well organized discussions proceed to cover statistical methods with heavy emphasis on examples. The fourth edition enhances these special features. More particularly, the major improvements are:

More Emphasis on Understanding Data. We have expanded the first chapter by including an extended discussion of population and sample with more examples to tie to student experiences. New material on using a random digit table to select a sample enables students to appreciate the importance of properly selecting a sample from a population.

New exercises are abundant. Nearly a third of the exercises are new or modified. All exercises are now numbered sequentially within a chapter. For instance, 8.73 refers to the 73rd problem in Chapter 8.

Titles are added to each example to clarify their purpose and emphasize the main point.

New figures show *P*—values and rejection regions for hypotheses testing examples that involve the normal or student's *t* distribution.

New statistics in context sections, or small case studies, give students an early exposure to the power of statistical tools. Chapter 2 contains an application of statistics in the context of quality monitoring. This example provides strong motivation for learning more about the subject of statistics.

Another section, in Chapter 7, concerns a problem a flower importer faces because of a fluctuating exchange rate. We show how to obtain a model for changes in the U.S.–Canadian exchange rate.

More Data Based Exercises. Some of the new exercises are keyed to the new data based examples given an extended discussion. The Data Bank now includes a data set on wolves and one on malt extraction which are connected to new exercises. As with all the data sets in the Data Bank, many additional techniques can be applied beyond those specifically detailed in any exercise. Overall, there are a large number of new or updated exercises.

ORGANIZATION

This book is organized into fifteen chapters, an optional technical appendix (Appendix A), and a collection of tables (Appendix B). Although designed for a one-semester or a two-quarter course, it is enriched with ample additional material to allow the instructor some choices of topics. Beyond Chapter 1, which sets the theme of statistics, and distinguishes population and sample, the subject matter could be classified as follows:

Topic	Chapter
Descriptive study of data	2, 3
Probability and distributions	4, 5, 6
Sampling variability	7
Core ideas and methods of statistical inference	8, 9, 10
Special topics of statistical inference	11, 12, 13, 14, 15

We regard Chapters 1 to 10 as constituting the core material of an introductory statistics course, with the exception of the starred sections in Chapter 6.

Although this material is just about enough for a one-semester course, many instructors may wish to eliminate some sections in order to cover the basics of regression analysis in Chapter 11. This is most conveniently done by initially skipping Chapter 3 and then taking up only those portions that are linked to Chapter 11. Also, instead of a thorough coverage of probability that is provided in Chapter 4, the later sections of that chapter may receive a lighter coverage.

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