

PREFACE

Statistics for the Life Sciences is an introductory text in statistics, specifically addressed to students specializing in the life sciences. Its primary aims are (1) to show students how statistical reasoning is used in biological, medical, and agricultural research; (2) to enable students confidently to carry out simple statistical analyses and to interpret the results; and (3) to raise students' awareness of basic statistical issues such as randomization, confounding, and the role of independent replication.

Style and Approach

The style of *Statistics for the Life Sciences* is informal and uses only minimal mathematical notation. There are no prerequisites except elementary algebra; anyone who can read a biology or chemistry textbook can read this text. It is suitable for use by graduate or undergraduate students in biology, agronomy, medical and health sciences, nutrition, pharmacy, animal science, physical education, forestry, and other life sciences.

Use of Real Data Real examples are more interesting and often more enlightening than artificial ones. *Statistics for the Life Sciences* includes hundreds of examples and exercises that use real data, representing a wide variety of research in the life sciences. Each example has been chosen to illustrate a particular statistical issue. The exercises have been designed to reduce computational effort and focus students' attention on concepts and interpretations.

Emphasis on Ideas The text emphasizes statistical ideas rather than computations or mathematical formulations. Probability theory is included only to support statistics concepts. Throughout the discussion of descriptive and inferential statistics, interpretation is stressed. By means of salient examples, the student is shown why it is important that an analysis be appropriate for the research question to be answered, for the statistical design of the study, and for the nature of the underlying distributions. The student is warned against the common blunder of confusing statistical nonsignificance with practical insignificance and is encouraged to use confidence intervals to assess the magnitude of an effect. The student is led to recognize the impact on real research of design concepts such as random sampling, randomization, efficiency, and the control of extraneous variation by blocking or adjustment. Numerous exercises amplify and reinforce the student's grasp of these ideas.

The Role of Technology The analysis of research data is usually carried out with the aid of a computer. Computer-generated graphs are shown at several places in the text. However, in studying statistics it is desirable for the student to gain experience working directly with data, using paper and pencil and a hand-held calculator, as well as a computer. This experience will help the student appreciate the nature and purpose of the statistical computations. The student is thus prepared to make intelligent use of the computer—to give it appropriate instructions and properly interpret the output. Accordingly, most of the exercises

in this text are intended for hand calculation. However, electronic data files are provided for many of the exercises, so that a computer can be used if desired. Selected exercises are identified as being intended to be completed with use of a computer. (Typically, the computer exercises require calculations that would be unduly burdensome if carried out by hand.)

Organization

This text is organized to permit coverage in one semester of the maximum number of important statistical ideas, including power, multiple inference, and the basic principles of design. By including or excluding optional sections, the instructor can also use the text for a one-quarter course or a two-quarter course. It is suitable for a terminal course or for the first course of a sequence.

The following is a brief outline of the text.

Chapter 1: Introduction. The nature and impact of variability in biological data. The hazards of observational studies, in contrast with experiments. Random sampling.

Chapter 2: Description of distributions. Frequency distributions, descriptive statistics, the concept of population versus sample.

Chapters 3, 4, and 5: Theoretical preparation. Probability, binomial and normal distributions, sampling distributions.

Chapter 6: Confidence intervals for a single mean and for a difference in means.

Chapter 7: Hypothesis testing, with emphasis on the t test. The randomization test, the Wilcoxon-Mann-Whitney test.

Chapter 8: Inference for paired samples. Confidence interval, t test, sign test, and Wilcoxon signed-rank test.

Chapter 9: Inference for a single proportion. Confidence intervals and the chi-square goodness-of-fit test.

Chapter 10: Relationships in categorical data. Conditional probability, contingency tables. Optional sections cover Fisher's exact test, McNemar's test, and odds ratios.

Chapter 11: Analysis of variance. One-way layout, multiple comparison procedures, one-way blocked ANOVA, two-way ANOVA. Contrasts and multiple comparisons are included in optional sections.

Chapter 12: Correlation and regression. Descriptive and inferential aspects of correlation and simple linear regression and the relationship between them.

Chapter 13: A summary of inference methods.

Statistical tables are provided at the back of the book. The tables of critical values are especially easy to use, because they follow mutually consistent layouts and so are used in essentially the same way.

Optional appendices at the back of the book give the interested student a deeper look into such matters as how the Wilcoxon-Mann-Whitney null distribution is calculated.

Changes to the Fourth Edition

- Some of the material that was in Chapter 8, on statistical principles of design, is now found in Chapter 1. Other parts of old Chapter 8 are now found sprinkled throughout the book, in the hope that students will come to appreciate that all statistical studies involve issues of data collection and scope of inference (much as appropriate graphics are not to be studied and used in isolation but are a central part of statistical analysis and thus appear throughout the book).
- Several other chapters have been reorganized. Changes include the following:
 - Inference for a single proportion has been moved from Chapter 6 to new Chapter 9.
 - The confidence interval for a difference in means has been moved from Chapter 7 to Chapter 6.
 - A new chapter (9) presents inference procedures for a categorical variable observed on a single sample.
 - Chapter 11 provides deeper treatment of two-way ANOVA and of multiple comparison procedures in analysis of variance.
 - Chapter 12 now begins with correlation and then moves to regression, rather than the other way around.
- 25% of the problems in the book are new or revised. As before, the majority are based on real data and draw from a variety of subjects of interest to life science majors. Selected data sets that are used in the problems and exercises are available online.
- The tables used for the sign test, signed-rank test, and Wilcoxon-Mann-Whitney test have been reorganized.

Instructor Supplements

Online Instructor's Solutions Manual

Solutions to all exercises are provided in this manual. Careful attention has been paid to ensure that all methods of solution and notation are consistent with those used in the core text. Available for download from Pearson Education's online catalog at www.pearsonhighered.com/irc.

PowerPoint Slides

Selected figures and tables from throughout the textbook are available on PowerPoint slides for use in creating custom PowerPoint Lecture presentations. These slides are available for download at www.pearsonhighered.com/irc.

Student Supplements

Student's Solutions Manual (ISBN-13: 978-0-321-69307-5;
ISBN-10: 0-321-69307-8)

Fully worked out solutions to selected exercises are provided in this manual. Careful attention has been paid to ensure that all methods of solution and notation are consistent with those used in the core text.

Technology Supplements and Packaging Options

Data Sets

The larger data sets used in problems and exercises in the book are available as .csv files on the Pearson Statistics Resources and Data Sets website:

www.pearsonhighered.com/datasets

StatCrunch™ eText (ISBN-13: 978-0-321-73050-3; ISBN-10: 0-321-73050-X)

This interactive, online textbook includes StatCrunch, a powerful, web-based statistical software. Embedded StatCrunch buttons allow users to open all data sets and tables from the book with the click of a button and immediately perform an analysis using StatCrunch.

The Student Edition of Minitab (ISBN-13: 978-0-321-11313-9; ISBN-10: 0-321-11313-6)

The Student Edition of Minitab is a condensed edition of the professional release of Minitab statistical software. It offers the full range of statistical methods and graphical capabilities, along with worksheets that can include up to 10,000 data points. Individual copies of the software can be bundled with the text.

JMP Student Edition (ISBN-13: 978-0-321-67212-4; ISBN-10: 0-321-67212-7)

JMP Student Edition is an easy-to-use, streamlined version of JMP desktop statistical discovery software from SAS Institute, Inc., and is available for bundling with the text.

SPSS, an IBM Company[†] (ISBN-13: 978-0-321-67537-8; ISBN-10: 0-321-67537-1)

SPSS, a statistical and data management software package, is also available for bundling with the text.

StatCrunch™

StatCrunch™ is web-based statistical software that allows users to perform complex analyses, share data sets, and generate compelling reports of their data. Users can upload their own data to StatCrunch, or search the library of over twelve thousand publicly shared data sets, covering almost any topic of interest. Interactive graphical outputs help users understand statistical concepts, and are available for export to enrich reports with visual representations of data. Additional features include:

- A full range of numerical and graphical methods that allow users to analyze and gain insights from any data set.
- Reporting options that help users create a wide variety of visually-appealing representations of their data.

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

- An online survey tool that allows users to quickly build and administer surveys via a web form.

StatCrunch is available to qualified adopters. For more information, visit our website at www.statcrunch.com, or contact your Pearson representative.

Study Cards are also available for various technologies, including Minitab, SPSS, JMP, StatCrunch, R, Excel and the TI Graphing Calculator.

Acknowledgments for the Fourth Edition

The fourth edition of *Statistics for the Life Science* retains the style and spirit of the writing of Myra Samuels. Prior to her tragic death from cancer, Myra wrote the first edition of the text, based on her experience both as a teacher of statistics and as a statistical consultant. Without her vision and efforts there never would have been a first edition, let alone a fourth.

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JAW

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AAS