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research methods for the  
**BIOSCIENCES**

*Debbie Holmes, Peter Moody,  
and Diana Dine*



SECOND EDITION

*'I think this is an excellent book and I started recommending it immediately after I received a copy. I flag it up to students in all years including Masters.'*

Dr Michael Winson, Aberystwyth University

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Scientific research is the ultimate tool in pushing forward the limit of our understanding. But, as with any tool, research is only powerful if used properly and to its full effect.

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- DECISION WEB** An electronic version of the Decision web from the book, which you can use when planning your research.
- INTERACTIVE EXERCISES** For you to work through to test your understanding of the topics in the book.
- SPSS, MINITAB & EXCEL** Interactive and printable risk assessment form with notes.
- SPSS, MINITAB & EXCEL** Interactive and printable decision web to aid in designing your experiment.

**Lecturer resources**

- TEST QUESTIONS AND ANSWERS** A bank of test questions and answers.
- FIGURES** Figures from the book available to download.

#### For students:

- Statistical software walkthroughs for SPSS, Excel, and Minitab
- Complete details of calculations given in boxes
- Interactive and printable decision web, to aid in designing your experiment
- Interactive and printable risk assessment form
- Integrative exercises based on published and unpublished student work
- Weblinks
- Hyperlinked glossary

#### For lecturers:

- A bank of test questions and answers
- Figures from the book available to download

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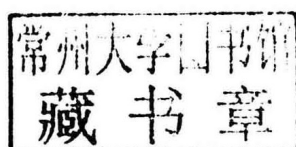
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## Research Methods for the Biosciences

# Preface

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## **Getting the most out of this book**

We write this section with some uncertainty since we rarely read a preface in a book and wonder if anyone is going to read what we've written here. Nonetheless, there are several important things we need to explain to you to enable you to get the best out of this book and its Online Resource Centre, so we'd encourage you to take a few moments to read on.

## **Who should read this book?**

This book is primarily written for undergraduates who wish to develop their understanding of designing, carrying out, and reporting research. We anticipate that graduates, although familiar with most of this material, will find this book and its Online Resource Centre to be a useful reference too. We have therefore used examples almost entirely drawn from real undergraduate and some graduate research projects. We are indebted to all our students who have allowed us to use their ideas and data in this book.

## **Content**

The content is designed to take you through all the steps you need to follow when choosing, planning, evaluating and reporting undergraduate research. The content is therefore laid out in a number of sections:

How to choose a suitable topic for undergraduate research (Appendix a)

Section 1: Planning an experiment (Chapters 1 – 4)

Section 2: Handling your data (Chapters 5 – 10)

Section 3: Reporting your results (Chapter 11).

In addition, in the appendices, we have included an explanation of the mathematical processes used in the chapters (Appendix e), a decision web to help you plan your research (Appendix b), and a summary of the information you need to choose the correct statistical test to test hypotheses (Appendix c).

There is a close and essential link between planning research and understanding how statistics fit into this process. We have demonstrated these links

in Section 1 by cross references to content in Section 2. In Section 2 we have included an overview at the end of each chapter on statistics explaining how this relates to experimental design.

## Getting started

You may be coming to this book with very little in the way of training in maths. If you do not know how to calculate this sum  $(4\ 3)^2/2$ , or if you do not recognize the symbols  $<$  or  $>$ , then we suggest you first look at Appendix e and the additional examples on the Online Resource Centre.

You may wish to analyse data you have gathered from an experiment carried out in your course. For this we suggest you start with Appendix c, which will then direct you to the correct sections in Chapters 5 to 10.

You may wish to prepare a critique of published research. The chapter that considers this is Chapter 2, with cross-referencing to earlier and some later chapters.

If you wish to design a research project and you are familiar with terms such as variable, parametric, aim, hypothesis, etc., then go to Appendix a and Chapter 2. If you are not familiar with these terms still refer to Appendix a, and then continue from Chapter 1.

## Learning features

### Sign posts

There are a number of ways we have tried to help you quickly find the information you need. We have included chapter ('In a nutshell') and section ('Key points') summaries. At the top of each chapter in Section 2 we have included both an introduction and a guide to choosing the correct statistical test for that chapter. All these chapter specific guides are integrated in Appendix c.

#### 7.1 Chi-squared goodness-of-fit test

**Key points** In some experiments, you may have a reason for expecting your data to be explained by an equation or particular ratio. You may analyse data to examine whether your data fit this *a priori* expectation. If your data are counts or frequencies, one of the most common statistical tests used to test this type of hypothesis is the chi-squared goodness-of-fit test.

There are three types of investigations where you may use a goodness-of-fit test:

- 1) You can reasonably argue that all samples should have the same

### Key terms

We know that most people will dip in to this book and so we have included a glossary of most terms that you need to be familiar with towards the end. Key terms are shown in coloured type the first time they appear; definitions of these key terms then appear in the glossary at the end of the book.

### Boxes

In our experience we have found that students best understand the statistics element of this book if they first use a calculator to work out the calculation.



BOX 7.6 How to calculate a 2 x 2 chi-squared test for association	
GENERAL DETAILS	EXAMPLE 7.5
1. Hypotheses to be tested $H_0$ : There is no association between the two variables. $H_1$ : There is an association between the two variables.	1. Hypotheses to be tested $H_0$ : There is no association between the two variables (Cepaea nemoralis habitat (hedgerow and woodland)). $H_1$ : There is an association between the two variables (C. nemoralis and (hedgerow and woodland)).
2. Have all the criteria for using this test been met?	2. Have all the criteria for using this test been met? Yes (see answer to Q4).
3. How to work out expected values In chi-squared tests for association, you have no a priori expectation against which to compare your observed data. Instead, the expected values are calculated from the observed data.	3. How to work out expected values Look first at the expected values in Table 7.12. To calculate the column total for the hedgerow habitat (1473), multiply the row total for the hedgerow habitat (1473) by the column total for the woodland habitat (1473) and divide the result by the total number of observations (1473).

Therefore we have arranged the statistical information in boxes with general details and a worked example for you to follow.

In the calculations we've included in this book we have rounded all values, usually to five decimal places. However, we carried out all the calculations using all decimal places (as you should). This means that some of our sums do not appear to quite add up. Any minor differences in the calculations should be the result of this rounding of values.

In the boxes some the mathematical steps have not been included. We have therefore included the full calculations in the Online Resource Centre. We have also included an explanation of how to use SPSS, Excel, and Minitab to carry out the same calculations in the Online Resource Centre.

be an integral part of the investigation and must be carried out at the same time as the rest of the investigation.

**Q2** In the experiment described in Example 2.2 on the antibacterial properties of triclosan and tea-tree oil, are any controls needed? If so what?

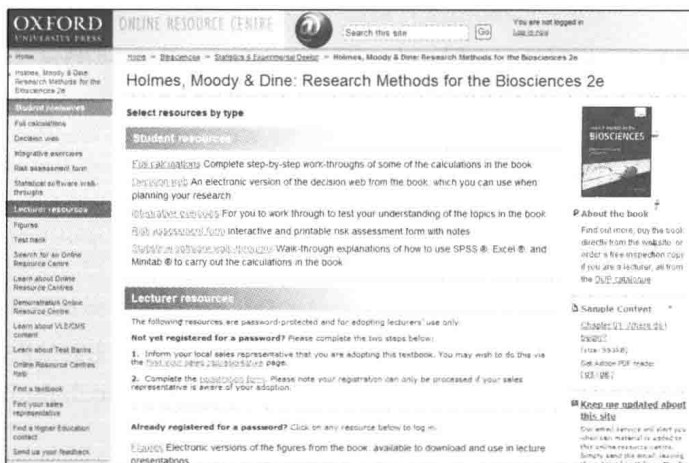
A control may not always be necessary. For example, in an investigation into the effect of temperature on the behaviour of *Oniscus asellus*

## Questions

To help you check your understanding of the topics covered by this book we have included a number of questions. The answers are provided at the end of each chapter. More questions are included in the Online Resource Centre.

## Online Resource Centre

*Research Methods for the Biosciences* is more than just this printed book. The *Research Methods for the Biosciences* Online Resource Centre features extensive online materials to help you really get to grips with the skills you need to carry out research work. This can be found at: [www.oxfordtextbooks.co.uk/orc/holmes2e/](http://www.oxfordtextbooks.co.uk/orc/holmes2e/)



The student area of the Online Resource Centre includes:

- full details of all calculations in this book: every step in each calculation is shown so you can see exactly how we reach the answers shown in the book
- walk-through explanations of how to use SPSS, Excel, and Minitab to carry out these calculations
- interactive tasks for you to work through to test your understanding of the topics in this book, and hone your research methods skills.
- an electronic version of the decision web which you can use when planning your research
- an electronic risk assessment which may be used to help you complete this process

You'll see the Online Resource Centre icon throughout the book. This icon tells you that the part of the text you are reading has online materials to accompany it.



The lecturer area of the Online Resource Centre provides additional materials to make the book easier to teach from. These materials include:

- figures from the book, available to download for use in lecture slides
- test bank of questions

Simply go to [www.oxfordtextbooks.co.uk/orc/holmes2e/](http://www.oxfordtextbooks.co.uk/orc/holmes2e/) and register as a user of the book to gain free access to these materials.

## And finally ...

Just in case OUP ask us to produce a third edition, we would like to hear about any errors (we hope there are none) and any suggestions you have for improvements. You can contact us by using the 'Send us your feedback' option in the Online Resource Centre.

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# Detailed Contents

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