CONTENTS

CHAPTER 1: INTRODUCING R: WHAT IT IS AND HOW TO GET IT	1
Getting the Hang of R	2
The R Website	3
Downloading and Installing R from CRAN	3
Installing R on Your Windows Computer	4
Installing R on Your Macintosh Computer	7
Installing R on Your Linux Computer	7
Running the R Program	8
Finding Your Way with R	10
Getting Help via the CRAN Website and the Internet	10
The Help Command in R	10
Help for Windows Users	11
Help for Macintosh Users	11
Help for Linux Users	13
Help For All Users	13
Anatomy of a Help Item in R	14
Command Packages	16
Standard Command Packages	16
What Extra Packages Can Do for You	16
How to Get Extra Packages of R Commands	18
How to Install Extra Packages for Windows Users	18
How to Install Extra Packages for Macintosh Users	18
How to Install Extra Packages for Linux Users	19
Running and Manipulating Packages	20
Loading Packages	21
Windows-Specific Package Commands	21
Macintosh-Specific Package Commands	21
Removing or Unloading Packages	22
Summary	22
CHAPTER 2: STARTING OUT: BECOMING FAMILIAR WITH R	25
Some Simple Math	26
Use R Like a Calculator	26
Storing the Results of Calculations	29

Reading and Getting Data into R	30
Using the combine Command for Making Data	30
Entering Numerical Items as Data	30
Entering Text Items as Data	31
Using the scan Command for Making Data	32
Entering Text as Data	33
Using the Clipboard to Make Data	33
Reading a File of Data from a Disk	35
Reading Bigger Data Files	37
The read.csv() Command	37
Alternative Commands for Reading Data in R	39
Missing Values in Data Files	40
Viewing Named Objects	41
Viewing Previously Loaded Named-Objects	42
Viewing All Objects	42
Viewing Only Matching Names	42
Removing Objects from R	44
Types of Data Items	45
Number Data	45
Text Items	45
Converting Between Number and Text Data	46
The Structure of Data Items	47
Vector Items	48
Data Frames	48
Matrix Objects	49
List Objects	49
Examining Data Structure	49
Working with History Commands	51
Using History Files	52
Viewing the Previous Command History	52
Saving and Recalling Lists of Commands	52
Alternative History Commands in Macintosh OS	52
Editing History Files	53
Saving Your Work in R	54
Saving the Workspace on Exit	54
Saving Data Files to Disk	54
Save Named Objects	54
Save Everything	55
Reading Data Files from Disk	56
Saving Data to Disk as Text Files	57
Writing Vector Objects to Disk	58
Writing Matrix and Data Frame Objects to Disk	58

Writing List Objects to Disk Converting List Objects to Data Frames Summary	59 60 61
CHAPTER 3: STARTING OUT: WORKING WITH OBJECTS	65
Manipulating Objects	65
Manipulating Vectors	66
Selecting and Displaying Parts of a Vector	66
Sorting and Rearranging a Vector	68
Returning Logical Values from a Vector	70
Manipulating Matrix and Data Frames	70
Selecting and Displaying Parts of a Matrix or Data Frame	71
Sorting and Rearranging a Matrix or Data Frame	74
Manipulating Lists	76
Viewing Objects within Objects	77
Looking Inside Complicated Data Objects	77
Opening Complicated Data Objects	78
Quick Looks at Complicated Data Objects	80
Viewing and Setting Names	82
Rotating Data Tables	86
Constructing Data Objects	86
Making Lists	87
Making Data Frames	88
Making Matrix Objects	89
Re-ordering Data Frames and Matrix Objects	92
Forms of Data Objects: Testing and Converting	96
Testing to See What Type of Object You Have	96
Converting from One Object Form to Another	97
Convert a Matrix to a Data Frame	97
Convert a Data Frame into a Matrix	98
Convert a Data Frame into a List	99
Convert a Matrix into a List	100
Convert a List to Something Else	100
Summary	104
CHAPTER 4: DATA: DESCRIPTIVE STATISTICS AND TABULATION	107
Summary Commands	108
Summarizing Samples	110
Summary Statistics for Vectors	110
Summary Commands With Single Value Results	110
Summary Commands With Multiple Results	113

Cumulative Statistics	115
Simple Cumulative Commands	115
Complex Cumulative Commands	117
Summary Statistics for Data Frames	118
Generic Summary Commands for Data Frames	119
Special Row and Column Summary Commands	119
The apply() Command for Summaries on Rows or Columns	120
Summary Statistics for Matrix Objects	120
Summary Statistics for Lists	121
Summary Tables	122
Making Contingency Tables	123
Creating Contingency Tables from Vectors	123
Creating Contingency Tables from Complicated Data	123
Creating Custom Contingency Tables	126
Creating Contingency Tables from Matrix Objects	128
Selecting Parts of a Table Object	130
Converting an Object into a Table	132
Testing for Table Objects	133
Complex (Flat) Tables	134
Making "Flat" Contingency Tables	134
Making Selective "Flat" Contingency Tables	138
Testing "Flat" Table Objects	139
Summary Commands for Tables	139
Cross Tabulation	142
Testing Cross-Table (xtabs) Objects	144
A Better Class Test	144
Recreating Original Data from a Contingency Table	145
Switching Class	146
Summary	147
CHAPTER 5: DATA: DISTRIBUTION	151
CHAI TER 3. DATA. DISTRIBUTION	
Looking at the Distribution of Data	151
Stem and Leaf Plot	152
Histograms	154
Density Function	158
Using the Density Function to Draw a Graph	159
Adding Density Lines to Existing Graphs	160
Types of Data Distribution	161
The Normal Distribution	161
Other Distributions	164
Random Number Generation and Control	166
Random Numbers and Sampling	168

The Shapiro-Wilk Test for Normality	171
The Kolmogorov-Smirnov Test	172
Quantile-Quantile Plots	174
A Basic Normal Quantile-Quantile Plot	174
Adding a Straight Line to a QQ Plot	174
Plotting the Distribution of One Sample Against Another	175
Summary	177
CHAPTER 6: SIMPLE HYPOTHESIS TESTING	181
Using the Student's t-test	181
Two-Sample t-Test with Unequal Variance	182
Two-Sample t-Test with Equal Variance	183
One-Sample t-Testing	183
Using Directional Hypotheses	183
Formula Syntax and Subsetting Samples in the t-Test	184
The Wilcoxon U-Test (Mann-Whitney)	188
Two-Sample U-Test	189
One-Sample U-Test	189
Using Directional Hypotheses	189
Formula Syntax and Subsetting Samples in the U-test	190
Paired t- and U-Tests	193
Correlation and Covariance	196
Simple Correlation	197
Covariance	199
Significance Testing in Correlation Tests	199
Formula Syntax	200
Tests for Association	203
Multiple Categories: Chi-Squared Tests	204
Monte Carlo Simulation	205
Yates' Correction for 2×2 Tables	206
Single Category: Goodness of Fit Tests	206
Summary	210
CHAPTER 7: INTRODUCTION TO GRAPHICAL ANALYSIS	215
Box-whisker Plots	215
Basic Boxplots	216
Customizing Boxplots	217
Horizontal Boxplots	218
Scatter Plots	222
Basic Scatter Plots	222
Adding Axis Labels	223

Plotting Symbols	223
Setting Axis Limits	224
Using Formula Syntax	225
Adding Lines of Best-Fit to Scatter Plots	225
Pairs Plots (Multiple Correlation Plots)	229
Line Charts	232
Line Charts Using Numeric Data	232
Line Charts Using Categorical Data	233
Pie Charts	236
Cleveland Dot Charts	239
Bar Charts	245
Single-Category Bar Charts	245
Multiple Category Bar Charts	250
Stacked Bar Charts	250
Grouped Bar Charts	250
Horizontal Bars	253
Bar Charts from Summary Data	253
Copy Graphics to Other Applications	256
Use Copy/Paste to Copy Graphs	257
Save a Graphic to Disk	257
Windows	257
Macintosh	258
Linux	258
Summary	259
CHAPTER 8: FORMULA NOTATION AND COMPLEX STATISTICS	263
Examples of Using Formula Syntax for Basic Tests	264
Formula Notation in Graphics	266
Analysis of Variance (ANOVA)	268
One-Way ANOVA	268
Stacking the Data before Running Analysis of Variance	269
Running aov() Commands	270
Simple Post-hoc Testing	271
Extracting Means from aov() Models	271
Two-Way ANOVA	273
More about Post-hoc Testing	275
Graphical Summary of ANOVA	277
Graphical Summary of Post-hoc Testing	278
Extracting Means and Summary Statistics	281
Model Tables	281
Table Commands	283

Interaction Dieta	283
Interaction Plots More Complex ANOVA Models	203 289
Other Options for aov()	290
Replications and Balance	290
Summary	292
Sammary	202
CHAPTER 9: MANIPULATING DATA AND EXTRACTING COMPONENTS	295
Creating Data for Complex Analysis	295
Data Frames	296
Matrix Objects	299
Creating and Setting Factor Data	300
Making Replicate Treatment Factors	304
Adding Rows or Columns	306
Summarizing Data	312
Simple Column and Row Summaries	312
Complex Summary Functions	313
The rowsum() Command	314
The apply() Command	315
Using tapply() to Summarize Using a Grouping Variable	316
The aggregate() Command	319
Summary	323
CHAPTER 10: REGRESSION (LINEAR MODELING)	327
Simple Linear Regression	328
Linear Model Results Objects	329
Coefficients	330
Fitted Values	330
Residuals	330
Formula	331
Best-Fit Line	331
Similarity between Im() and aov()	334
Multiple Regression	335
Formulae and Linear Models	335
Model Building	337
Adding Terms with Forward Stepwise Regression	337
Removing Terms with Backwards Deletion	339
Comparing Models	341
Curvilinear Regression	343
Logarithmic Regression	344
Polynomial Regression	345

Plotting Linear Models and Curve Fitting Best-Fit Lines Adding Line of Best-Fit with abline() Calculating Lines with fitted() Producing Smooth Curves using spline() Confidence Intervals on Fitted Lines Summarizing Regression Models Diagnostic Plots Summary of Fit Summary	347 348 348 348 350 351 356 357 359
CHAPTER 11: MORE ABOUT GRAPHS	363
Adding Elements to Existing Plots	364
Error Bars	364
Using the segments() Command for Error Bars	364
Using the arrows() Command to Add Error Bars	368
Adding Legends to Graphs	368
Color Palettes	370
Placing a Legend on an Existing Plot	371
Adding Text to Graphs	372
Making Superscript and Subscript Axis Titles	373
Orienting the Axis Labels	375
Making Extra Space in the Margin for Labels	375
Setting Text and Label Sizes	375
Adding Text to the Plot Area	376
Adding Text in the Plot Margins	378
Creating Mathematical Expressions	379
Adding Points to an Existing Graph	382
Adding Various Sorts of Lines to Graphs	386
Adding Straight Lines as Gridlines or Best-Fit Lines	386
Making Curved Lines to Add to Graphs	388
Plotting Mathematical Expressions	390
Adding Short Segments of Lines to an Existing Plot	393
Adding Arrows to an Existing Graph	394
Matrix Plots (Multiple Series on One Graph)	396
Multiple Plots in One Window	399
Splitting the Plot Window into Equal Sections	399
Splitting the Plot Window into Unequal Sections	402
Exporting Graphs	405
Using Copy and Paste to Move a Graph	406
Saving a Graph to a File	406

Windows	406
Macintosh	406
Linux	406
Using the Device Driver to Save a Graph to Disk	407
PNG Device Driver	407
PDF Device Driver	407
Copying a Graph from Screen to Disk File	408
Making a New Graph Directly to a Disk File	408
Summary	410
CHAPTER 12: WRITING YOUR OWN SCRIPTS: BEGINNING TO PROGRAM	415
BEGINNING TO PROGRAM	415
Copy and Paste Scripts	416
Make Your Own Help File as Plaintext	416
Using Annotations with the # Character	417
Creating Simple Functions	417
One-Line Functions	417
Using Default Values in Functions	418
Simple Customized Functions with Multiple Lines	419
Storing Customized Functions	420
Making Source Code	421
Displaying the Results of Customized Functions and Scripts	421
Displaying Messages as Part of Script Output	422
Simple Screen Text	422
Display a Message and Wait for User Intervention	424
Summary	428
APPENDIX: ANSWERS TO EXERCISES	433
INDEX	404
INDEX	461