

Contents

PART I • INTRODUCTION

CHAPTER 1

What Is Science?

Why Learn Science?	3
Our Definition of Science	6
Understanding	6
Generality	6
Experimental Test	7
Science versus the Humanities	7
The Case Histories	9
The General Principles	10
Mathematics and Science	11
Suggested Reading	11

CHAPTER 2

Facts

What Are They?	12
Fooling the Eye	12
Seeing after Blindness	13
Facts Are "Theory Laden"	17
How Facts Are Used	18
How Science Begins	19
Collecting All the Facts	19

The Facts about Motion	20
Which Facts Are Relevant?	21
Science and Public Facts	21
Reference Notes	22
Suggested Reading	22

PART II • CASE HISTORIES

CHAPTER 3 Snow on Cholera

Introduction: The Man, the Background	25
The Disease	27
Introduction to the Study	28
The History of Cholera	29
Cholera is Contagious	30
How Does Cholera Spread? The "Effluvia" Theory	31
Snow's Theory	33
The First Experiment: 1849	37
The Broad Street Pump	37
The Pump Handle	40
The Second Experiment: 1853-54	41
A Controlled Experiment—Where Did They Get Their Water?	41
The Natural Experiment	42
Being Critical	46
Objections to Snow's Theory	46
Other Theories: Effluvia, Elevation, Hard Water, and Soft Water	49
Applications to Other Problems	51
What about Other Diseases?	51
What to Do? Measures to Prevent the Spread of Cholera	53
What Snow Overlooked	54
The Epidemiology of Cancer	55
Reference Notes	62
Suggested Reading	62

CHAPTER 4 Is Heat a Substance?

Introduction	63
What Is Heat?	63
The Caloric Theory	64
The Kinetic Theory	65

The Usefulness of the Wrong Theory	65
What Is to Come	66
Measuring Hotness	68
Making Things Quantitative	68
Thermometers	70
The Equilibrium of Heat	74
Science and Quantification	74
Exact and Inexact Sciences	75
Heat and Heat Capacity	77
The Invention of "Caloric"	77
Conservation of Heat	78
Joseph Black	78
Heat versus Temperature	79
What Will the Final Temperature Be?	80
"The Capacity for Heat"	82
Latent Heat	86
Melting Ice	86
Latent Heat and Caloric	90
Other Triumphs of the Caloric Theory: The Flow of Heat	91
Rumford: Does Heat Have Weight?	92
Benjamin Thomson, Count Rumford	92
Rumford's War against the Caloric Theory	93
Does Heat Weigh Anything?	93
Heat from Friction	98
The Boring of Cannons	98
Why Rumford Didn't Win	102
Molecular Motion	103
Do Atoms and Molecules Move?	103
Demonstration of the Constant Motion of Molecules	104
Heat as Molecular Motion	107
Why Caloric Survived	109
How Does Heat Get through a Vacuum?	109
What Is Light?	111
The Objectivity of Scientists	112
Reference Notes	112
Suggested Reading	113

CHAPTER 5 Who Is Mad?

Introduction	114
Who Is Mad?	114

A Depressed Genius	115
History	116
Classification as the Starting Point of Science	120
Classification	120
Facts and Their Classification	121
The Kinds of Mental Disorders	123
The Risks of an Improved Classification	125
Another Way of Looking at the Same "Collection of Facts"	125
Schizophrenia and Depressive Disorders	126
Description of Schizophrenia	126
Description of Depressive Disorders	127
Comparison of the Two Groups	128
Diagnosis	129
Pattern Recognition—Art or Science?	130
The Experience of Madness	131
Theories of the Causes of Mental Disorders	135
Psychoanalytical Theories	136
Biological Theories	137
Interaction of Biological and Psychodynamic Factors	138
An Epidemiological Study	138
United States and British Rates of Mental Disorder—A Clue to Causes	138
Explanations	139
Caution! Discovery or Artifact?	140
Previous Studies of Reliability of Diagnoses	142
A Study of Diagnostic Practices	144
A Thermometer for Mental Disorder?	144
The Project Diagnosis	145
The Results	146
How Good Is the Project Diagnosis?	147
Other Studies	148
The Schizophrenia Epidemic in New York State	149
The Psychiatrists Again	149
What Have We Learned?	150
The Mental Hospital	151
Deterioration in Schizophrenia	151
Institutional Neurosis or Schizophrenia?	157
The Origin of Institutional Neurosis	158
The Cure	160
Generalizing a Concept	163
Focus in Science	163
A New Discovery?	166

Total Institutions	166
What Do Convents and Concentration Camps Have in Common?	167
The Institution and the Condition	170
Belief and Evidence	170
What Have We Learned So Far?	171
Labeling	172
Eskimos and Yorubas	173
Genetic Studies	174
Why Does Schizophrenia Run in Families?.....	174
Inheritance	176
Genetic Studies of Schizophrenia	177
Implications for Classification of Schizophrenia	182
Another Classification of Schizophrenia	183
The "Myth" of Schizophrenia	184
Implications for the Psychodynamic Approach	184
Therapeutic Consequences	185
Postscript	186
Reference Notes	186
Suggested Reading	188

PART III • GENERAL PRINCIPLES

CHAPTER 6

Science—Search For Understanding

Understanding as a Common Experience	191
The Dancing Atoms	192
A Sense of Exhilaration	194
Religion, Poetry	195
... Alcohol	196
... and Insanity	196
Science Is a Consensus	197
Reference Notes	197

CHAPTER 7

Science—The Goal of Generality

What It Is	198
Einstein's Generalization	199

Cholera and the Germ Theory	199
The Price of Generality	199
The Loss of Individuality	201
Science and Maps	201
Is History a Science?	202
Reference Notes	203

CHAPTER 8 Science—The Experimental Test

Testing Theories	204
The Development of the Experimental Method	204
The End of Authority	206
Repeatability	207
Quantity Rather Than Quality—The Faith in Mathematics	208
Testing—Planned and Unplanned	209
The Experiment Must Make a Difference	209
An Awareness of Alternatives	210
Women Drivers and the Lisbon Earthquake	210
Refutability	211
You Cannot Prove a Theory Right	212
You Cannot Prove a Theory Wrong	213
Indirectness of Experimental Tests	213
Generality and Indirectness	214
What Do We Test, and When?	215
Appendix	215
The Experimental Method in the Humanities	215
Images as Facts	216
A Controlled Experiment	216
Results	217
Reference Notes	219
Suggested Reading	219

CHAPTER 9 The Experimenter and the Experiment

The Uncertainty Principle	221
A Useful Metaphor	222
The Smart Mice	223
Placebo Pills in Drug Trials	223

Blind and Double Blind	224
The Lively Flatworms	225
Mental Telepathy	226
The Clever Horse	226
Interviewers and Interviewees	227
Rumford's Mistake	228
The Self-Fulfilling Prophecy	229
Reference Notes	230

CHAPTER 10 Measurement and Its Pitfalls

Measurement and Science	231
Reliability and Validity	232
Precision	232
Accuracy	233
When to Stop	234
The Fall of a Leaf	235
The Point of Diminishing Returns	235
Counting	236
How to Fool People	236
How to Fool Oneself	237
The Speed of Light	237
The Crime Problem	238
The Teenage Widowers	240
The Bulgarian Pigs	241
Reference Notes	241

CHAPTER 11 Where Do Hypotheses Come From?

We All Make Them	242
The Moment of Insight	244
Poetry Also	247
Folk Wisdom	247
Chance	249
The Lost Keys	250
The Collective Unconscious	251
The Tactics of Science	252
Reference Notes	253
Suggested Reading	253

CHAPTER 12
The Dispassionate Scientist

The Myths	254
The Reality	254
For Example: Isaac Newton	255
Freud Also	256
Why Scientists Care So Much	257
The Depersonalization of Discovery	258
Reference Notes	259
Suggested Reading	259

CHAPTER 13
The Cultural Roots of Science

The Subjective Element	260
The Tacit Component	261
The Belief in Witchcraft	262
Arguing with the Azande	263
Carelessness and Witchcraft	264
Why? and How?	266
The Poison Oracle	267
The Confirmatory Test	269
Dealing with Contradictory Results	270
Science versus Witchcraft	271
Cultures and Subcultures	272
Scientific Subcultures	273
Breaking Through	273
Reference Notes	275
Suggested Reading	275

PART IV • MATHEMATICS AND SCIENCE

CHAPTER 14
Logic and Mathematics

Introduction	279
The Nature of Logic	280
Probable Inference	281
Logical Difficulties and Fallacies	282

An Example of Logical Reasoning	283
The Nature of Mathematics	285
The Rules of the Game	287
The Truth of Mathematics	287
The Use of Mathematics in Science	288
The Reasons for Mathematics	289
Economy of Effort	291
Precision	291
Another Kind of Precision	292
How Many Prime Numbers Are There? An Example of Mathematical Reasoning	295
Mathematics without Quantities—The Bridges of Koenigsberg ..	298
A Nontrivial Problem: The Nature of the Universe	301
Appendix	307
Galaxies	307
Energy Received from a Star	307
Solid Geometry of the Problem	308
Reference Notes	309
Suggested Reading	310

CHAPTER 15

Probability

How to Deal with Uncertainty	311
How to Gamble and Win	311
Heads or Tails?	312
Numerical Magnitudes	313
Are Tosses Independent?	313
The ‘Law of Averages’	313
Sequences of Tosses	314
A Proof of the Obvious	316
The Familiar Bell-Shaped Curve	317
Another Paradox	318
The Law of Averages Justified	322
Uncertainty Remains	322
Black Balls and White Balls	323
Another Meaning of Probability	326
Appendix: Applications of Probability Theory to Molecular Diffusion and Genetics	327
Introduction	327
Molecules in Motion	327

Genetics	334
Reference Notes	340
Suggested Reading	340

CHAPTER 16 Statistics

The Problem Turned Around	341
How Tall Is the Average Person?	342
Is the Drug Effective?	343
Random versus Nonrandom	344
Another Meaning of "Statistics"	345
How Good Is an Average?	346
Statistics and Science	347
Reference Note	348
Suggested Reading	348
Index	349