Contents

Preface **ix**

Programs for Simulating Some of the Games in the Book **xxiii**

1 Introduction, and a Short History of the Second Law of Thermodynamics **1**

1.1. The *Non-Atomistic* Formulation of the Second Law 1
1.2. The Atomistic Formulation of the Second Law 9

2 A Brief Introduction to Probability Theory, Information Theory, and all the Rest **19**

2.1. The Classical Definition 31
2.2. The Relative Frequency Definition 33
2.3. Independent Events and Conditional Probability 37
2.4. Three Caveats 42
2.4.1. Conditional probability and subjective probability 42
2.4.2. Conditional probability and cause and effect 46

2.4.3. Conditional probability and joint probability 49
2.5. A Teaspoon of Information Theory 51
2.6. A Tip of a Teaspoon of Mathematics, Physics and Chemistry 60
2.7. A Matter of Lottery 67
2.8. A Matter of Order-Disorder 69
2.9. A Challenging Problem 70
2.10. Answers to the Problems 73
2.10.1. Answers to the roulette problems . . . 73
2.10.2. Answer to "a matter of lottery" 74
2.10.3. Answer to "a matter of order-disorder" 75
2.10.4. Answer to "a challenging problem" . . 76

3 First Let Us Play with Real Dice 78

3.1. One Die 78
3.2. Two Dice 79
3.3. Three Dice 84
3.4. Four Dice and More 86

4 Let's Play with Simplified Dice and have a Preliminary Grasp of the Second Law 92

4.1. Two Dice; $N = 2$ 95
4.2. Four Dice; $N = 4$ 98
4.3. Ten Dice; $N = 10$ 100
4.4. Hundred Dice; $N = 100$ 106
4.5. Thousand Dice; $N = 1000$ 108
4.6. Ten Thousand Dice; $N = 10^4$ and Beyond . . . 110

5 Experience the Second Law with all Your Five Senses 116

5.1. See it with your Visual Sense 117
5.2. Smell it with your Olfactory Sense 119

5.3. Taste it with your Gustatory Sense 122
5.4. Hear it with your Auditory Sense 123
5.5. Feel it with your Touch (Tactile) Sense 125

6 Finally, Grasp it with Your Common Sense 129

7 Translating from the Dice-World to the Real World 146

7.1. The Correspondence with the Expansion Process 147
7.2. The Correspondence with the Deassimilation Process 157
7.3. Summary of the Evolution of the System towards the Equilibrium State 164
7.4. Mixing of Three Components 172
7.5. Heat Transfer from a Hot to a Cold Gas 174
7.6. Test Your Understanding of the Second Law . . 180

8 Reflections on the Status of the Second Law of Thermodynamics as a Law of Physics 186

8.1. What is the Source of the Mystery? 189
8.2. The Association of Entropy with "Disorder" . 196
8.3. The Association of Entropy with Missing Information 199
8.4. Is the Second Law Intimately Associated with the Arrow of Time? 208
8.5. Is the Second Law of Thermodynamics a Law of Physics? 213
8.6. Can We Do Away with the Second Law? 216
References and Suggested Reading 219

Index 223