

# Contents

|  |         |
|--|---------|
| Foreword   | page xv |
| Preface  | xv      |
| Acknowledgments  | xv      |
| <b>1 Introduction to the Tree of Life: Drawing Trees and Why There Is No Trunk</b> |         |
| The Last Universal Common Ancestor and Growing the Tree of Life                    |         |
| How Does Evolution Happen?   |         |
| How Do Lineages Diverge? Geographic Speciation                                     |         |
| Speciation Continues, Life Diversifies, and the Tree of Life “Grows”               |         |
| Types of Evolutionary Diagrams: Chronograms and Cladograms                         |         |
| Are Phylogenies  | 1       |
| There Is No Trunk in Twenty-First-Century Trees: There Is No Ladder of Progress    | 1       |
| This Tale Starts with Humans: Cousin Trees   | 1       |
| Avoiding Misconceptions about Evolution and the Tree of Life                       | 1       |
| <b>2 Human Origins: We Are African . . . Mostly</b>                                | 2       |
| We Are All African   | 2       |
| Side Branches Need Not Be Ancestral  | 2       |
| Other Parts of the Genome: Evidence of Hybridization                               | 2       |
| How Old Is the Human Species?  | 3       |
| Age of Species from Evolutionary Trees?  | 3       |
| How Old Is Your Family?  | 3       |

|  |     |
|--|-----|
| <b>3 Primates: Our Closest Living Cousins</b>  | 40  |
| Relationships among African Apes: How to Infer Trees   | 42  |
| Building Trees One Character at a Time: Parsimony and Other Approaches                       | 46  |
| Reconstructing Ancestral Character States  | 48  |
| Asian Apes: Orangutans and Gibbons   | 50  |
| "Monkeys" Are Not a Natural Group  | 53  |
| Tarsiers and Lemurs: Are Prosimians "Lower Primates"?  | 56  |
| Our Ancestry in the Trees  | 60  |
| <b>4 Which Mammals Are the Most Primitive? None of Us</b>                                    | 62  |
| Human-Centric Bias: Viewing Evolution from the Echidna Perspective                           | 65  |
| Marsupials: The Reproductive Advantages of the Pouch   | 68  |
| Placental Mammals and Taxonomic Ranks: Kingdom, Phylum, Class, Order, Family, Genus, Species | 71  |
| Largest Placental Clades: Rapid Morphological Diversification                                | 75  |
| What Aspects of Mammal Group Ages Can Be Compared?   | 75  |
| The Subjectivity of Group Limits and Group Age   | 79  |
| <b>5 Birds Are Reptiles, Birds Are Theropod Dinosaurs</b>                                    | 83  |
| Retained Ancestral Characteristics versus Shared Derived Characteristics                     | 86  |
| Convergent Evolution: Independent Evolution of Similarity                                    | 88  |
| Crown Ages of Major Clades: How Old Are Crocs?   | 89  |
| Bird Diversity and Evolutionary History  | 91  |
| The Impact of "Taxonomic Order" in Species Lists   | 92  |
| Tree Drawing Impacts How We Interpret Them   | 99  |
| Why Are Ostriches Mislabeled as "Primitive"?   | 100 |
| What Can Phylogenetic Trees Be Used For?   | 102 |
| <b>6 The Crawl Onto Land: Tetrapod Evolution and the Gain and Loss of Limbs</b>              | 108 |
| Basic Tetrapod Shape: Four Limbs and a Tail  | 111 |
| Extant Tetrapod Lineages: Amniotes and Amphibians  | 112 |
| Gains and Losses of Legs   | 113 |

|  |            |
|--|------------|
| Tetrapod Branch Rotation: Changes in Order Does Not<br>Change Nodes                                      | 116        |
| Did We Evolve from Amphibians?   | 118        |
| Did We Evolve from <i>Tiktaalik</i> ? Is <i>Tiktaalik</i> Our Ancestor?                                  | 120        |
| <b>7 Which Fishes Are "Primitive"? Do Fish Even Exist?</b>   | <b>123</b> |
| Which of These Lineages of "Fishes" Are Considered "Primitive"?  | 125        |
| The History and Future of the Term "Living Fossil"   | 128        |
| Gars, Sturgeons, Bowfins, and Paddlefishes: Slow Molecular<br>Evolution?                                 | 130        |
| The Problem with Labeling Lineages as Primitive: Changing<br>Perspectives                                | 131        |
| Sharks and Tree Focus: Humans as an Outgroup   | 134        |
| Should There Even Be a Chapter on Fishes? Fish Don't Even Exist!   | 136        |
| <b>8 Animal Evolution: Sponges and Comb Jellies Are Our Cousins</b>                                      | <b>138</b> |
| Misleading Headlines about Comb Jellies Being Ancestral  | 141        |
| Some Helpful Headlines: Comb Jellies as the Sister Group to<br>All Animals                               | 143        |
| Our Closest Invertebrate Cousins: Sea Squirts and Clade Chordata   | 145        |
| Shared Larval Development: Echinoderms and Mouth Second<br>Development                                   | 146        |
| Protostomes: The Most Diverse Animal Clade – Arthropods,<br>Mollusks, and Their Kin                      | 149        |
| The Other Jellies: Stinging Jellies, Coral, and Anemones – Radial<br>Symmetry                            | 150        |
| Conclusion: All Our Animal Cousins   | 151        |
| <b>9 Plants, Animals, Fungi, and "Protists": We Are Eukaryotes</b>                                       | <b>153</b> |
| Plant Evolution  | 156        |
| Which Plant Lineages Are Considered Primitive and Why?   | 158        |
| <i>Amborella</i> : The Angiosperm Considered the "Most Basal,"<br>"Most Primitive," "Earliest Diverging" | 162        |
| Protists Are Wildly Paraphyletic: Diversity from Amoebas to<br>Algae to Malarial Parasites               | 163        |
| Conclusion: "Protozoa" Are No More   | 166        |

|  |     |
|--|-----|
| <b>10 Archaea Then Bacteria Are Our Most Distant Cousins</b>                     | 168 |
| “Prokaryotes” Are Paraphyletic   | 169 |
| The Three “Domain” Model   | 171 |
| Understanding the <i>Web of Life</i>   | 174 |
| Are Bacteria Older, Lower, or More Ancestral?                                    | 177 |
| What Came before LUCA? The “Origin” of Life                                      | 180 |
| Reviewing Themes and Cousin Relationships for <i>Homo sapiens</i>                | 182 |
| <br>   |     |
| <b>Concluding Remarks: The Success, Importance, and Conservation of All Life</b> | 186 |
| Summary of Common Misunderstandings  | 189 |
| References and Further Reading   | 193 |
| Figure Credits   | 210 |
| Index  | 212 |