Principles of Evolution

Systems, Species, and the History of Life

Jonathan Bard



Contents

Acknowledg	ments	ix
Section 1	An Introduction to Evolution	1
Chapter 1	Approaching Evolution A systems biology perspective Further reading	3 4 6
Chapter 2	A Potted History of Evolutionary Science The pre-Darwinian era The Darwinian era The era of evolutionary genetics The molecular era	7 7 8 9 10
Chapter 3	Life Today: Species, Diversity, and Classification The numbers of species today Scale: from microns to meters Variation within a species The anatomical differences between species Taxonomy and the grouping of species Classifying life today The mechanisms of speciation – a summary Key points Further reading	13 14 15 16 16 18 20 23 25 25
Section 2	The Evidence for Evolution and the History of Life	27
Chapter 4	The Fossil Record The beginnings The Cambrian explosion Extinctions Invertebrate evolution Chordate and vertebrate evolution Plant evolution Key points Further reading	29 30 32 34 34 37 43 45
Chapter 5	Darwinian Descent with Modifications: Evolutionary Taxonomy and Cladistics Cladistics Convergent evolution and homoplasies Plant cladistics An example of a hidden plesiomorphy Key points Further reading	47 50 53 54 57 58 59
Chapter 6	The Anatomical Evidence for Vertebrate Evolution: from Fish to Birds Fish From sea to land	61 62 66

	Amphibians The transition to reptiles and the evolution of the amniote egg Reptiles The origin of birds Key points Further reading	71 72 74 81 82 82
Chapter 7	The Anatomical Evidence for Vertebrate Evolution: Mammals Prototheria (monotremes) Metatheria (marsupials) Eutheria (placental mammals) The transition from synapsid reptile to early mammal The early evolution of mammals The evolution of some key mammalian features Back to the sea and the evolution of whales Key points Further reading	83 83 85 86 87 91 99 100
Chapter 8	The Genomic Evidence for Evolution Phylograms and cladograms are subtly different Choosing sequences for phylogenetic analysis Constructing sequence-based phylogenetic trees How accurate are phylogenies? Gene trees and species trees Adding timings – the ticking of the molecular clock Historical population analysis using coalescent theory Key points Further reading	103 104 106 108 113 115 116 117
Chapter 9	The First Three Billion Years of Life: from the First Universal Common Ancestor to the Last Eukaryote Common Ancestor and Beyond Prokaryotes The origin of life FUCA, the first universal common ancestor LUCA, the last universal common ancestor FECA, the first eukaryote common ancestor LECA, the last eukaryote common ancestor LECA, the last eukaryote rommon ancestor Early eukaryote evolution and the roots of the major groups The acquisition of multicellularity from the social behavior of eukaryote protists The origins of multicellularity Key points Further reading	121 123 124 125 127 128 130 134 136 137 138
Chapter 10	Evo-devo 1: Embryos Diploblast and triploblast embryos Early development and the protostome/deuterostome divide Model systems The processes that drive development How tissues form Tissue modules The origins of anatomical differences	141 142 143 145 151 154 158

	The genome Key points Further reading	160 161 162
Chapter 11	Evo-devo 2: The Evidence from Functional Homologies Functional homologies Urbilateria Key points Further reading	163 165 176 179 179
Section 3	The Mechanisms of Evolution	181
Chapter 12	Variation 1: Populations and Genes Phenotypic variation Genotype variation The role of the environment in generating variation-epigenetic inheritance The dynamics of variation across a population: the broader view Key points Further reading	183 185 189 193 194 196
Chapter 13	Variation 2: Clades and Networks	197
·	The effect of mutation on protein systems and networks Examples of anatomical change due to variation in network outputs Developmental constraints on variation The mutational basis of trait change – the broader view Key points Further reading	198 201 209 211 212 212
Chapter 14	Adaptation, Fitness, and Selection	213
	Adaptation Increasing fitness Selection The speed of change under natural selection The modern evolutionary synthesis Population genetics The strengths of the modern evolutionary synthesis The limitations of the modern evolutionary synthesis The multilevel view of how phenotypic change happens Key points Further reading	214 215 217 225 228 229 231 232 234 235 235
Chapter 15	Speciation Defining a species	237 238
	The population genetics of small groups	240
	Speciation is due to the accumulation of small genetic differences	241
	Process of speciation	243
	Species flocks	245
	Artificial speciation The genetics of speciation	246 247
	The genetics of speciation The rate of speciation	247
	The broader perspective	250
	Key points	250
	Further reading	251

Chapter 16	Human Evolution The context of human evolution	25 :
	The fossil evidence	25
		26
	The genetic evidence	26
	Homo migrations out of Africa	
	Genetic origin of the various human groups and their differences	26
	Artefacts, art, and behavior	26
	Selection and speciation	27
	Key points	27
	Further reading	27
Chapter 17	Conclusions	27
•	Contemporary challenges	27
	Is anything missing?	27
Appendix 1	Systems Biology	28:
Appendix i	The narrow view	28
	The broader view	28
		28
	A note on systems terminology	
	Further reading	28
Appendix 2	A History of Evolutionary Thought	29
	The early days	29.
	The move to evolutionary thinking	29
	The early nineteenth century	29.
	The era of Darwin	29
	The nineteenth century after Darwin	30
	The early twentieth century	30
	The molecular era	30
	Further reading	30
Appendix 3	Rocks, Dates, and Fossils	309
	Rock types	30
	Aging rocks (geochronology)	31
	How fossils form	31
	Further reading	31
Appendix 4	Evolution Versus Creationism	317
пренил т	Evolution	318
	Creationism	324
	Conclusions	32
	Conclusions	
Glossary		329
References		337
Figure Acknowledgments		36
Index		365