

Contents

Preface Approaches to understanding early life on Earth	vii
Stephen Jay Gould Introduction: The coherence of history	1

Theme 1: Life's Gestation and Infancy

Sherwood Chang The planetary setting of prebiotic evolution	10
Donald R. Lowe Early environments: Constraints and opportunities for early evolution	24
Kenneth M. Towe Earth's early atmosphere: Constraints and opportunities for early evolution	36
Juan Oró Early chemical stages in the origin of life	48
Antonio Lazcano The transition from non-living to living	60
Antonio Lazcano The RNA world, its predecessors and descendants	70
Herrick Baltscheffsky and Margareta Baltscheffsky Molecular origin and evolution of early biological energy conversion	81
Benjamin Gedulin and Gustaf Arrhenius Sources and geochemical evolution of RNA precursor molecules: The role of phosphate	91
David W. Deamer, Elizabeth Harang Mahon, and Giovanni Bosco Self-assembly and function of primitive membrane structures	107
Günter Wächtershäuser Vitalysts and virulysts: A theory of self-expanding reproduction	124
Leo W. Buss Protocell life cycles	133
Tomoko Ohta Early evolution of genes and genomes	135
Karl O. Stetter The lesson of Archaeobacteria	143
Otto Kandler The early diversification of life	152
Beverly K. Pierson The emergence, diversification, and role of photosynthetic eubacteria	161
Mitchell L. Sogin The origin of eukaryotes and evolution into major kingdoms	181
J. William Schopf The oldest known records of life: Early Archean stromatolites, microfossils, and organic matter	193

Theme 2: The Maturation of Earth and Life

Ján Veizer The Archean–Proterozoic transition and its environmental implications	208
John M. Hayes Global methanotrophy at the Archean–Proterozoic transition	220
Heinrich D. Holland Early Proterozoic atmospheric change	237

John P. Grotzinger Trends in Precambrian carbonate sediments and their implication for understanding evolution	245
Guy Ourisson Biomarkers in the Proterozoic record	259
Malcolm R. Walter Stromatolites: The main source of information on the evolution of the early benthos	270
Bruce Runnegar Proterozoic eukaryotes: Evidence from biology and geology	287
Gonzalo Vidal Early ecosystems: Limitations imposed by the fossil record	298
F.J.R. "Max" Taylor The role of phenotypic comparisons of living protists in the determination of probable eukaryotic phylogeny	312
Lynn Margulis and Joel E. Cohen Combinatorial generation of taxonomic diversity: Implication of symbiogenesis for the Proterozoic fossil record	327
Stjepko Golubic The continuing importance of cyanobacteria	334

Theme 3: Multicellularity and the Phanerozoic Revolution

Hans J. Hofmann Proterozoic carbonaceous compressions ("metaphytes" and "worms")	342
Sun Weiguo Early multicellular fossils	358
Mikhail A. Fedonkin Vendian body fossils and trace fossils	370
Adolf Seilacher Early multicellular life: Late Proterozoic fossils and the Cambrian explosion	389
James W. Valentine The Cambrian explosion	401
Stefan Bengtson The advent of animal skeletons	412
Robert Riding Evolution of algal and cyanobacterial calcification	426
Andrew H. Knoll Neoproterozoic evolution and environmental change	439
Simon Conway Morris Early metazoan evolution: First steps to an integration of molecular and morphological data	450
Jan Bergström Ideas on early animal evolution	460
Richard Christen Molecular phylogeny and the origin of Metazoa	467
Reinhard M. Rieger Evolution of the "lower" Metazoa	475
Rudolf A. Raff Developmental mechanisms in the evolution of animal form: Origins and evolvability of body plans	489
George L. Gabor Miklos and K.S.W. Campbell From protein domains to extinct phyla: Reverse-engineering approaches to the evolution of biological complexities	501
References	517
Index	599