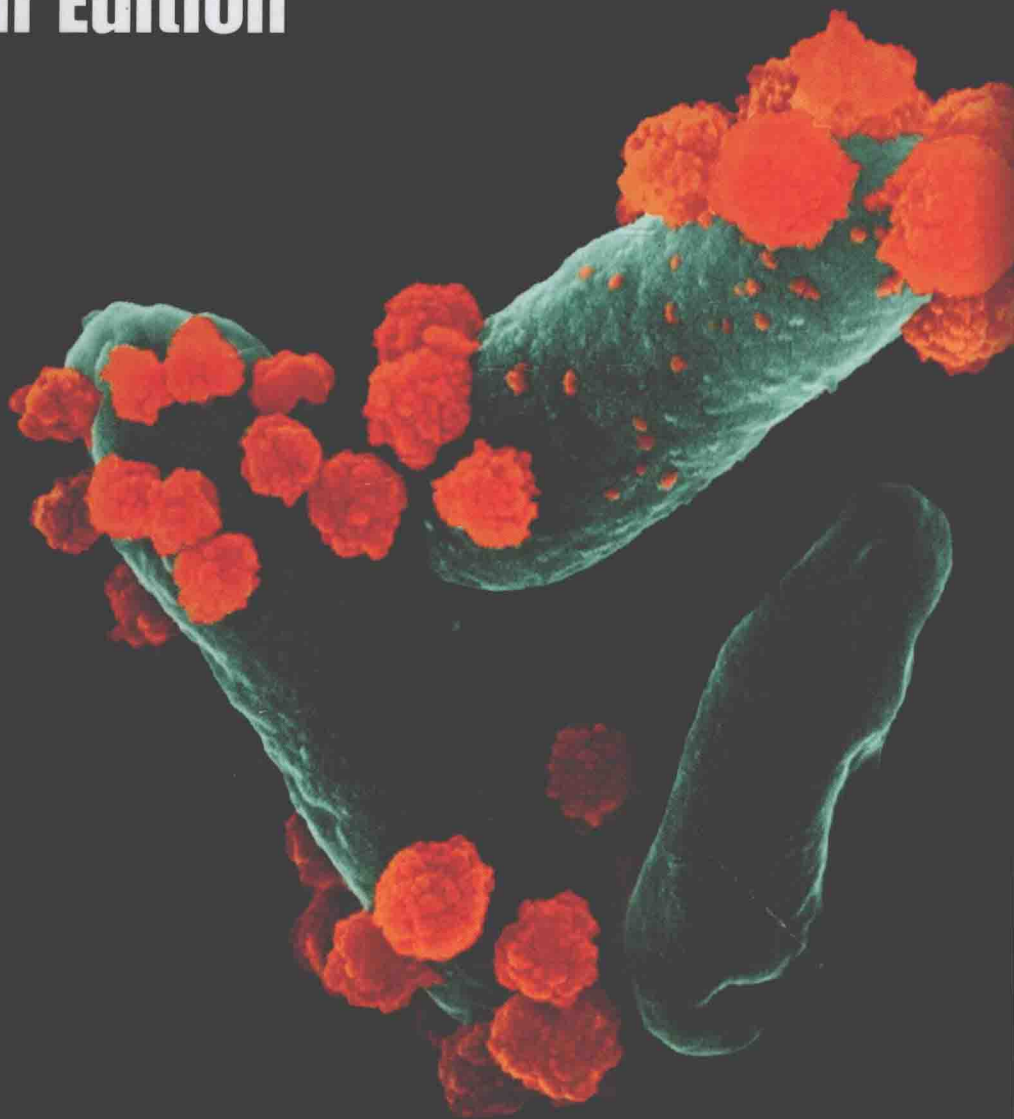


# GEOMICROBIOLOGY

**Fifth Edition**



CRC Press  
Taylor & Francis Group

**Henry Lutz Ehrlich**  
**Dianne K. Newman**

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# Dedication

*We dedicate this edition to Terry Beveridge:  
dear friend, inspiring mentor, and geomicrobiologist par excellence.*

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# Preface

Several important advances have occurred in the field of geomicrobiology since the last edition of this book, including a number of observations made possible by the introduction of genetic and molecular biological techniques that make revision and updating of the previous edition of *Geomicrobiology* timely.

Henry Lutz Ehrlich, author of the earlier four editions, has been joined by Dianne K. Newman for this fifth edition to lend her expertise in the area of molecular geomicrobiology. This has resulted in a new chapter (Chapter 8) in this edition, which is entitled “Molecular Methods in Geomicrobiology.” The techniques described in this chapter illuminate the processes by which bacteria catalyze important geomicrobial reactions. For example, we are beginning to understand the molecular details whereby some gram-negative bacteria export electrons to mineral oxides with which they are in physical contact in their respiratory metabolism. Such electron transfer is enabled by respiratory enzymes in the outer membrane and periplasm of such organisms. Molecular techniques have also demonstrated that at least one gram-negative bacterium can import electrons donated by an electron donor, ferrous iron, in contact with the outer surface of the outer membrane of this organism. In some cases, electron shuttles have been shown to facilitate electron transfer. Further important advances in this area are anticipated. Collectively, these mechanistic observations make clear that microbes play a much more direct role in the transformation of oxidizable and reducible minerals than had been previously believed by many researchers in this field. We anticipate that as mechanistic molecular approaches are increasingly applied to diverse problems in geomicrobiology, exciting discoveries will be made about how life sustains itself even in seemingly inhospitable environments such as the deep subsurface.

Just as in the case of the previous editions of *Geomicrobiology*, the chief aim of the fifth edition is to serve as an introduction to the subject and an up-to-date reference. To continue to provide a broad perspective of the development of the field, discussion of the older literature that appeared in earlier editions of this book has been retained. Changes in understanding and viewpoints are pointed out where necessary. Although we do not claim that the reference citations at the end of each chapter are exhaustive, cross-referencing should reveal other pertinent literature. As before, a glossary of terms that may be unfamiliar to some readers has been added. All chapters have been updated where necessary by introducing the findings of recent research.

We are continuing to retain some of the drawings prepared by Stephen Chiang for the first edition. Other illustrations from the fourth edition have been retained in the current edition, with appropriate acknowledgments to their source when not originating from us, and some new illustrations have been added. We are very grateful to Andreas Kappler for allowing us to use the photomicrograph of *Chlorobium ferrooxidans* for the book cover illustration of this edition.

We owe special thanks to Martin Polz, Victoria Orphan, and Alex Sessions for stimulating discussions that shaped the content of Chapter 8; and we gratefully acknowledge Alexandre Poulain for his help in preparing the figures for this chapter. We also owe sincere thanks to Jon Price for his assistance in obtaining the photograph of the sample of basalt from the rock collection at Rensselaer Polytechnic Institute.

We appreciate the encouragement and editorial assistance of Judith Spiegel, Barbara Norwitz, and Patricia Roberson of Taylor & Francis Group LLC.

Responsibility for the presentation and interpretation of the subject matter in this edition rests entirely with the authors.

**Henry Lutz Ehrlich  
Dianne K. Newman**

---

# Authors

**Dr. Henry Lutz Ehrlich** earned a BS degree from Harvard College (major: biochemical sciences) in 1948, an MS degree in 1949 (major: agricultural bacteriology), and a PhD degree in 1951 (major: agricultural bacteriology; minor: biochemistry); both of the latter degrees from the University of Wisconsin, Madison. He joined the faculty of the Biology Department of Rensselaer Polytechnic Institute as an assistant professor in the fall of 1951, attaining the rank of full professor in 1964. Dr. Ehrlich became professor emeritus in 1994 but continues to be active in the department in pursuit of some scholarly work. He began teaching a course in geomicrobiology in the spring semester of 1966.

Dr. Ehrlich is a fellow of the American Academy of Microbiology, American Association for the Advancement of Science, the International Union of Pure and Applied Chemistry, and the International Symposia on Environmental Biogeochemistry. He is a member of the Interdisciplinary Committee of the World Cultural Council (Consejo Cultural Mundial) and an honoree of the 11th International Symposium on Water/Rock held in 1994 in Saratoga Springs, New York. Dr. Ehrlich has been a consultant at various times for a number of different companies. He was editor-in-chief of *Geomicrobiology Journal* (1983–1995) and has since continued as co-editor-in-chief. He is a member of the editorial boards of *Applied and Environmental Microbiology* and *Applied Microbiology and Biotechnology*. He is also emeritus member of American Association for the Advancement of Science, American Institute of Biological Sciences, American Society for Microbiology, and the Society of Industrial Microbiology.

Dr. Ehrlich's research interests have resided in bacterial oxidation of Mn(II) and reduction of Mn(IV) associated with marine ferromanganese concretions, marine hydrothermal vent communities, and some freshwater environments; bacterial oxidation of arsenic(III); bacterial reduction of Cr(VI); bacterial interaction with bauxite; and bioleaching of ores including metal sulfides, bauxite, and others. He is author or coauthor of more than 100 articles dealing with various topics in geomicrobiology.

**Dr. Dianne K. Newman** earned a BA degree from Stanford University (major: German studies) in 1993, and a PhD degree in 1997 (major: environmental engineering with an emphasis on microbiology) from the Massachusetts Institute of Technology (MIT). She spent two years as an exchange scholar at Princeton University in the Geosciences department from 1995 to 1997. Dr. Newman was a postdoctoral fellow in the Department of Microbiology and Molecular Genetics at Harvard Medical School from 1998 to 2000. She joined the faculty of the California Institute of Technology in 2000, where she was jointly appointed in the divisions of Geological and Planetary Sciences and Biology. In 2007, she returned to MIT, where she is currently the John and Dorothy Wilson Professor of Biology and Geobiology, with a joint appointment in the departments of Biology and Earth, Atmospheric and Planetary Sciences. Dr. Newman is also an Investigator of the Howard Hughes Medical Institute.

Dr. Newman's honors include being a Clare Boothe Luce assistant professor, an Office of Naval Research young investigator, a David and Lucille Packard Fellow in science and engineering, an Investigator of the Howard Hughes Medical Institute, and a fellow of the American Academy of Microbiology. She was the 2008 recipient of the Eli Lilly and Company Research Award from the American Society for Microbiology. She is an editor of the *Geobiology Journal*, and is on the editorial board of the *Annual Review of Earth and Planetary Science*. She is on the scientific advisory board of Mascoma Corporation, and is a member of the American Society of Microbiology and the American Geophysical Union.

Dr. Newman's laboratory seeks to gain insights into the evolution of metabolism as recorded in ancient rocks by studying how modern bacteria catalyze geochemically significant reactions. Specifically, she focuses on putatively ancient forms of photosynthesis and respiration, with a specific interest in the cellular mechanisms that enable these complex processes to work.

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# Contents

|                                                                                                                                                                         |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Preface.....                                                                                                                                                            | xix |
| Authors.....                                                                                                                                                            | xxi |
| <b>Chapter 1</b> Introduction .....                                                                                                                                     | 1   |
| References .....                                                                                                                                                        | 3   |
| <b>Chapter 2</b> Earth as a Microbial Habitat .....                                                                                                                     | 5   |
| 2.1 Geologically Important Features.....                                                                                                                                | 5   |
| 2.2 Biosphere .....                                                                                                                                                     | 10  |
| 2.3 Summary .....                                                                                                                                                       | 11  |
| References .....                                                                                                                                                        | 11  |
| <b>Chapter 3</b> Origin of Life and Its Early History .....                                                                                                             | 15  |
| 3.1 Beginnings.....                                                                                                                                                     | 15  |
| 3.1.1 Origin of Life on Earth: Panspermia .....                                                                                                                         | 15  |
| 3.1.2 Origin of Life on Earth: <i>de novo</i> Appearance .....                                                                                                          | 16  |
| 3.1.3 Life from Abiotically Formed Organic Molecules in Aqueous<br>Solution (Organic Soup Theory) .....                                                                 | 16  |
| 3.1.4 Surface Metabolism Theory .....                                                                                                                                   | 18  |
| 3.1.5 Origin of Life through Iron Monosulfide Bubbles in Hadean<br>Ocean at the Interface of Sulfide-Bearing Hydrothermal<br>Solution and Iron-Bearing Ocean Water..... | 19  |
| 3.2 Evolution of Life through the Precambrian: Biological<br>and Biochemical Benchmarks .....                                                                           | 20  |
| 3.2.1 Early Evolution According to Organic Soup Scenario .....                                                                                                          | 21  |
| 3.2.2 Early Evolution According to Surface Metabolist Scenario .....                                                                                                    | 27  |
| 3.3 Evidence .....                                                                                                                                                      | 28  |
| 3.4 Summary .....                                                                                                                                                       | 31  |
| References .....                                                                                                                                                        | 32  |
| <b>Chapter 4</b> Lithosphere as Microbial Habitat .....                                                                                                                 | 37  |
| 4.1 Rock and Minerals.....                                                                                                                                              | 37  |
| 4.2 Mineral Soil .....                                                                                                                                                  | 39  |
| 4.2.1 Origin of Mineral Soil .....                                                                                                                                      | 39  |
| 4.2.2 Some Structural Features of Mineral Soil .....                                                                                                                    | 40  |
| 4.2.3 Effects of Plants and Animals on Soil Evolution.....                                                                                                              | 42  |
| 4.2.4 Effects of Microbes on Soil Evolution .....                                                                                                                       | 42  |
| 4.2.5 Effects of Water on Soil Erosion.....                                                                                                                             | 43  |
| 4.2.6 Water Distribution in Mineral Soil .....                                                                                                                          | 43  |
| 4.2.7 Nutrient Availability in Mineral Soil .....                                                                                                                       | 44  |
| 4.2.8 Some Major Soil Types .....                                                                                                                                       | 45  |
| 4.2.9 Types of Microbes and Their Distribution in Mineral Soil .....                                                                                                    | 47  |

|                  |                                                                                                                                                                          |           |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.3              | Organic Soils .....                                                                                                                                                      | 49        |
| 4.4              | The Deep Subsurface .....                                                                                                                                                | 50        |
| 4.5              | Summary .....                                                                                                                                                            | 51        |
|                  | References .....                                                                                                                                                         | 52        |
| <b>Chapter 5</b> | <b>The Hydrosphere as Microbial Habitat .....</b>                                                                                                                        | <b>57</b> |
| 5.1              | The Oceans .....                                                                                                                                                         | 57        |
| 5.1.1            | Physical Attributes .....                                                                                                                                                | 57        |
| 5.1.2            | Ocean in Motion .....                                                                                                                                                    | 59        |
| 5.1.3            | Chemical and Physical Properties of Seawater.....                                                                                                                        | 62        |
| 5.1.4            | Microbial Distribution in Water Column and Sediments .....                                                                                                               | 68        |
| 5.1.5            | Effects of Temperature, Hydrostatic Pressure, and Salinity<br>on Microbial Distribution in Oceans .....                                                                  | 70        |
| 5.1.6            | Dominant Phytoplankters and Zooplankters in Oceans.....                                                                                                                  | 71        |
| 5.1.7            | Plankters of Geomicrobial Interest .....                                                                                                                                 | 72        |
| 5.1.8            | Bacterial Flora in Oceans.....                                                                                                                                           | 72        |
| 5.2              | Freshwater Lakes.....                                                                                                                                                    | 73        |
| 5.2.1            | Some Physical and Chemical Features of Lakes .....                                                                                                                       | 74        |
| 5.2.2            | Lake Bottoms .....                                                                                                                                                       | 76        |
| 5.2.3            | Lake Fertility .....                                                                                                                                                     | 77        |
| 5.2.4            | Lake Evolution .....                                                                                                                                                     | 77        |
| 5.2.5            | Microbial Populations in Lakes .....                                                                                                                                     | 77        |
| 5.3              | Rivers.....                                                                                                                                                              | 78        |
| 5.4              | Groundwaters .....                                                                                                                                                       | 79        |
| 5.5              | Summary .....                                                                                                                                                            | 82        |
|                  | References .....                                                                                                                                                         | 83        |
| <b>Chapter 6</b> | <b>Geomicrobial Processes: Physiological and Biochemical Overview .....</b>                                                                                              | <b>89</b> |
| 6.1              | Types of Geomicrobial Agents.....                                                                                                                                        | 89        |
| 6.2              | Geomicrobially Important Physiological Groups of Prokaryotes.....                                                                                                        | 90        |
| 6.3              | Role of Microbes in Inorganic Conversions in Lithosphere<br>and Hydrosphere.....                                                                                         | 91        |
| 6.4              | Types of Microbial Activities Influencing Geological Processes.....                                                                                                      | 92        |
| 6.5              | Microbes as Catalysts of Geochemical Processes.....                                                                                                                      | 93        |
| 6.5.1            | Catabolic Reactions: Aerobic Respiration .....                                                                                                                           | 94        |
| 6.5.2            | Catabolic Reactions: Anaerobic Respiration .....                                                                                                                         | 96        |
| 6.5.3            | Catabolic Reactions: Respiration Involving Insoluble<br>Inorganic Substrates as Electron Donors or Acceptors .....                                                       | 98        |
| 6.5.4            | Catabolic Reactions: Fermentation .....                                                                                                                                  | 100       |
| 6.5.5            | How Energy Is Generated by Aerobic and Anaerobic<br>Respirers and Fermenters During Catabolism.....                                                                      | 101       |
| 6.5.6            | How Chemolithoautotrophic Bacteria (Chemosynthetic<br>Autotrophs) Generate Reducing Power for Assimilating<br>CO <sub>2</sub> and Converting It into Organic Carbon..... | 103       |
| 6.5.7            | How Photosynthetic Microbes Generate Energy<br>and Reducing Power.....                                                                                                   | 103       |
| 6.5.8            | Anabolism: How Microbes Use Energy Trapped in High-Energy<br>Bonds to Drive Energy-Consuming Reactions .....                                                             | 105       |
| 6.5.9            | Carbon Assimilation by Mixotrophs, Photoheterotrophs,<br>and Heterotrophs.....                                                                                           | 108       |

|                  |                                                                                             |            |
|------------------|---------------------------------------------------------------------------------------------|------------|
| 6.6              | Microbial Mineralization of Organic Matter .....                                            | 108        |
| 6.7              | Microbial Products of Metabolism That Can Cause<br>Geomicrobial Transformations.....        | 110        |
| 6.8              | Physical Parameters That Influence Geomicrobial Activity .....                              | 110        |
| 6.9              | Summary .....                                                                               | 112        |
|                  | References .....                                                                            | 113        |
| <b>Chapter 7</b> | <b>Nonmolecular Methods in Geomicrobiology.....</b>                                         | <b>117</b> |
| 7.1              | Introduction .....                                                                          | 117        |
| 7.2              | Detection, Isolation, and Identification of Geomicrobially<br>Active Organisms .....        | 118        |
| 7.2.1            | <i>In Situ</i> Observation of Geomicrobial Agents.....                                      | 118        |
| 7.2.2            | Identification by Application of Molecular Biological Techniques .....                      | 120        |
| 7.3              | Sampling.....                                                                               | 120        |
| 7.3.1            | Terrestrial Surface/Subsurface Sampling .....                                               | 121        |
| 7.3.2            | Aquatic Sampling.....                                                                       | 121        |
| 7.3.3            | Sample Storage.....                                                                         | 122        |
| 7.3.4            | Culture Isolation and Characterization of Active Agents<br>from Environmental Samples ..... | 124        |
| 7.4              | <i>In Situ</i> Study of Past Geomicrobial Activity .....                                    | 125        |
| 7.5              | <i>In Situ</i> Study of Ongoing Geomicrobial Activity .....                                 | 126        |
| 7.6              | Laboratory Reconstruction of Geomicrobial Processes in Nature.....                          | 128        |
| 7.7              | Quantitative Study of Growth on Surfaces.....                                               | 132        |
| 7.8              | Test for Distinguishing between Enzymatic and Nonenzymatic<br>Geomicrobial Activity .....   | 134        |
| 7.9              | Study of Reaction Products of Geomicrobial Transformation .....                             | 134        |
| 7.10             | Summary .....                                                                               | 135        |
|                  | References .....                                                                            | 135        |
| <b>Chapter 8</b> | <b>Molecular Methods in Geomicrobiology .....</b>                                           | <b>139</b> |
| 8.1              | Introduction .....                                                                          | 139        |
| 8.2              | Who Is There? Identification of Geomicrobial Organisms .....                                | 139        |
| 8.2.1            | Culture-Independent Methods .....                                                           | 139        |
| 8.2.2            | New Culturing Techniques .....                                                              | 141        |
| 8.3              | What Are They Doing? Deducing Activities of Geomicrobial<br>Organisms.....                  | 141        |
| 8.3.1            | Single-Cell Isotopic Techniques .....                                                       | 142        |
| 8.3.2            | Single-Cell Metabolite Techniques.....                                                      | 144        |
| 8.3.3            | Community Techniques Involving Isotopes.....                                                | 145        |
| 8.3.4            | Community Techniques Involving Genomics.....                                                | 146        |
| 8.3.5            | Probing for Expression of Metabolic Genes<br>or Their Gene Products .....                   | 147        |
| 8.4              | How Are They Doing It? Unraveling the Mechanisms<br>of Geomicrobial Organisms .....         | 147        |
| 8.4.1            | Genetic Approaches .....                                                                    | 148        |
| 8.4.2            | Bioinformatic Approaches .....                                                              | 151        |
| 8.4.3            | Follow-Up Studies.....                                                                      | 151        |
| 8.5              | Summary .....                                                                               | 152        |
|                  | References .....                                                                            | 152        |

|                   |                                                                                         |            |
|-------------------|-----------------------------------------------------------------------------------------|------------|
| <b>Chapter 9</b>  | <b>Microbial Formation and Degradation of Carbonates .....</b>                          | <b>157</b> |
| 9.1               | Distribution of Carbon in Earth's Crust .....                                           | 157        |
| 9.2               | Biological Carbonate Deposition.....                                                    | 157        |
| 9.2.1             | Historical Perspective of Study of Carbonate Deposition .....                           | 158        |
| 9.2.2             | Basis for Microbial Carbonate Deposition.....                                           | 161        |
| 9.2.3             | Conditions for Extracellular Microbial Carbonate Precipitation.....                     | 164        |
| 9.2.4             | Carbonate Deposition by Cyanobacteria .....                                             | 167        |
| 9.2.5             | Possible Model for Oolite Formation.....                                                | 168        |
| 9.2.6             | Structural or Intracellular Carbonate Deposition by Microbes .....                      | 168        |
| 9.2.7             | Models for Skeletal Carbonate Formation.....                                            | 171        |
| 9.2.8             | Microbial Formation of Carbonates Other Than<br>Those of Calcium.....                   | 173        |
| 9.2.8.1           | Sodium Carbonate .....                                                                  | 173        |
| 9.2.8.2           | Manganous Carbonate .....                                                               | 174        |
| 9.2.8.3           | Ferrous Carbonate.....                                                                  | 176        |
| 9.2.8.4           | Strontium Carbonate.....                                                                | 177        |
| 9.2.8.5           | Magnesium Carbonate .....                                                               | 177        |
| 9.3               | Biodegradation of Carbonates .....                                                      | 178        |
| 9.3.1             | Biodegradation of Limestone.....                                                        | 178        |
| 9.3.2             | Cyanobacteria, Algae, and Fungi That Bore into Limestone .....                          | 180        |
| 9.4               | Biological Carbonate Formation and Degradation and the Carbon Cycle.....                | 183        |
| 9.5               | Summary .....                                                                           | 184        |
|                   | References .....                                                                        | 184        |
| <b>Chapter 10</b> | <b>Geomicrobial Interactions with Silicon .....</b>                                     | <b>191</b> |
| 10.1              | Distribution and Some Chemical Properties.....                                          | 191        |
| 10.2              | Biologically Important Properties of Silicon and Its Compounds .....                    | 192        |
| 10.3              | Bioconcentration of Silicon .....                                                       | 193        |
| 10.3.1            | Bacteria.....                                                                           | 193        |
| 10.3.2            | Fungi.....                                                                              | 195        |
| 10.3.3            | Diatoms.....                                                                            | 195        |
| 10.4              | Biomobilization of Silicon and Other Constituents of Silicates<br>(Bioweathering) ..... | 198        |
| 10.4.1            | Solubilization by Ligands.....                                                          | 198        |
| 10.4.2            | Solubilization by Acids.....                                                            | 200        |
| 10.4.3            | Solubilization by Alkali .....                                                          | 201        |
| 10.4.4            | Solubilization by Extracellular Polysaccharide.....                                     | 202        |
| 10.4.5            | Depolymerization of Polysilicates.....                                                  | 202        |
| 10.5              | Role of Microbes in the Silica Cycle .....                                              | 202        |
| 10.6              | Summary .....                                                                           | 203        |
|                   | References .....                                                                        | 204        |
| <b>Chapter 11</b> | <b>Geomicrobiology of Aluminum: Microbes and Bauxite .....</b>                          | <b>209</b> |
| 11.1              | Introduction .....                                                                      | 209        |
| 11.2              | Microbial Role in Bauxite Formation.....                                                | 210        |
| 11.2.1            | Nature of Bauxite .....                                                                 | 210        |
| 11.2.2            | Biological Role in Weathering of the Parent Rock Material.....                          | 210        |
| 11.2.3            | Weathering Phase .....                                                                  | 211        |
| 11.2.4            | Bauxite Maturation Phase .....                                                          | 211        |

|                   |                                                                                        |            |
|-------------------|----------------------------------------------------------------------------------------|------------|
| 11.2.5            | Bacterial Reduction of Fe(III) in Bauxites from Different Locations .....              | 214        |
| 11.2.6            | Other Observations of Bacterial Interaction with Bauxite.....                          | 214        |
| 11.3              | Summary .....                                                                          | 215        |
|                   | References .....                                                                       | 215        |
| <b>Chapter 12</b> | <b>Geomicrobial Interactions with Phosphorus.....</b>                                  | <b>219</b> |
| 12.1              | Biological Importance of Phosphorus .....                                              | 219        |
| 12.2              | Occurrence in Earth's Crust .....                                                      | 219        |
| 12.3              | Conversion of Organic into Inorganic Phosphorus and Synthesis of Phosphate Esters..... | 220        |
| 12.4              | Assimilation of Phosphorus.....                                                        | 221        |
| 12.5              | Microbial Solubilization of Phosphate Minerals.....                                    | 222        |
| 12.6              | Microbial Phosphate Immobilization .....                                               | 223        |
| 12.6.1            | Phosphorite Deposition.....                                                            | 223        |
| 12.6.1.1          | Authigenic Formations.....                                                             | 224        |
| 12.6.1.2          | Diagenetic Formation.....                                                              | 226        |
| 12.6.2            | Occurrences of Phosphorite Deposits.....                                               | 226        |
| 12.6.3            | Deposition of Other Phosphate Minerals .....                                           | 226        |
| 12.7              | Microbial Reduction of Oxidized Forms of Phosphorus .....                              | 227        |
| 12.8              | Microbial Oxidation of Reduced Forms of Phosphorus.....                                | 228        |
| 12.9              | Microbial Role in the Phosphorus Cycle.....                                            | 229        |
| 12.10             | Summary .....                                                                          | 229        |
|                   | References .....                                                                       | 229        |
| <b>Chapter 13</b> | <b>Geomicrobially Important Interactions with Nitrogen .....</b>                       | <b>233</b> |
| 13.1              | Nitrogen in Biosphere.....                                                             | 233        |
| 13.2              | Microbial Interactions with Nitrogen .....                                             | 233        |
| 13.2.1            | Ammonification.....                                                                    | 233        |
| 13.2.2            | Nitrification.....                                                                     | 235        |
| 13.2.3            | Ammonia Oxidation.....                                                                 | 235        |
| 13.2.4            | Nitrite Oxidation.....                                                                 | 236        |
| 13.2.5            | Heterotrophic Nitrification .....                                                      | 236        |
| 13.2.6            | Anaerobic Ammonia Oxidation (Anammox).....                                             | 236        |
| 13.2.7            | Denitrification.....                                                                   | 237        |
| 13.2.8            | Nitrogen Fixation.....                                                                 | 238        |
| 13.3              | Microbial Role in the Nitrogen Cycle.....                                              | 239        |
| 13.4              | Summary .....                                                                          | 240        |
|                   | References .....                                                                       | 240        |
| <b>Chapter 14</b> | <b>Geomicrobial Interactions with Arsenic and Antimony.....</b>                        | <b>243</b> |
| 14.1              | Introduction .....                                                                     | 243        |
| 14.2              | Arsenic.....                                                                           | 243        |
| 14.2.1            | Distribution.....                                                                      | 243        |
| 14.2.2            | Some Chemical Characteristics.....                                                     | 243        |
| 14.2.3            | Toxicity .....                                                                         | 244        |
| 14.2.4            | Microbial Oxidation of Reduced Forms of Arsenic.....                                   | 245        |
| 14.2.4.1          | Aerobic Oxidation of Dissolved Arsenic .....                                           | 245        |
| 14.2.4.2          | Anaerobic Oxidation of Dissolved Arsenic .....                                         | 247        |

|                   |                                                                                          |            |
|-------------------|------------------------------------------------------------------------------------------|------------|
| 14.2.5            | Interaction with Arsenic-Containing Minerals .....                                       | 247        |
| 14.2.6            | Microbial Reduction of Oxidized Arsenic Species .....                                    | 250        |
| 14.2.7            | Arsenic Respiration .....                                                                | 251        |
| 14.2.8            | Direct Observations of Arsenite Oxidation and Arsenate<br>Reduction <i>In Situ</i> ..... | 254        |
| 14.3              | Antimony .....                                                                           | 256        |
| 14.3.1            | Antimony Distribution in Earth's Crust .....                                             | 256        |
| 14.3.2            | Microbial Oxidation of Antimony Compounds .....                                          | 256        |
| 14.3.3            | Microbial Reduction of Oxidized Antimony Minerals .....                                  | 257        |
| 14.4              | Summary .....                                                                            | 257        |
|                   | References .....                                                                         | 258        |
| <b>Chapter 15</b> | <b>Geomicrobiology of Mercury .....</b>                                                  | <b>265</b> |
| 15.1              | Introduction .....                                                                       | 265        |
| 15.2              | Distribution of Mercury in Earth's Crust .....                                           | 265        |
| 15.3              | Anthropogenic Mercury .....                                                              | 266        |
| 15.4              | Mercury in Environment .....                                                             | 266        |
| 15.5              | Specific Microbial Interactions with Mercury .....                                       | 267        |
| 15.5.1            | Nonenzymatic Methylation of Mercury by Microbes .....                                    | 267        |
| 15.5.2            | Enzymatic Methylation of Mercury by Microbes .....                                       | 268        |
| 15.5.3            | Microbial Diphenylmercury Formation .....                                                | 269        |
| 15.5.4            | Microbial Reduction of Mercuric Ion .....                                                | 269        |
| 15.5.5            | Formation of Meta-Cinnabar ( $\beta$ -HgS) from Hg(II)<br>by Cyanobacteria .....         | 270        |
| 15.5.6            | Microbial Decomposition of Organomercurials .....                                        | 270        |
| 15.5.7            | Oxidation of Metallic Mercury .....                                                      | 270        |
| 15.6              | Genetic Control of Mercury Transformations .....                                         | 271        |
| 15.7              | Environmental Significance of Microbial Mercury<br>Transformations .....                 | 272        |
| 15.8              | Mercury Cycle .....                                                                      | 272        |
| 15.9              | Summary .....                                                                            | 273        |
|                   | References .....                                                                         | 274        |
| <b>Chapter 16</b> | <b>Geomicrobiology of Iron .....</b>                                                     | <b>279</b> |
| 16.1              | Iron Distribution in Earth's Crust .....                                                 | 279        |
| 16.2              | Geochemically Important Properties .....                                                 | 279        |
| 16.3              | Biological Importance of Iron .....                                                      | 280        |
| 16.3.1            | Function of Iron in Cells .....                                                          | 280        |
| 16.3.2            | Iron Assimilation by Microbes .....                                                      | 280        |
| 16.4              | Iron as Energy Source for Bacteria .....                                                 | 282        |
| 16.4.1            | Acidophiles .....                                                                        | 282        |
| 16.4.2            | Domain Bacteria: Mesophiles .....                                                        | 282        |
| 16.4.2.1          | <i>Acidithiobacillus</i> (Formerly <i>Thiobacillus</i> )<br><i>ferrooxidans</i> .....    | 282        |
| 16.4.2.2          | <i>Thiobacillus prosperus</i> .....                                                      | 294        |
| 16.4.2.3          | <i>Leptospirillum ferrooxidans</i> .....                                                 | 294        |
| 16.4.2.4          | <i>Metallogenium</i> .....                                                               | 295        |
| 16.4.2.5          | <i>Ferromicrobium acidophilum</i> .....                                                  | 295        |
| 16.4.2.6          | Strain CCH7 .....                                                                        | 295        |

|                   |                                                                                                         |            |
|-------------------|---------------------------------------------------------------------------------------------------------|------------|
| 16.4.3            | Domain Bacteria: Thermophiles .....                                                                     | 295        |
| 16.4.3.1          | <i>Sulfobacillus thermosulfidooxidans</i> .....                                                         | 295        |
| 16.4.3.2          | <i>Sulfobacillus acidophilus</i> .....                                                                  | 296        |
| 16.4.3.3          | <i>Acidimicrobium ferrooxidans</i> .....                                                                | 296        |
| 16.4.4            | Domain Archaea: Mesophiles .....                                                                        | 296        |
| 16.4.4.1          | <i>Ferroplasma acidiphilum</i> .....                                                                    | 296        |
| 16.4.4.2          | <i>Ferroplasma acidarmanus</i> .....                                                                    | 296        |
| 16.4.5            | Domain Archaea: Thermophiles .....                                                                      | 296        |
| 16.4.5.1          | <i>Acidianus brierleyi</i> .....                                                                        | 296        |
| 16.4.5.2          | <i>Sulfolobus acidocaldarius</i> .....                                                                  | 298        |
| 16.4.6            | Domain Bacteria: Neutrophilic Iron Oxidizers .....                                                      | 298        |
| 16.4.6.1          | Unicellular Bacteria .....                                                                              | 298        |
| 16.4.7            | Appendaged Bacteria .....                                                                               | 298        |
| 16.4.7.1          | <i>Gallionella ferruginea</i> .....                                                                     | 298        |
| 16.4.7.2          | Sheathed, Encapsulated, and Wall-Less Iron Bacteria ....                                                | 301        |
| 16.5              | Anaerobic Oxidation of Ferrous Iron .....                                                               | 302        |
| 16.5.1            | Phototrophic Oxidation .....                                                                            | 302        |
| 16.5.2            | Chemotrophic Oxidation .....                                                                            | 303        |
| 16.6              | Iron(III) as Terminal Electron Acceptor in Bacterial Respiration .....                                  | 304        |
| 16.6.1            | Bacterial Ferric Iron Reduction Accompanying Fermentation .....                                         | 304        |
| 16.6.2            | Ferric Iron Respiration: Early History .....                                                            | 306        |
| 16.6.3            | Metabolic Evidence for Enzymatic Ferric Iron Reduction .....                                            | 308        |
| 16.6.4            | Ferric Iron Respiration: Current Status .....                                                           | 309        |
| 16.6.5            | Electron Transfer from Cell Surface of a Dissimilatory<br>Fe(III) Reducer to Ferric Oxide Surface ..... | 313        |
| 16.6.6            | Bioenergetics of Dissimilatory Iron Reduction .....                                                     | 314        |
| 16.6.7            | Ferric Iron Reduction as Electron Sink .....                                                            | 314        |
| 16.6.8            | Reduction of Ferric Iron by Fungi .....                                                                 | 315        |
| 16.6.9            | Types of Ferric Compounds Attacked by Dissimilatory<br>Iron(III) Reduction .....                        | 315        |
| 16.7              | Nonenzymatic Oxidation of Ferrous Iron and Reduction<br>of Ferric Iron by Microbes .....                | 316        |
| 16.7.1            | Nonenzymatic Oxidation .....                                                                            | 316        |
| 16.7.2            | Nonenzymatic Reduction .....                                                                            | 317        |
| 16.8              | Microbial Precipitation of Iron .....                                                                   | 318        |
| 16.8.1            | Enzymatic Processes .....                                                                               | 318        |
| 16.8.2            | Nonenzymatic Processes .....                                                                            | 319        |
| 16.8.3            | Bioaccumulation of Iron .....                                                                           | 320        |
| 16.9              | Concept of Iron Bacteria .....                                                                          | 320        |
| 16.10             | Sedimentary Iron Deposits of Putative Biogenic Origin .....                                             | 322        |
| 16.11             | Microbial Mobilization of Iron from Minerals in Ore, Soil,<br>and Sediments .....                       | 325        |
| 16.12             | Microbes and Iron Cycle .....                                                                           | 326        |
| 16.13             | Summary .....                                                                                           | 327        |
|                   | References .....                                                                                        | 329        |
| <b>Chapter 17</b> | <b>Geomicrobiology of Manganese .....</b>                                                               | <b>347</b> |
| 17.1              | Occurrence of Manganese in Earth's Crust .....                                                          | 347        |
| 17.2              | Geochemically Important Properties of Manganese .....                                                   | 347        |
| 17.3              | Biological Importance of Manganese .....                                                                | 348        |

|          |                                                                                                                    |     |
|----------|--------------------------------------------------------------------------------------------------------------------|-----|
| 17.4     | Manganese-Oxidizing and Manganese-Reducing Bacteria and Fungi.....                                                 | 348 |
| 17.4.1   | Manganese-Oxidizing Bacteria and Fungi.....                                                                        | 348 |
| 17.4.2   | Manganese-Reducing Bacteria and Fungi.....                                                                         | 351 |
| 17.5     | Biooxidation of Manganese.....                                                                                     | 352 |
| 17.5.1   | Enzymatic Manganese Oxidation .....                                                                                | 352 |
| 17.5.2   | Group I Manganese Oxidizers .....                                                                                  | 354 |
| 17.5.2.1 | Subgroup Ia.....                                                                                                   | 354 |
| 17.5.2.2 | Subgroup Ib.....                                                                                                   | 357 |
| 17.5.2.3 | Subgroup Ic .....                                                                                                  | 357 |
| 17.5.2.4 | Subgroup Id.....                                                                                                   | 358 |
| 17.5.2.5 | Uncertain Subgroup Affiliations.....                                                                               | 359 |
| 17.5.3   | Group II Manganese Oxidizers .....                                                                                 | 359 |
| 17.5.4   | Group III Manganese Oxidizers.....                                                                                 | 362 |
| 17.5.5   | Nonenzymatic Manganese Oxidation .....                                                                             | 362 |
| 17.6     | Bioreduction of Manganese.....                                                                                     | 363 |
| 17.6.1   | Organisms Capable of Reducing Manganese Oxides Only Anaerobically .....                                            | 364 |
| 17.6.2   | Reduction of Manganese Oxides by Organisms Capable of Reducing Manganese Oxides Aerobically and Anaerobically..... | 365 |
| 17.6.3   | Bacterial Reduction of Manganese(III).....                                                                         | 370 |
| 17.6.4   | Nonenzymatic Reduction of Manganese Oxides .....                                                                   | 371 |
| 17.7     | Bioaccumulation of Manganese .....                                                                                 | 372 |
| 17.8     | Microbial Manganese Deposition in Soil and on Rocks .....                                                          | 375 |
| 17.8.1   | Soil.....                                                                                                          | 375 |
| 17.8.2   | Rocks .....                                                                                                        | 377 |
| 17.8.3   | Ores .....                                                                                                         | 378 |
| 17.9     | Microbial Manganese Deposition in Freshwater Environments .....                                                    | 379 |
| 17.9.1   | Bacterial Manganese Oxidation in Springs.....                                                                      | 379 |
| 17.9.2   | Bacterial Manganese Oxidation in Lakes .....                                                                       | 379 |
| 17.9.3   | Bacterial Manganese Oxidation in Water Distribution Systems.....                                                   | 383 |
| 17.10    | Microbial Manganese Deposition in Marine Environments .....                                                        | 384 |
| 17.10.1  | Microbial Manganese Oxidations in Bays, Estuaries, Inlets, the Black Sea, etc. ....                                | 385 |
| 17.10.2  | Manganese Oxidation in Mixed Layer of Ocean .....                                                                  | 386 |
| 17.10.3  | Manganese Oxidation on Ocean Floor.....                                                                            | 387 |
| 17.10.4  | Manganese Oxidation around Hydrothermal Vents.....                                                                 | 392 |
| 17.10.5  | Bacterial Manganese Precipitation in Seawater Column .....                                                         | 396 |
| 17.11    | Microbial Mobilization of Manganese in Soils and Ores .....                                                        | 397 |
| 17.11.1  | Soils .....                                                                                                        | 397 |
| 17.11.2  | Ores .....                                                                                                         | 398 |
| 17.12    | Microbial Mobilization of Manganese in Freshwater Environments.....                                                | 399 |
| 17.13    | Microbial Mobilization of Manganese in Marine Environments .....                                                   | 400 |
| 17.14    | Microbial Manganese Reduction and Mineralization of Organic Matter.....                                            | 401 |
| 17.15    | Microbial Role in Manganese Cycle in Nature .....                                                                  | 402 |
| 17.16    | Summary .....                                                                                                      | 405 |
|          | References .....                                                                                                   | 406 |

|                   |                                                                                                      |     |
|-------------------|------------------------------------------------------------------------------------------------------|-----|
| <b>Chapter 18</b> | Geomicrobial Interactions with Chromium, Molybdenum, Vanadium, Uranium, Polonium, and Plutonium..... | 421 |
| 18.1              | Microbial Interaction with Chromium .....                                                            | 421 |
| 18.1.1            | Occurrence of Chromium.....                                                                          | 421 |
| 18.1.2            | Chemically and Biologically Important Properties.....                                                | 421 |
| 18.1.3            | Mobilization of Chromium with Microbially Generated Lixiviants .....                                 | 422 |
| 18.1.4            | Biooxidation of Chromium(III).....                                                                   | 422 |
| 18.1.5            | Bioreduction of Chromium(VI).....                                                                    | 422 |
| 18.1.6            | <i>In Situ</i> Chromate Reducing Activity .....                                                      | 426 |
| 18.1.7            | Applied Aspects of Chromium(VI) Reduction .....                                                      | 427 |
| 18.2              | Microbial Interaction with Molybdenum .....                                                          | 427 |
| 18.2.1            | Occurrence and Properties of Molybdenum .....                                                        | 427 |
| 18.2.2            | Microbial Oxidation and Reduction.....                                                               | 427 |
| 18.3              | Microbial Interaction with Vanadium .....                                                            | 428 |
| 18.3.1            | Bacterial Oxidation of Vanadium.....                                                                 | 428 |
| 18.4              | Microbial Interaction with Uranium .....                                                             | 429 |
| 18.4.1            | Occurrence and Properties of Uranium.....                                                            | 429 |
| 18.4.2            | Microbial Oxidation of U(IV).....                                                                    | 429 |
| 18.4.3            | Microbial Reduction of U(IV).....                                                                    | 430 |
| 18.4.4            | Bioremediation of Uranium Pollution .....                                                            | 431 |
| 18.5              | Bacterial Interaction with Polonium.....                                                             | 432 |
| 18.6              | Bacterial Interaction with Plutonium .....                                                           | 432 |
| 18.7              | Summary .....                                                                                        | 432 |
|                   | References .....                                                                                     | 433 |
| <b>Chapter 19</b> | Geomicrobiology of Sulfur .....                                                                      | 439 |
| 19.1              | Occurrence of Sulfur in Earth's Crust.....                                                           | 439 |
| 19.2              | Geochemically Important Properties of Sulfur.....                                                    | 439 |
| 19.3              | Biological Importance of Sulfur.....                                                                 | 440 |
| 19.4              | Mineralization of Organic Sulfur Compounds .....                                                     | 440 |
| 19.5              | Sulfur Assimilation .....                                                                            | 441 |
| 19.6              | Geomicrobially Important Types of Bacteria That React with Sulfur and Sulfur Compounds.....          | 442 |
| 19.6.1            | Oxidizers of Reduced Sulfur.....                                                                     | 442 |
| 19.6.2            | Reducers of Oxidized Forms of Sulfur .....                                                           | 446 |
| 19.6.2.1          | Sulfate Reduction.....                                                                               | 446 |
| 19.6.2.2          | Sulfite Reduction.....                                                                               | 448 |
| 19.6.2.3          | Reduction of Elemental Sulfur .....                                                                  | 448 |
| 19.7              | Physiology and Biochemistry of Microbial Oxidation of Reduced Forms of Sulfur .....                  | 449 |
| 19.7.1            | Sulfide.....                                                                                         | 449 |
| 19.7.1.1          | Aerobic Attack .....                                                                                 | 449 |
| 19.7.1.2          | Anaerobic Attack .....                                                                               | 450 |
| 19.7.1.3          | Oxidation of Sulfide by Heterotrophs and Mixotrophs ...                                              | 451 |
| 19.7.2            | Elemental Sulfur.....                                                                                | 451 |
| 19.7.2.1          | Aerobic Attack .....                                                                                 | 451 |
| 19.7.2.2          | Anaerobic Oxidation of Elemental Sulfur.....                                                         | 451 |
| 19.7.2.3          | Disproportionation of Sulfur.....                                                                    | 451 |

|           |                                                                                                         |     |
|-----------|---------------------------------------------------------------------------------------------------------|-----|
| 19.7.3    | Sulfite Oxidation.....                                                                                  | 452 |
| 19.7.3.1  | Oxidation by Aerobes .....                                                                              | 452 |
| 19.7.3.2  | Oxidation by Anaerobes .....                                                                            | 453 |
| 19.7.4    | Thiosulfate Oxidation.....                                                                              | 453 |
| 19.7.4.1  | Disproportionation of Thiosulfate .....                                                                 | 455 |
| 19.7.5    | Tetrathionate Oxidation.....                                                                            | 456 |
| 19.7.6    | Common Mechanism for Oxidizing Reduced Inorganic<br>Sulfur Compounds in Domain Bacteria .....           | 456 |
| 19.8      | Autotrophic and Mixotrophic Growth on Reduced Forms of Sulfur.....                                      | 456 |
| 19.8.1    | Energy Coupling in Bacterial Sulfur Oxidation.....                                                      | 456 |
| 19.8.2    | Reduced Forms of Sulfur as Sources of Reducing Power<br>for CO <sub>2</sub> Fixation by Autotrophs..... | 457 |
| 19.8.2.1  | Chemosynthetic Autotrophs.....                                                                          | 457 |
| 19.8.2.2  | Photosynthetic Autotrophs.....                                                                          | 457 |
| 19.8.3    | CO <sub>2</sub> Fixation by Autotrophs .....                                                            | 457 |
| 19.8.3.1  | Chemosynthetic Autotrophs.....                                                                          | 457 |
| 19.8.3.2  | Photosynthetic Autotrophs.....                                                                          | 458 |
| 19.8.4    | Mixotrophy .....                                                                                        | 458 |
| 19.8.4.1  | Free-Living Bacteria .....                                                                              | 458 |
| 19.8.5    | Unusual Consortia .....                                                                                 | 458 |
| 19.9      | Anaerobic Respiration Using Oxidized Forms of Sulfur as Terminal<br>Electron Acceptors .....            | 459 |
| 19.9.1    | Reduction of Fully or Partially Oxidized Sulfur.....                                                    | 459 |
| 19.9.2    | Biochemistry of Dissimilatory Sulfate Reduction .....                                                   | 459 |
| 19.9.3    | Sulfur Isotope Fractionation.....                                                                       | 461 |
| 19.9.4    | Reduction of Elemental Sulfur .....                                                                     | 462 |
| 19.9.5    | Reduction of Thiosulfate .....                                                                          | 463 |
| 19.9.6    | Terminal Electron Acceptors Other Than Sulfate, Sulfite,<br>Thiosulfate, or Sulfur .....                | 463 |
| 19.9.7    | Oxygen Tolerance of Sulfate-Reducers .....                                                              | 464 |
| 19.10     | Autotrophy, Mixotrophy, and Heterotrophy among Sulfate-Reducing<br>Bacteria.....                        | 464 |
| 19.10.1   | Autotrophy .....                                                                                        | 464 |
| 19.10.2   | Mixotrophy .....                                                                                        | 465 |
| 19.10.3   | Heterotrophy .....                                                                                      | 465 |
| 19.11     | Biodeposition of Native Sulfur .....                                                                    | 466 |
| 19.11.1   | Types of Deposits .....                                                                                 | 466 |
| 19.11.2   | Examples of Syngenetic Sulfur Deposition.....                                                           | 466 |
| 19.11.2.1 | Cyrenaican Lakes, Libya, North Africa .....                                                             | 466 |
| 19.11.2.2 | Lake Senoye .....                                                                                       | 469 |
| 19.11.2.3 | Lake Eyre.....                                                                                          | 469 |
| 19.11.2.4 | Solar Lake .....                                                                                        | 470 |
| 19.11.2.5 | Thermal Lakes and Springs.....                                                                          | 470 |
| 19.11.3   | Examples of Epigenetic Sulfur Deposits .....                                                            | 472 |
| 19.11.3.1 | Sicilian Sulfur Deposits .....                                                                          | 472 |
| 19.11.3.2 | Salt Domes .....                                                                                        | 472 |
| 19.11.3.3 | Gaurdak Sulfur Deposit.....                                                                             | 474 |
| 19.11.3.4 | Shor-Su Sulfur Deposit .....                                                                            | 474 |
| 19.11.3.5 | Kara Kum Sulfur Deposit.....                                                                            | 475 |

|                   |                                                                                  |            |
|-------------------|----------------------------------------------------------------------------------|------------|
| 19.12             | Microbial Role in Sulfur Cycle .....                                             | 475        |
| 19.13             | Summary .....                                                                    | 476        |
|                   | References .....                                                                 | 477        |
| <b>Chapter 20</b> | <b>Biogenesis and Biodegradation of Sulfide Minerals at Earth's Surface.....</b> | <b>491</b> |
| 20.1              | Introduction .....                                                               | 491        |
| 20.2              | Natural Origin of Metal Sulfides.....                                            | 491        |
| 20.2.1            | Hydrothermal Origin (Abiotic).....                                               | 491        |
| 20.2.2            | Sedimentary Metal Sulfides of Biogenic Origin .....                              | 493        |
| 20.3              | Principles of Metal Sulfide Formation .....                                      | 494        |
| 20.4              | Laboratory Evidence in Support of Biogenesis of Metal Sulfides .....             | 495        |
| 20.4.1            | Batch Cultures .....                                                             | 495        |
| 20.4.2            | Column Experiment: Model for Biogenesis of Sedimentary<br>Metal Sulfides.....    | 497        |
| 20.5              | Biooxidation of Metal Sulfides.....                                              | 498        |
| 20.5.1            | Organisms Involved in Biooxidation of Metal Sulfides .....                       | 498        |
| 20.5.2            | Direct Oxidation .....                                                           | 499        |
| 20.5.3            | Indirect Oxidation .....                                                         | 503        |
| 20.5.4            | Pyrite Oxidation .....                                                           | 504        |
| 20.6              | Bioleaching of Metal Sulfide and Uraninite Ores .....                            | 507        |
| 20.6.1            | Metal Sulfide Ores.....                                                          | 507        |
| 20.6.2            | Uraninite Leaching.....                                                          | 511        |
| 20.6.3            | Mobilization of Uranium in Granitic Rocks by Heterotrophs.....                   | 512        |
| 20.6.4            | Study of Bioleaching Kinetics.....                                               | 513        |
| 20.6.5            | Industrial versus Natural Bioleaching.....                                       | 513        |
| 20.7              | Bioextraction of Metal Sulfide Ores by Complexation .....                        | 513        |
| 20.8              | Formation of Acid Coal Mine Drainage .....                                       | 514        |
| 20.8.1            | New Discoveries Relating to Acid Mine Drainage .....                             | 515        |
| 20.9              | Summary .....                                                                    | 517        |
|                   | References .....                                                                 | 518        |
| <b>Chapter 21</b> | <b>Geomicrobiology of Selenium and Tellurium.....</b>                            | <b>527</b> |
| 21.1              | Occurrence in Earth's Crust .....                                                | 527        |
| 21.2              | Biological Importance .....                                                      | 527        |
| 21.3              | Toxicity of Selenium and Tellurium .....                                         | 528        |
| 21.4              | Biooxidation of Reduced Forms of Selenium.....                                   | 528        |
| 21.5              | Bioreduction of Oxidized Selenium Compounds.....                                 | 528        |
| 21.5.1            | Other Products of Selenate and Selenite Reduction .....                          | 530        |
| 21.5.2            | Selenium Reduction in the Environment.....                                       | 531        |
| 21.6              | Selenium Cycle .....                                                             | 532        |
| 21.7              | Biooxidation of Reduced Forms of Tellurium.....                                  | 532        |
| 21.8              | Bioreduction of Oxidized Forms of Tellurium.....                                 | 533        |
| 21.9              | Summary .....                                                                    | 533        |
|                   | References .....                                                                 | 534        |
| <b>Chapter 22</b> | <b>Geomicrobiology of Fossil Fuels .....</b>                                     | <b>537</b> |
| 22.1              | Introduction .....                                                               | 537        |
| 22.2              | Natural Abundance of Fossil Fuels .....                                          | 537        |