

Contents

ABOUT THE EDITORS — v

HISTORICAL DEVELOPMENT
AND PERSPECTIVES OF THE SERIES — vii

PREFACE TO VOLUME 17 — ix

CONTRIBUTORS TO VOLUME 17 — xix

TITLES OF VOLUMES 1–44 IN THE
METAL IONS IN BIOLOGICAL SYSTEMS SERIES — xxiii

CONTENTS OF VOLUMES IN THE
METAL IONS IN LIFE SCIENCES SERIES — xxv

Wolfgang Maret

**1 THE BIOINORGANIC CHEMISTRY OF LEAD IN THE CONTEXT
OF ITS TOXICITY — 1**

Abstract — 2

1. Introduction — 2
2. Lead Chemistry with Regard to Biochemistry — 3
3. History and Manufacturing of Lead-Containing Materials — 5
4. Safe Levels of Exposures? — 7
5. Regulatory Levels for Lead in Water, Food, and Air — 7
6. Transport in Blood and Cellular Uptake — 8
7. Lead Toxicity — 9
8. Cellular and Molecular Actions — 12
9. General Conclusions — 16

Acknowledgment — 17

Abbreviations — 17

References — 18

Jay T. Cullen and Jason McAlister

**2 BIOGEOCHEMISTRY OF LEAD. ITS RELEASE TO THE
ENVIRONMENT AND CHEMICAL SPECIATION — 21**

Abstract — 22

1. Introduction — 22

2.	Geochemistry of Lead	— 23
3.	Mobilization of Lead	— 25
4.	Lead in the Atmosphere	— 27
5.	Lead in the Terrestrial and Freshwater Environment	— 30
6.	Lead in Ocean Waters	— 34
7.	Summary and Conclusions	— 41
	Acknowledgement	— 41
	Abbreviations and Definitions	— 42
	References	— 42

Peter C. Hauser

3 ANALYTICAL METHODS FOR THE DETERMINATION OF LEAD IN THE ENVIRONMENT — 49

Abstract — 49

1. Introduction — 49
2. Sampling — 51
3. Spectrophotometry — 53
4. X-ray Fluorescence — 54
5. Electrochemical Methods — 54
6. Atomic Spectroscopy — 56
7. Speciation — 57

Abbreviations — 58

References — 58

Bartosz Tylkowski and Renata Jastrzęb

4 SMART CAPSULES FOR LEAD REMOVAL FROM INDUSTRIAL WASTEWATER — 61

Abstract — 61

1. Lead Ion Separation from Wastewater — 62
2. Encapsulation Technology — 63
3. Alginate-Based Capsules — 64
4. Carbon Nanotubes Core-in-Hematite Capsules — 71
5. Polymer Swelling Capsules — 74
6. General Conclusions — 75

Acknowledgments — 76

Abbreviations and Definitions — 76

References — 76

Theodora J. Stewart

5 LEAD SPECIATION IN MICROORGANISMS — 79

Abstract — 80

1. Introduction — 80
2. Intracellular Metal Speciation Techniques — 81
3. Intracellular Metal Localization Techniques — 86
4. Lead Speciation in Microorganisms — 88
5. Remaining Questions and Future Directions — 92

Acknowledgment	— 93
Abbreviations	— 93
References	— 94

Katrin Klotz and Thomas Göen

6 HUMAN BIOMONITORING OF LEAD EXPOSURE — 99

Abstract	— 100
1. Introduction	— 100
2. Pharmacokinetics	— 102
3. Biomarkers of Exposure	— 103
4. Biomarkers of Effect	— 112
5. Conclusions	— 115
Abbreviations and Definitions	— 115
References	— 116

Katsuyuki Aoki, Kazutaka Murayama, and Ning-Hai Hu

7 SOLID STATE STRUCTURES OF LEAD COMPLEXES WITH RELEVANCE FOR BIOLOGICAL SYSTEMS — 123

Abstract	— 124
1. Introduction	— 125
2. Amino Acid, Small-Peptide, and Protein Complexes	— 126
3. Nucleic Acid Constituent Complexes	— 157
4. Simple-Carbohydrate Complexes	— 169
5. Complexes of Other Biorelevant Ligands	— 179
6. Concluding Remarks	— 191
Abbreviations	— 192
References	— 193

Etelka Farkas and Péter Buglyó

8 LEAD(II) COMPLEXES OF AMINO ACIDS, PEPTIDES, AND OTHER RELATED LIGANDS OF BIOLOGICAL INTEREST — 201

Abstract	— 202
1. Introduction	— 202
2. Complexation of Lead(II)	— 204
3. Lead(II) Complexes of Amino Acids and Derivatives	— 208
4. Lead(II) Complexes of Hydroxamic Acids, Related Small Ligands, and Hydroxamic Acid Derivatives of Amino Acids	— 215
5. Complexes of Lead(II) with Small Peptides and Related Ligands	— 224
6. Complexes of Lead(II) with Thiol-Rich Natural Peptides	— 228
7. Factors Determining Lead Selectivity against Zinc, Calcium or Cadmium	— 231
Acknowledgments	— 235
Abbreviations and Definitions	— 235
References	— 236

Daisy L. Wong, Maureen E. Merrifield-MacRae, and Martin J. Stillman

9 LEAD(II) BINDING IN METALLOTHIONEINS — 241

Abstract — **242**

1. Introduction — **242**

2. Metallothioneins and Toxic Metals — **250**

3. Metallothioneins and Lead — **255**

4. Conclusions — **265**

Acknowledgments — **266**

Abbreviations — **266**

References — **266**

Virginia Cangelosi, Leela Ruckthong, and Vincent L. Pecoraro

10 LEAD(II) BINDING IN NATURAL AND ARTIFICIAL PROTEINS — 271

Abstract — **272**

1. Introduction — **272**

2. Lead in Natural Systems — **273**

3. Lead Chemistry with Designed Proteins — **285**

4. General Conclusions — **309**

Acknowledgment — **310**

Abbreviations and Definitions — **310**

References — **312**

Astrid Sigel, Bert P. Operschall, and Helmut Sigel

11 COMPLEX FORMATION OF LEAD(II) WITH NUCLEOTIDES AND THEIR CONSTITUENTS — 319

Abstract — **320**

1. Introduction — **321**

2. Comparisons of the Properties of Lead(II) with Those of Related Divalent Metal Ions — **323**

3. Lead(II) Interactions with Hydroxyl Groups and Sugar Residues — **330**

4. Interactions of Lead(II) with Nucleobase Residues — **339**

5. Complexes of Lead(II) with Phosphates — **362**

6. Lead(II) Complexes of Nucleotides — **366**

7. Lead(II) Binding in Dinucleotides — **380**

8. Concluding Remarks — **391**

Acknowledgment — **392**

Abbreviations and Definitions — **392**

References — **394**

Joana Palou-Mir, Miquel Barceló-Oliver, and Roland K. O. Sigel

12 THE ROLE OF LEAD(II) IN NUCLEIC ACIDS — 403

Abstract — **404**

1. Introduction — **404**

2. Relevant Properties of Lead(II) in Comparison to Other Divalent Metal Ions — **405**
3. Structures of Lead(II) Binding Sites in Nucleic Acids — **406**
4. Lead(II) as Hydrolytic Cleavage Agent to Probe Divalent Metal Ion Binding Sites and Single-Stranded RNA Regions — **412**
5. Lead(II) as Catalytic and Structural Metal Ion — **416**
6. Concluding Remarks and Future Directions — **429**
- Acknowledgments — **429**
- Abbreviations and Definitions — **429**
- References — **431**

Hana R. Pohl, Susan Z. Ingber, and Henry G. Abadin

13 HISTORICAL VIEW ON LEAD: GUIDELINES AND REGULATIONS — 435

Abstract — **436**

1. Introduction — **436**
2. Historical Views on Lead Toxicity — **437**
3. Development of Guidelines and Regulations in the U.S. — **438**
4. Development of Guidelines and Regulations Around the World — **445**
5. Conclusion — **464**
- Abbreviations — **464**
- References — **465**

Montserrat Filella and Josep Bonet

14 ENVIRONMENTAL IMPACT OF ALKYL LEAD(IV) DERIVATIVES: PERSPECTIVE AFTER THEIR PHASE-OUT — 471

Abstract — **472**

1. Introduction — **472**
2. The Past — **474**
3. Current Uses — **476**
4. Chemistry — **476**
5. After the Phase-Out — **480**
6. Lessons and Perspectives — **486**
- Abbreviations — **487**
- References — **487**

Hendrik Küpper

15 LEAD TOXICITY IN PLANTS — 491

Abstract — **491**

1. Introduction: Environmental Relevance of Lead Toxicity in Plants — **492**
2. Critical Review of Proposed Mechanisms of Lead Toxicity in Plants — **493**
3. Conclusions and Outlook — **497**
- Acknowledgments — **498**

Abbreviations — **498**

References — **498**

Samuel Caito, Ana Carolina B. Almeida Lopes, Monica M. B. Paoliello, and Michael Aschner

16 TOXICOLOGY OF LEAD AND ITS DAMAGE TO MAMMALIAN ORGANS — 501

Abstract — **502**

1. Introduction — **502**

2. Neurotoxicity of Lead — **507**

3. Immuno- and Hematotoxicity of Lead — **510**

4. Nephrotoxicity of Lead — **512**

5. Reproductive Toxicity of Lead — **514**

6. Osteotoxicity of Lead — **515**

7. Epidemiological Studies and Variables Associated with Low Blood Lead Levels — **517**

8. Concluding Remarks — **521**

Acknowledgments — **527**

Abbreviations — **527**

References — **528**

SUBJECT INDEX — 535