Book Reviews *

Biomimetic Materials Chemistry. Edited by Stephen Mann (University of Bath). VCH: New York. 1996. xxi + 383 pp. $125.00. ISBN 1-56081-669-4.

The world is replete with forms that reveal the remarkable ability of living systems to construct materials. From bones, tusks, and teeth to shells, stromatolites, and coral reefs, natural constructs inspire awe and wonder. But, it is not only the shapes and functions that are unusual. The inorganic phases found in or around organisms are often not produced under similar conditions of pH and temperature in the absence of the living system. For example, a metastable ferrihydrite phase is deposited inside the ferritin protein shell, while the spicules of ascidians contain vaterite rather than the expected calcite phase of $CaCO_3$.

Key questions are raised: What are the major components of these remarkable mineralized (often composite) structures? What mechanisms are used by the biological system to control the phase, size, and shape of the inorganic components? What do these structures look like at the various magnifications (length scales) available to modern science? What underlying physical and chemical principles does nature exploit to create these forms? Can biology teach us something about how to construct materials?

This volume provides some answers to these questions with distinct emphasis on the last one. *Biomimetic Materials Chemistry* edited by Stephen Mann brings us a broad survey of this burgeoning field. The biomimetic adjective is applied liberally to describe activities in which ideas and/or molecules from biology are used in the construction of materials that may be distinctly nonbiological, either in composition or in use. As the authors make clear, the term biomimetic, in its strictest sense, does not convey the spirit of a number of the contributions. Much of the research discussed here, while clearly inspired by (or at least envious of) biology, does not *directly* mimic biological systems. Nevertheless, ideas of structural hierarchy, organic/inorganic templating, compartmentalized/controlled crystallization, epitaxy, vectorial growth, and self-assembly permeate this volume. While the exact biological connection may be tenuous, the stimulus of biological inspiration fills this book.

The interdisciplinary nature of the field, and, especially, of this collection, is clearly indicated by the affiliations of the 22 contributors. The authors represent departments of Chemistry, Physics, Materials Science and Engineering, Molecular Biology, Biology, Microbiology, Environmental Toxicology, and Orthopedic Surgery. The nonbiological, "unnatural" inorganic phases discussed include CdS, CdSe, TiO_2, $BaSO_4$, $BaTiO_3$, Pd, Pt, and Ag, aptly illustrating the generality of the concepts and methods.

The first two chapters, by Mann and by Kuhn, Fink, and Heuer, respectively, present overviews of the field. The principles (or principal themes) of biomineralization include control of inorganic crystal phase, size, and shape by templating, compartmentalization, and matrix effects; the hierarchy of length scales and their integration; and the processing (metamorphosis) of formed crystallites. The generalization of these biologically derived ideas to inorganic/organic systems is the theme of these introductory chapters, which also define some of the jargon that is evolving in this field. While some of this terminology, mostly borrowed from biology, is apt, some of it seems contrived. Terms such as metamorphosis, vectorial regulation, and microarchitecture are useful, but others, such as molecular tectonics (from tekton = builder) or molecular blueprinting, do not (at least to this reviewer) convey additional useful information. This field has great potential for jargon, which one hopes will be kept under control.

Chapters on biogenic formation of CdS, on ferritin as a molecular reaction chamber, and on the use of bacterial threads in the formation of mineralized products (bionites) are contributed by Dameron and Winge, by T. Douglas, and by Mendelson, respectively. These offerings illustrate the use of an intact biological or biochemical system to make inorganic materials that are not found in the realm of biology.

K. Douglas describes the construction of nanoheterostructures using a combination of biological and inorganic components, and Heywood illustrates the clever use of ligands and surfactants, both natural and synthetic, to alter the growth and morphology of crystalline phases and faces. Meldrum and Fendler highlight the Langmuir−Blodgett technique used to organize particulate films while Katari, Colvin, and Alivasatos use patterned solid surfaces to deposit semiconductor nanocrystals. These chapters illustrate the use of eclectic combinations of biological and inorganic compounds to elicit desired structural effects.

Aksay, Staley, and Prud'homme use biogenic additives for the processing of ceramic precursors, while the contributions of Calvert and of Gianellis each describe organic/inorganic protocols, which use polymers and additives in producing materials that qualify, *inter alia*, as bioinspired ceramics.

While control of the rate of formation, shape, or size of crystallites is a major theme of this volume, it is only a slight extension to consider the *prevention* of mineralization entirely. Just as chemical manipulations allow control of the types of crystals that do form, Sikes and Wierzbicki illustrate the use of related compounds, mostly anionic poly(amino acids), as antiscalant, antifreeze, and gelling agents.

This book shows that ideas and molecules from biology can be used in the development of controlled mineralization systems. Although this is a fast-moving field with new developments continually emerging, the present volume has features that should allow it to endure for some time. First, it is well referenced, with all articles having citations to 1994 papers. Second, the first 2 articles and parts of many of the 11 subsequent articles explain carefully the philosophy, jargon, and technical merits of their approaches. There is ample reference to the guiding systems, i.e., biomineralization texts and literature, but this is the first monograph (excluding conference proceedings) to emphasize *biomimetic* material science. Moreover, the contingent of materials scientists among the authors assures that processing of materials as well as their synthesis per se is a major part of the book.

The chemistry in this volume is well presented, always interesting, and sometimes close enough to the biology that the obvious connections and inspirational threads can be traced. In other cases, the connections are more tenuous. Nevertheless, having all these excellent chapters in one place, each seeking to make the biological/materials science connection, cannot help but continue to inspire new chemistry. This collection is recommended to those seeking an introduction and overview of this hot and likely expanding field.

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Kirk-Othmer Encyclopedia of Chemical Technology, Volume 19: Pigments to Powders, Handling. Edited by Jacqueline I. Kroschwitz and Mary Howe-Grant. John Wiley & Sons: New York. 1996. xxviii + 1141 pp. $325.00. ISBN 0-471-52688-6.

This is the 19th volume of a 25-volume encyclopedia set, 4 volumes being published each year. The Fourth Edition is similar in format to the earlier editions with updates to the entries as necessary and the addition of several new subjects. This volume contains 31 entries ranging from Pigments to Handling Powders. This volume does not contain an index; however, paperback indexes are published every four volumes and the supplement and index volume are scheduled for publication in 1998.

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Alkaloids: Chemical and Biological Perspectives, Volume 10. Edited by S. William Pelletier (Institute for Natural Products Research and The University of Georgia−Athens). Pergamon: Oxford. 1996. xv + 430 pp. $190.00. ISBN 0-08-042791-X.

This monograph series provides interdisciplinary coverage of research relating to the chemistry and biological properties of alkaloids−a class of biologically active compounds of more than 10 000 members. The series features chapters on chemical properties and structure elucidation, synthesis, biosynthesis, taxonomy, spectroscopy, pharmacology, toxicology, and X-ray crystallography of alkaloids. Subject and organism indexes are included for each volume.

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