

NATURE'S NANOSTRUCTURES*

The Earth system, comprising geologic, hydrologic, biologic, atmospheric, and anthropic subsystems, cannot be studied effectively without crossing many traditional disciplinary boundaries. *Nature's Nanostructures* is a strategically named volume, edited by Amanda S. Barnard and Haibo Guo, that exemplifies not only the ease with which boundaries can be crossed but also the necessity of doing so.

There is a natural tendency in nanogeoscience to want to show how nanoparticles are "special" in that their chemical behavior differs from that of their macroscopic structural counterparts. While interesting and important, this can sometimes lead to the impression that nanoparticles are merely idiosyncratic, an oddity. Overall, this book gives a different impression—that nanoscale materials and structures are a major part of the world we live in. *Nature's Nanostructures* includes explorations into biomaterials, photonic crystals, extraterrestrial particles, aerosols, and anthropogenic/engineered particles in the environment. The book consists of an introductory overview and 20 chapters grouped into four categories: Nanominerals and Mineral Nanoparticles (with an emphasis on inorganic nanomaterials and aqueous settings), Biominerals, Nanoparticles in Space and in the Atmosphere, and Engineered Nanoparticles in the Environment. Covering these subjects in about 550 pages is a feat of brevity, considering that there are about 130 pages of references, along with a 9-page index and 20 blank or title pages between chapters. Separate from the 550-page text is a 32-page section at the end consisting of color versions of many of the figures in the text. The book is thus an unusually broad overview and not a deep exploration of one subject (though certain chapters might be considered exceptions). While some chapters delve into moderate mathematical detail, for the most part the chapters are relatively short and liberally referenced to encourage further reading.

An initial chapter attempts a rough quantification of global nanoparticle reservoirs and fluxes, akin to an elemental geochemical cycle. Following this are several chapters on oxides, particularly iron oxides and hydroxides, and a chapter on pyrite surface energies. Proceeding along largely inorganic lines, subsequent chapters deal with noble metal nanoparticles (including so-called "invisible gold" in sulfide ore minerals), diamondoids, and "negative curvature" nanoparticles (nanoscale pores) with a focus on uranium transport. The section on biominerals then starts with an overview of nanoscale biominerals of many different types (from shell and bone minerals to bio-

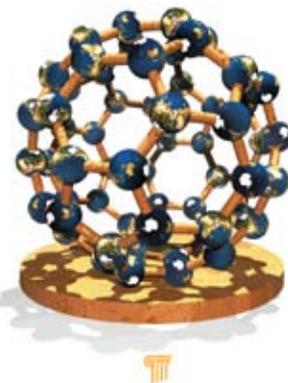
magnetites). The next two chapters are concerned with magnetic biominerals, including nanoscale magnetoreceptors in birds and bird navigation. A theory-based chapter deals with ways in which organisms can direct nucleation and growth of nanominerals. The last chapter in the section notes that "all iridescence in nature arises from photonic crystals" and discusses the case of photonic crystals in beetles. Anyone who has taught an introductory course in which the origin of the Solar System is related to literally nebulous "dust clouds" will appreciate the three chapters at the beginning of the section on nanoparticles in space and in the atmosphere. These chapters treat everything from vapor condensation models and aggregation to dust that enters the Earth's atmosphere. The discussion gradually comes down to Earth (sorry, I couldn't help it) in the form of a chapter on the formation of atmospheric aerosols. Aerosol-formation events mostly occur in the daytime, emphasizing the importance of photochemistry in such processes.

The final section covers engineered nanoparticles, although the degree to which nanoparticles are intentionally (as opposed to inadvertently) "engineered" is open to debate. The section essentially deals with anthropogenic nanoparticles in the environment. Diesel engines and bioparticles (including everything from viruses to pollen) exemplify inadvertent nanoparticle production. Chemical processes in industry taking advantage of chemical vapor deposition, particle deposition, and aggregated particle deposition result in nanomaterials that can also enter the environment. The final paragraphs in this chapter deal with the relatively new field of nanotoxicology. Allophane and imogolite in soils are treated next (with relevance to soil organic matter and carbon sequestration), followed by a final chapter focusing largely on organic nanomaterials in the environment and their transformations (one section even deals with engineered quantum dots and their effect on algal photosynthesis).

This is not a textbook in which one will find separate chapters on the chemical and physical underpinnings of nanoscience. No chapters are devoted to the origin of quantum size effects, to the nature of the aqueous electric double layer around nanoparticles, or to the lack of band bending and potential differences between the surface and interior of small particles. Some of this information is scattered throughout the chapters, of course, but the book largely assumes basic familiarity with physical chemistry.

Nature's Nanostructures

Edited by
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Nature's Nanostructures will be of interest to those wanting to learn more about the broad field of nanostructures in the environment. It will also be useful as a reference source, in which brief chapters are backed up with many references. It will be less useful as a textbook on nanogeoscience. That said, the book occupies an important niche between what one might call the "primary literature" (the papers referenced in each chapter of the book) and basic information that one can obtain in a few seconds in a Google search. It contains a great deal of information that is difficult to assemble in any other form. For anyone even remotely concerned with nanoparticles and nanoscience in the environment, this book is worth reading because it just might change and broaden one's perspective.

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