book should be accessible to a wide readership. It provides a fascinating insight into the author's journey of seeing and discovering as the early pictures of the Mandelbrot set started to reveal a whole new world. It gives a feeling for his philosophy and approach of experimental mathematics — an approach that has changed the way we think about mathematics and science. ■

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Living machinery

Bionanotechnology: Lessons from Nature
by David S. Goodsell
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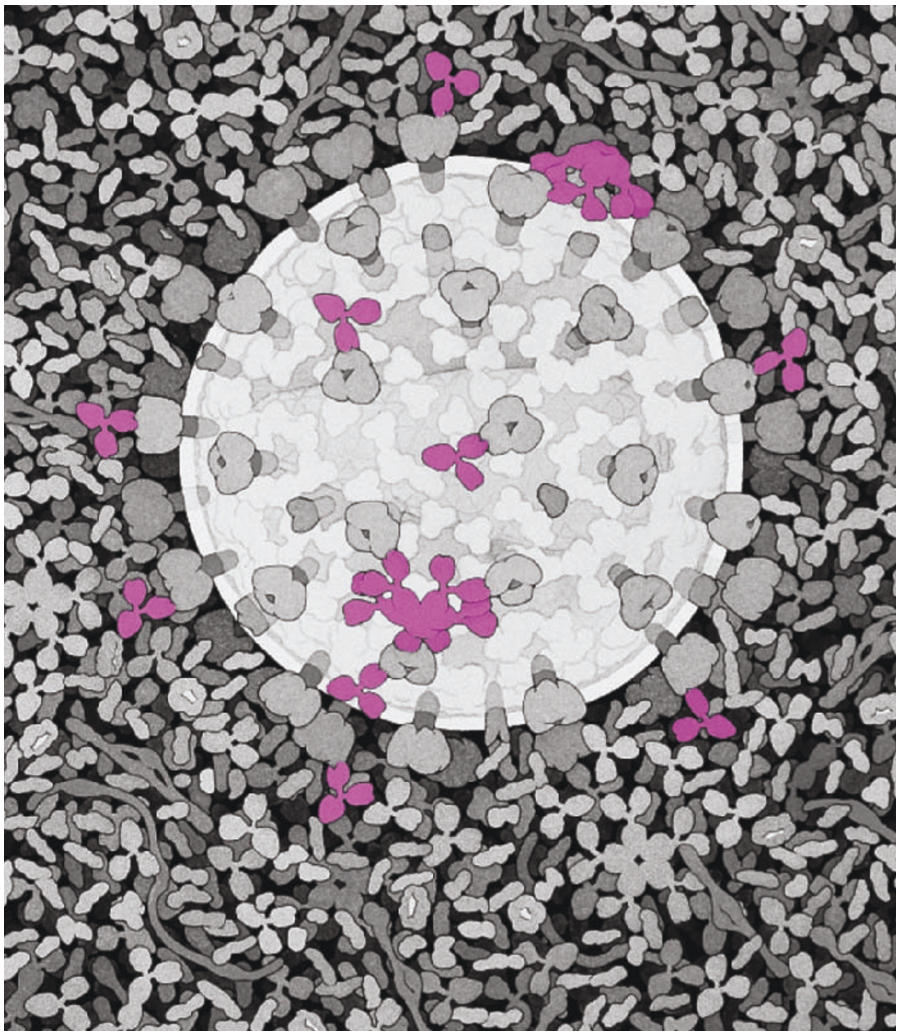
Christof M. Niemeyer

Nanotechnology is perfectly realized in biological systems. Cells are essentially biological assemblers that build thousands of custom-designed molecules and construct new assemblers. In *Bionanotechnology*, structural biologist David Goodsell describes what biology can teach us about engineering and manufacturing at the nanometre scale.

Goodsell kicks off with an introduction to the history of nanotechnology, which was pioneered by Richard Feynman and widely popularized by Eric Drexler's evocative idea of a self-replicating assembler building nanoscale devices atom by atom. He then takes a detailed look at the composition and structural principles of biomolecules harnessed in the cell, describing numerous bionanomachines in action, ranging from proteins, nucleic acids and membranes, to enzyme catalysis, the machinery of DNA transcription and translation, and biomolecular motors. The basic functional principles of nature's nanotechnology are elucidated, in particular the information-driven synthesis of biological molecules, the energetics and regulation of biological processes, and the traffic across membranes and signal transduction along them. The mechanistic aspects of biomaterials are also highlighted, for instance the interplay of myosin and actin filaments within the muscle sarcomere.

Throughout this fascinating journey, many fundamental principles are highlighted to introduce the reader to the unfamiliar world of nature's nanotechnology: the various bonding forces, thermal motion, the negligibility of gravity and inertia at the nanoscale, molecular recognition, self-assembly and biomolecular flexibility.

A survey of what is known about the general principles underpinning the structure and function of natural nanomachines is rounded off by an overview of the techniques that biotechnology has at its disposal to harness and modify this machinery — for example, recombinant DNA and protein technology, biomolecular structure determination, modelling and the tailoring of proteins and nucleic acids by directed evolution. The author then describes exciting applications of bionanotechnology that were the subject of published research at the time of writing in mid-2002. These include projects involving nanomedicine, self-assembly at various length scales, harnessing biomolecular motors, DNA computers, artificial life and biomolecular/bio(in)organic hybrid materials.



Small wonder: antibodies (purple) are just one example of the way nature uses nanotechnology.

In the final chapter, Goodsell speculates about the future of bionanotechnology. He uses the best currently available data to relate three futuristic case studies: a "nanotube synthase" (an enzyme that would build nanotubes); a nanoscale assembler (a ribosome-like device that places molecular fragments in three-dimensional space with full positional control at the nanometre scale); and autonomous nanorobots that would inspect all the cells in the human body for mutations in the cancer-associated *p53* gene.

Bionanotechnology, being a synonym for nanobiotechnology, is a rapidly growing field that encompasses contributions from various disciplines, ranging from engineering and computational sciences to physics, chemistry and biology. Hence, there is an increasing need for a didactic textbook that provides a thorough introduction to biomolecular sciences and their impact on nanotechnology. Godsell's book is the first to meet this demand.

Written in the style of an excellent biochemistry textbook, *Bionanotechnology* points the reader to general principles of the biological nanoworld, and thus provides readers with guidance on the design of their own devices and systems. The intention of this book is to invite further reading, so one should not expect too many technical details taken from the growing literature in this field. There are many graphic illustrations of bionanomachines, although it is a pity that these were not reproduced in full colour. I can highly recommend this book. I enjoyed reading every single page. ■

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