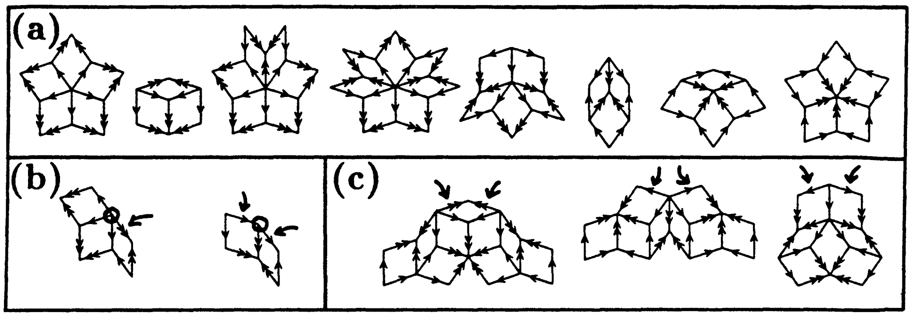
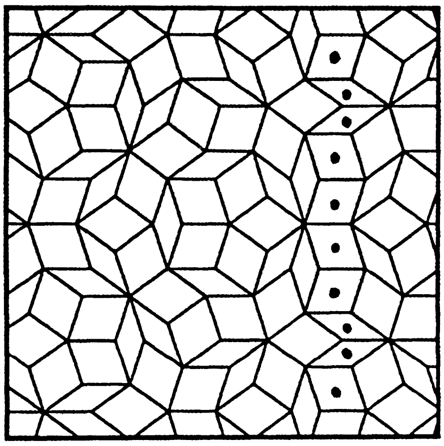


"The [Onoda-Steinhardt-DiVincenzo-Socolar] classification of sites for Penrose tiling growth. (a) The eight allowed vertex configurations, shown with the edge-arrow decoration of the tiles. (b) Examples of forced edges. There is only one way to add to the edges indicated, owing to the structure around the circled vertex. Note that in the case on the left, the edge is forced even though the entire vertex may be either the third or fourth from the left in (a). (c) The edges indicated are classified as marginal." [From J. Socolar's chapter in *Quasicrystals*]



"A perfect Penrose tiling. The dotted sequence of tiles is referred to as a track." [From Tin-Lun Ho's chapter in *Quasicrystals*]

selection is not parochial—some important Japanese and European work is also included. However, a more balanced portrait of the field would give more weight to structure determination and would include a summary of the extensive body of work that takes the scaling properties of quasicrystals (and Penrose tilings) as its starting point. I would have also liked to see a more complete picture of current research on related mathematical problems.

Despite these reservations, this book is timely and useful. The editors have assembled an impressive collection of essays on recent advances in many areas of quasicrystal studies, both experimental and theoretical. On the experimental side, there are reports on high-resolution electron microscopy and scanning tunnel microscopy, as well as studies of electronic transport, order and disorder in icosahedral alloys, and neutron scattering. On the theoretical side, there are discussions of tiling models, energy calculations, and even the possibility that some liquid crystals (chiral smectics) might be quasicrystals. Most of the contributions are well written and jargon-free, a noteworthy achievement in a field that is famous for its bewildering opacity.

The issues addressed in this book are central, and the authors are indeed "leading experts in their areas, and are engaged in the cutting-edge research that they describe." However, the editors' assertions aside, it is not a book for beginners. Readers approaching the subject for the first time are advised to spend some time acquiring the necessary background—for example, by way of *Introduction to Quasicrystals* (Academic Press, 1988) and *Introduction to the Mathematics of Quasicrystals* (Academic Press, 1989), both edited by Marko Jaric, or *The Physics of Quasicrystals* (World Scientific, 1987), edited by P. J. Steinhardt. That said, I recommend this book to those in the field and to everyone sufficiently interested in quasicrystals to invest the time and energy needed to understand them.

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Planetary Reconnoiter

Uranus. JAY T. BERGSTRALH, ELLIS D. MINER, and MILDRED SHAPLEY MATTHEWS, Eds. University of Arizona Press, Tucson, 1991. xiv, 1076 pp., illus. $65. Space Science Series. Based on a colloquium, Pasadena, CA, June 1988.

In 1781, Sir William Herschel found, quite by accident, the first new planet—that is, a planet that had been unknown to the ancient civilizations—in our solar system. Although the discovery of Uranus created quite a stir at the time, the remoteness of the planet caused it to remain very poorly understood for nearly two centuries. Until recently, textbooks and encyclopedias mentioned little more than the details of its discovery, its size and orbit, and a few other sparse facts. Uranus was believed, along with the other giant planets—Jupiter, Saturn, and Neptune—to be composed largely of the lighter elements, hydrogen and helium, along with some heavier materials, such as methane, water, and rock. Five small-to-medium-sized satellites had been discovered, and their individual orbital motions indicated that the rotation axis of Uranus was so strongly inclined to its orbital plane that the planet seemed to roll along on its side as it circled the sun.

About two decades ago technological advances in astronomical instrumentation began to give us new insight into the more remote bodies of our solar system. Uranus was found to be alone among the four giant planets in not radiating a measurable amount of excess, primordial heat. Water ice was identified on the surfaces of its larger satellites. In 1977, astronomers were taken aback by the surprising discovery of nine narrow rings surrounding Uranus, an event that forever deprived Saturn of its long-held unique status. Still, the tiny telescopic disk of Uranus remained nearly featureless to even the most advanced detectors, lacking the discrete clouds that could have revealed the planet's period of rotation and its global atmospheric circulation; to a large extent, Uranus remained an enigma. All this changed in 1986 when the Voyager 2 spacecraft flew through the Uranus system and sent back a wealth of scientific observations of this curious planet. Almost overnight, Uranus passed from the unknown to the known.

Uranus is the latest addition to the superb Space Science Series published by the University of Arizona Press and is based on a colloquium held at the Jet Propulsion Laboratory two years after the Voyager 2 encounter. Not surprisingly, the contributions strongly emphasize the data acquired by Voyager. The book presents an excellent, balanced review of our current perception of the entire Uranus system, including the interior and atmosphere of the planet itself and its rings, satellites, and magnetosphere. Although there is now a very much better understanding of the physics and chemistry that characterize the various components of the system, the reader will note that this new knowledge also poses many new questions and that much still remains to be learned. A case in point is Miranda. A mere 484 kilometers across and the smallest of the five earlier known Uranus satellites, Miranda was one of the great surprises to be captured by the Voyager cameras. Highly diverse and puzzling geological units are seen in close juxtaposition, with transition regions barely a few hundred meters wide. An entire chapter is allocated to this satellite alone. It begins, "Miranda is arguably the strangest body to have been reconnoitered in the age of planetary exploration, especially if the criterion is the gulf between unique characteristics and our understanding of their causes." In a sense, this single statement says it all.

The illustrations in the book, including pictures, diagrams, and several color plates, are clear and well reproduced. As is typical of the Space Science Series, a comprehensive bibliography and glossary are included. Researchers will welcome the bibliography, which contains some 1500 detailed references. The glossary provides invaluable assistance to the reader who may not be fully familiar with the terminology, abbreviations, and acronyms of contemporary planetary science. With the ever-increasing use of jargon and acronyms in today's scientific writing, the context can often be confusing, not only to the lay reader but even to those scientists who work in closely related fields. Unfortunately, inconsistencies in the content of the glossary—for example, the inclusion of acronyms for some, but not all, of the Voyager scientific instruments—would suggest that contributions to the glossary compilation were not uniform among the various authors.

The current state of funding for planetary exploration, both in this country and in Europe, is such that there can be little optimism that Uranus will be revisited by planetary spacecraft for at least a decade. And, though impressive advances in telescope design and instrumentation continue to improve the capability of gathering new knowledge from ground-based observatories, it seems unlikely that such facilities can add significantly to what Voyager has already shown us. This book is, and will continue to be, the primary source of information about the Uranus system at least to the turn of the millennium and probably longer.

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Buckyballs

Fullerenes. Synthesis, Properties, and Chemistry of Large Carbon Clusters. GEORGE S. HAMMOND and VALERIE J. KUCK, Eds. American Chemical Society, Washington, DC, 1991. xiv, 195 pp., illus. $44.95. ACS Symposium Series, 481. From a symposium, Atlanta, GA, April 1991.

It was less than two years ago that astrophysicists Krätschmer and Huffman reported the isolation of stable C_{60} and C_{70} molecules, now known as fullerenes or "buckyballs," from specially prepared graphite soot. These results substantiated previous work by Smalley, Kroto, and co-workers, who had not only suggested the structures (usually football and soccer-ball shapes, hence the term "buckyball"), but gave proof of their formation in the vapor phase. However, not until Krätschmer and Huffman's research made these compounds available on a macroscopic scale did study of their physical and chemical properties take off.

Fullerenes is the result of an American Chemical Society Fast-Breaking Events symposium organized only nine months after Krätschmer and Huffman's report, and it is remarkable that such a significant amount of pioneering research is presented in the volume. It opens with an editors' preface and an overview by Hammond. The succeeding 12 chapters include such diverse topics as synthetic approaches to C_{60} and other carbon clusters, theoretical studies, low-resolution, single-crystal x-ray structure determination, conductivity and superconductivity of alkali metal-doped C_{60} (a particularly intriguing subject with potentially great practical interest), the preparation and structural determination of the first well-defined monosubstituted C_{60} derivative (for example, osmylated C_{60}), mass spectrometry, and the chemical reactivity of C_{60}.

The expanding revelations of the properties and possible applications of fullerenes rightly fascinate chemists and physicists alike. Although the present pace of discovery will probably not continue unabated, these new caged-carbon allotropes are of great interest and their chemistry and physics hold substantial promise. How soon this promise will be fulfilled by practical application is difficult to judge. It is, however, reassuring that science continues to produce unexpected and fascinating results that open up new vistas.

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Immunological Reformulations

Metchnikoff and the Origins of Immunology. From Metaphor to Theory. ALFRED I. TAUBER and LEON CHERNYAK. Oxford University Press, New York, 1991. xx, 247 pp. + plates. $45. Monographs on the History and Philosophy of Biology.

Elie Metchnikoff clearly belongs in the pantheon of late-19th-century scientific medicine, alongside contemporaries such as Robert Koch and Paul Ehrlich. Born in 1845 as the fifth and youngest child on a minor Russian estate, Metchnikoff studied comparative zoology at the University of Kharkov and began his research career investigating the phylogenetic and ontogenetic development of a wide variety of invertebrate groups. In the 1870s he specialized in sponges and medusae in order to understand the origins of metazoans and the phylogenetic development of the digestive system.

In 1883, however, his career underwent a sudden reorientation—from comparative embryology to pathology. Today he is best known for the phagocyte theory of inflammation and immunity, which states that special amoeboid cells seek out and engulf pathogenic parasites and that inflammation is essentially this active response to the invading agent. Although most pathologists immediately opposed Metchnikoff's theory for its teleology, the gravest blows came from a number of studies in the late 1880s that showed that natural and acquired immunity was more likely mediated by a humoral factor. In 1890 Emil Behring and Shibasaburo Kitasato discovered serum antitoxins (later named antibodies), and thereafter the view that cells alone were responsible for immunity became increasingly untenable. Nevertheless, Metchnikoff did share the 1908 Nobel Prize with Paul Ehrlich, the leading proponent of the idea of antibody-mediated immunity.

Notwithstanding the renaissance of cellular immunology in the 1950s and 1960s, Metchnikoff has, until recently, been of interest only to historians of science and medicine. In a series of articles in *Cellular Immunology* and other journals, however, Boston University pathologist Alfred Tauber and philosopher Leon Chernyak have set out to resuscitate Metchnikoff, or rather his metaphysics, for present-day immunologists. Although their immediate philosophical motivation is not clearly explicated in the present book, a concurrently published work edited by Tauber (*Organism and the Origins of Self*, Kluwer, 1991) indicates that they have been challenged by the recent so-called autonomous network approach to the immune system, an epistemologically radical extension of Niels Jerne's well-known theory of idiotypic networks proposed in 1973.

Accordingly, notions of anti-reductionism, dialectics, and self-determining systems (albeit not autopoiesis) reverberate throughout this expanded book version of Tauber and Chernyak's articles. The authors' main claim is that the real novelty in Metchnikoff's phagocyte theory of inflammation and immunity was his reformulation of the notion of organismic integrity. Tra-