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The International System of Units (SI), 8th edition

Bureau International des Poids et Mesures, 2006
ISBN 92-822-2213-6

The Bureau International des Poids et Mesures has released its eighth edition of the *Système International d'Unités (the International System of Units)*, commonly called the SI Brochure. The brochure is published in hard copy and is also available in electronic form at <www.bipm.org/en/si/si_brochure/>.

The brochure defines and promotes the SI, which has been used around the world as the preferred language of science and technology since its adoption in 1948 through a resolution of the 9th Conférence Générale des Poids et Mesures (CGPM), known in English as the General Conference on Weights and Measures. The SI is a living system that evolves over time and reflects current best measurement practices; accordingly, this eighth edition contains a number of changes since the previous edition. As before, it defines of all the base units and includes all the resolutions and recommendations of the CGPM and the Comité International des Poids et Mesures (CIPM), known in English as the International Committee for Weights and Measures, relating to the SI.

Formal reference to CGPM and CIPM decisions can be found in the successive volumes of the Comptes Rendus of the CGPM and the Procès-Verbaux of the CIPM; many of these are also listed in *Metrologia*. To simplify practical use of the system, the text explains these decisions, and the first chapter provides an introduction to the concept of establishing a system of units in general and the SI in particular. The definitions and practical realizations of all the units are also considered in the context of general relativity. A brief discussion of units associated with biological quantities has been introduced for the first time. Appendix 1 reproduces, in chronological order, all the decisions (resolutions, recommendations, and declarations) promulgated since 1889 by the CGPM and the CIPM on units of measurement and the SI. Appendix 2 exists only in the electronic version and can be downloaded at <www.bipm.org/en/si/si_brochure/appendix2/>. It outlines the practical realization of some important units, consistent with the definitions given in the principal text, that metrological laboratories can make to realize physical units and to calibrate material standards and measuring instruments of the highest quality. This appendix will be updated regularly to reflect improvements in the experimental techniques for realizing the units. Appendix 3 presents units for photochemical and photobiological quantities.

The eighth edition is available on the BIPM Web site in PDF and HTML format, along with a four-page summary of the brochure and a handy pocket version. In addition, an English version is available (although the official record is always that of the French text, and it must be used when an authoritative reference is required or when there is doubt about the interpretation of the text). Translations, complete or partial, of this brochure (or of its earlier editions) have been published in various languages, notably in Bulgarian, Chinese, Czech, English, German, Japanese, Korean, Portuguese, Romanian, and Spanish.

The SI brochure is prefaced by Ernst Göbel, president of CIPM; Ian Mills, president of CCU; and Andrew Wallard, director of BIPM.

www.bipm.org

Obsessive Genius: The Inner World of Marie Curie

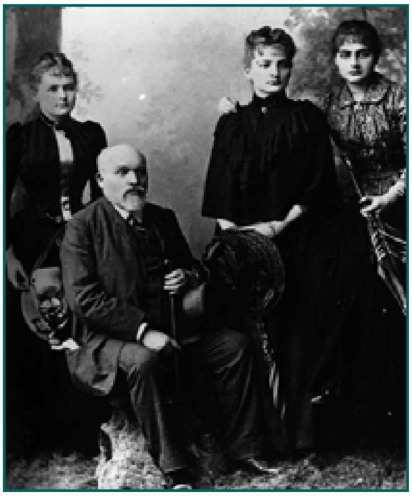
by Barbara Goldsmith
Great Discoveries Series
W.W. Norton & Co., New York, London, 2004
ISBN 0-393-32748-5

reviewed by Stanislaw Penczek

Barbara Goldsmith, a well-known historian and writer, was given access to Marie Curie's original diaries and letters and has used these documents to create a profound portrait of a brilliant scientist and a courageous woman. I believe that every chemist, and perhaps every scientist, should read this book.

Goldsmith tracks Curie's life from a childhood in Warsaw through instruction at the Sorbonne to her marriage to the young physicist Pierre Curie. She describes how the Curies built on A.H. Becquerel's discovery of radioactivity to explain its source as an atomic property and to subsequently discover the first two radioactive elements, which they termed *polon* and *radium*—opening the way to the exploration of the inner structure of atoms. In 1903, the Curies and collaborator Becquerel were awarded the Nobel Prize in physics in recognition for their discovery of radioactivity.

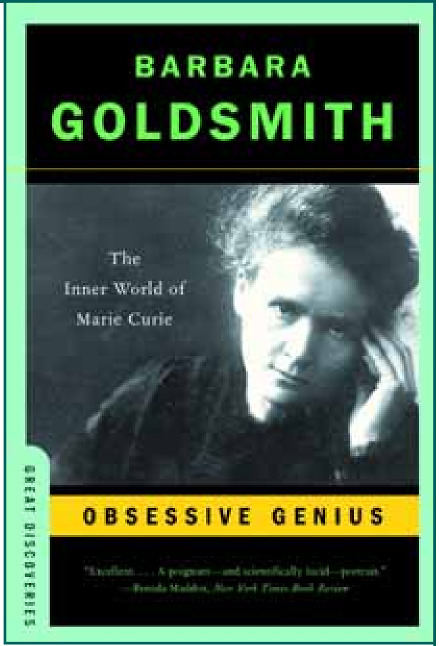
Goldsmith relates in detail, and with great sympathy, how triumph and tragedy ruled Curie's life in turn. Following the 1903 Nobel award, in 1906, Pierre Curie died in a roadside accident. In 1911, Marie Curie was awarded a second Nobel Prize, this time in chemistry—but the moment was clouded by the French Society's condemnation of Curie for her affair with married physicist Paul Langevin, a former student of Pierre Curie, and the Nobel Committee's attempt to rescind the award when news of the affair surfaced. Goldsmith quotes a letter from Curie regarding the scandal: “I cannot accept the idea that the appreciation of the value of the scientific work should be influenced by libel and slander.”



The young Marya Sklodowska, who became Madame Curie, is shown standing at left, behind her father, Wladyslaw, with her sisters Bronya and Helena at right. *Courtesy of the Curie and Joliot Association/Curie and Joliot-Curie Fund.*

During World War I, Curie commandeered the automobiles of well-to-do French women and organized a fleet of mobile X-ray units (that became known as “Les Petites Curies”) to assist the doctors working on the front lines of battle. In later years, she established two research institutes, one in Paris and one in Warsaw, dedicated to the study of radioactivity.

In 1934, the year of her death, Curie had a final triumph: her daughter and son-in-law's receipt of the Nobel Prize for their discovery of artificial radiation. Frederic Joliot-Curie, Curie's son-in-law, wrote of their discovery that “I will never forget the expression of intense joy which came over her [Marie] when Irene and I showed her the first artificially radioactive element in the glass tube.”



Goldsmith is a long-time admirer of Curie; she writes that as a teenager, “Madame Curie was my idol. Under the picture [I tacked up] I had placed two of Madame Curie's quotations: ‘Nothing in life is to be feared. It is only to be understood,’ and ‘You cannot hope to build a better world without improving the individuals.’” Goldsmith's accomplishment in this volume is in capturing the unparalleled joy that accompanied Curie's scientific discoveries and in revealing her dedication to scientific pursuit not as a sacrifice, but rather as the result of a fierce, internal drive—one that led her to refer to radium as “her child.”

Albert Einstein has referred to Marie Curie as being “as cold as a herring,” but the source material that Goldsmith mines (and reprints in this book, for the first time) paints a different picture. In a letter to her sister, the young Curie wrote, “Sometimes I laugh all by myself and contemplate my state of total stupidity with genuine satisfaction.”

Einstein was correct on one count: he repeatedly stated that character, persistence, and courage were the most important qualities for a scientist. Madame Curie had all three. On 20 April 1995, more than 50 years after her death, Curie was recognized for these attributes and for her scientific brilliance. Under the chairmanship of the presidents of France and of Poland, the ashes of Marie and Pierre Curie were moved to rest under the famous dome of the Panthéon in Paris. Curie was the first woman to be buried there in recognition of her own accomplishments.

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Volume G: Definition and Exchange of Crystallographic Data

Sydney Hall and Brian McMahon (editors)
International Tables for Crystallography
Published for the International Union of Crystallography by Springer, 2005, 594 + xii pp.
ISBN 1-4020-3138-6

The clear, efficient communication of data and results has always been fundamental to scientific work. This is especially true for data generated and used by computer software in the current era of high-throughput experimentation and e-science, particularly because data gathered in one scientific field increasingly inform other areas of research. The ability to link different information resources together seamlessly is a major goal of the semantic Web; data need to be accompanied by rich metadata to define their meaning and context. In a field as diverse as chemistry, many data exchange standards emerge and many flourish, but only for a time. Those that endure and have the greatest impact are flexible, extensible, and well documented—and therefore have the highest potential for interoperability.

The International Union of Crystallography (IUCr) has invested a great deal of effort in developing and promoting standards for the description of crystal and molecular structure data. Its Crystallographic Information Framework (CIF) has grown from a file format published in 1990 for the description of small-unit-cell structures to a collection of standards covering powder diffraction studies, biological macromolecular structures, area-detector and other image data, and other areas of structural science. Many of these standards are important components of large-scale database systems, such as the macromolecular (mmCIF) software ontology used by the Protein Data Bank. The crucial component of CIF is its rich semantic content, expressed not only in a large vocabulary of clearly defined tags, but also in machine-readable expressions of relationships between individual data items.

CIF has always been well documented on the Web, but now, as a mature standard, it is comprehensively described in the recent publication of *Volume G*, the latest in IUCr's flagship reference series *International Tables for Crystallography*.

The book, subtitled *Definition and Exchange of Crystallographic Data*, is edited by Syd Hall, the primary developer of CIF, and Brian McMahon of IUCr, who described CIF in the July-Aug 2002 *CI, p. 4*. *Volume G* brings together in a single location a full technical specification of CIF, with accounts of its historical background and philosophy, its use in publishing crystal structure reports, its synergistic relationship with other more general information exchange standards such as XML, and guidance on developing and using CIF-aware software.

The bulk of the volume concerns machine-readable dictionaries of individual data names that catalogue the items recorded in a structure determination experiment and the analysis of its results. The dictionaries are printed in full, and machine-readable versions are supplied on an accompanying CD-ROM (they can also be downloaded from the Web). Extensive commentary chapters have been commissioned to describe best practice in the use of the dictionaries. This level of detail is essential for software developers, but it also provides much useful information for the general scientist interested in the details of the data describing a crystallographic experiment and the resulting structure.

The volume also describes the Molecular Information File (MIF), a related standard for two-dimensional chemical structure representations, and provides food for thought on how to integrate the description of three-dimensional crystal structures with the conventional chemical description of their component molecules.

The book touches on other standards, such as Chemical Markup Language (CML), but as an authoritative reference for CIF, it provides the essential information needed to build interoperability between crystallographic information and the wide range of related chemical information systems.

In addition to the machine-readable dictionaries, the CD-ROM that accompanies the volume contains a large collection of software libraries and applications for use both by software developers and end users. The printed volume contains an up-to-date compendium on chemical informatics as of late 2005; in the rapidly changing world of software development, it will be particularly useful to have the entire contents of the volume available online, and revised on a rolling basis, as will be the case when IUCr launches its Web version of the entire *International Tables for Crystallography* series later in 2006.

Philosophy of Chemistry: Synthesis of a New Discipline

Davis Baird, Eric Scerri, and Lee McIntyre (editors)
***Boston Studies in the Philosophy of Science*, Vol. 242**
Dordrecht: Springer, 2006
ISBN 1-4020-3256-0

reviewed by Stephen Weininger

Before the late 1980s the phrase "philosophy of chemistry" would have undoubtedly elicited a "huh?" from most readers. Chemists would have deemed it irrelevant; philosophers, an oxymoron. But today there are two journals devoted to the field, *Hyle* and *Foundations of Chemistry*; a rising tide of presentations, journal articles, and monographs on the topic; and an International Society for the Philosophy of Chemistry, which has held annual meetings since 1997. The volume under review, in which 20 authors representing varied disciplines address a wide range of topics, is part of a distinguished series on the philosophy of science. Clearly, the philosophy of chemistry has found its place in the sun, albeit not without considerable struggle.

In the past, philosophers have given chemistry a mixed reception. For some of the greatest—Hegel, Comte, Engels, and Whitehead—it provided a source of fundamental insights into physical reality. In contrast, Kant asserted in 1786 that chemistry, unlike physics, was not and might never become a "proper science"—a judgment that, until fairly recently, prevailed among philosophers and scientists. Why was that so?

As the book's editors point out in their introduction, philosophers of science have traditionally preferred "grand, unifying theoretical visions instead of complicated local sights." Since chemistry abandoned such "unifying visions" after the demise of alchemy, it seemed hardly to merit consideration by philosophers. That conclusion was reinforced by a number of physicists, especially Dirac, who asserted in 1929 that chemistry was nothing more than applied quantum mechanics. Moreover, there was the inescapable fact that chemistry was both ubiquitous and complex. Since many philosophers of science focused on dictating how science *ought* to operate, they would likely have found a welter of messy specifics more distracting than helpful. As philosopher Joachim Schumer tartly observes in his informative history of the field, "the smaller the discipline, the more philosophers write about it."

Fortunately, the philosophy of chemistry gathered strength without the participation of philosophers. Because many of its concerns are directly relevant to chemical practice and pedagogy, chemists, chemical engineers, and historians have for some time been practicing philosophy of chemistry *avant la lettre*. Some of the major issues, insights, and conclusions in this essential work are summarized below. Note that the editors of this volume have not attempted to define "philosophy of chemistry"—rather, they have allowed the range of topics and diversity of authors to suggest the scope of the topic.

The Alleged Reduction of Chemistry to Physics (Hendry, Vemulapalli)

It is not hard to see why the reduction of chemistry to physics was one of the first issues to receive widespread attention in the current philosophy of chemistry, since it bears directly on the autonomy of chemistry. Not too long ago, most philosophers and scientists, including many chemists, thought that chemistry had indeed been reduced to physics and that any chemical phenomenon could be deduced "in principle" from the Schrödinger equation. A process of re-examination begun 25 years ago cast severe doubt on that supposition, and the present authors have carried that project forward very effectively.

Physical laws set limits on what can happen in nature. However, those laws have little to say about which of the myriad allowable possibilities *actually come to pass*. Quantum mechanical calculations from "first principles" can't even account for isomerism, one of the central phenomena in chemistry. In fact, the application of quantum mechanics to problems of molecular structure *requires us* to have some prior chemical knowledge if the output is to be remotely useful. It's clear that the autonomy of chemistry is assured, in principle as well as in practice.

The Dynamic Dimension in Chemistry (Benfey, Earley, Nordmann)

Chemists' conspicuous success in unraveling chemical structures has led many to fear that we are slighting our discipline's dynamic dimension. To paraphrase the message of these authors, it's time to think of time as more than an axis on a graph. After all, we recognize chemical substances as such only if they persist in time, on a scale defined by our measuring instruments. Furthermore, if we endow the temporal dimension with as much complexity as we do the spatial one, we encounter some very important phenomena. For instance, the concept of symmetry has been indispensable to our understanding of structure; applied to networks of coupled reactions, it yields equally potent results. Such networks, which are central in biological organisms, can achieve sufficient stability to qualify as substances if they have the proper symmetry.

What is the Subject Matter of Chemistry? (Needham, Weisberg)

The usual way of explaining chemical phenomena is to base the explanation on the structures and properties of molecules. Is this always the best way to proceed, and does it mean that chemistry is essentially the science of molecules? Many chemists and philosophers, including the present authors, have argued for a return to the concept of chemistry as the science of *substances*. From the molecular point of view, water, steam, and ice are pretty much the same thing, but from the thermodynamic standpoint, they are not. There are properties of the whole that are not inherent in the components, as recognized long ago by Aristotle.

Models in Chemistry (Scerri, Hunger, Woodyard)

Chemists never deal directly with nature, but rather with *models* of nature; chemistry has a wide variety, several of which are examined closely in these three chapters. Because models are never true or false, only more or less effective for a given task, we are free to use them all at different times, even if they are in conflict with one another or with the underlying theory—or both. Chemists rely heavily on these models to explain various experimental observations, even though the explanatory procedures usually don't satisfy philosophical criteria for proper "explanations." No worry—this is just another example of the inadequacies of one-size-fits-all philosophical pronouncements.

The Languages of Chemistry (Hefferlin, Johnson, Vollmer, Rothbart, and Schreifels)

Getting a true feel for chemistry requires appreciating its rich repertoire of representations. Ordinary language, specialized nomenclatures, molecular formulas, stereochemical drawings, spectrometer and microscope outputs, mathematical equations, computer simulations, physical models—all are used in various combinations to capture, describe, and assess experimental data and to plan future experiments. At one extreme, simple two-dimensional drawings can evoke a three-dimensional microworld. At the other extreme, highly sophisticated machines that are themselves reifications of complex theories allow us to "see" this microworld. Moreover, these tools are anything but passive—they interact dynamically with the science.

Chemistry and Society (Kovac, Bhushan)

The phrase "natural kind" denotes a group of objects that share a theoretically significant characteristic or property. Philosophers have long used chemical elements and compounds as examples of natural kinds. Here, Nalini Bhushan casts severe doubt on this appropriation. Chemists constantly regroup their materials depending on the properties that are relevant at the time. Furthermore, synthetic chemists can produce artificial compounds indistinguishable from natural ones and create new compounds that have never existed before, fatally weakening the distinction between natural and artificial. These achievements remind us that chemistry's impact on society goes far beyond the material. The ability of alchemists and chemists to synthesize natural materials in unnatural ways has been a central fact in the centuries-long religious and philosophical discussion of the boundaries between the natural and the artificial—and it makes a chapter on professional ethics most fitting.

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Recent Release

HYLE: International Journal for Philosophy of Chemistry, Vol. 12, No. 1, 2006

Special Issue: The Public Image of Chemistry, Part 1

J. Schummer, B. Bensaude-Vincent, and B. Van Tiggelen (editors)

<www.hyle.org/journal/issues/12-1>