planets would arise by the gravitational concretion of solid particles at low temperatures. Viktor S. Safronov revived and elaborated this hypothesis in the 1960s, and it is now accepted for the origin of the terrestrial planets.

All the theories of the Moon's origin proposed before the Apollo Moon landings of 1969—fission from, capture by or co-accretion with the Earth—became untenable when the rocks returned from the Moon proved to be as old as the Earth and significantly dissimilar. "Selenogonists," again to use Brush's term, now favor a giant impact of a Mars-like object with the Earth for the Moon's origin. During the late 1970s and early 1980s, scholars adopted the idea of a supernova trigger for the formation of the Solar System to account for isotopic anomalies; the idea was given up when the anomalies proved to be explicable otherwise. Accretion disks, long a subject of theory, have now been observed. And so on. Brush's account of many of the episodes is enhanced by his personal correspondence with the scientists involved.

Brush's text (all 600 pages of it, in 9-point type—I used a Bausch and Lomb magnifier to assist my aging eyesight) is workmanlike and probingly thoughtful. His overlapping reference lists for the three volumes run to 167 pages. This will be a standard work for a long time to come.

The Pioneers of NMR and Magnetic Resonance in Medicine: The Story of MRI

James Mattson and Merrill Simon
Dean Books, Jericho, N.Y., 1996.
838 pp. $75.00 hc
ISBN 09619243-1-4

This book gives a history of nuclear magnetic resonance (NMR) and brief biographies of nine NMR researchers, each of whom receives one chapter in a book of 840 pages. Magnetic resonance in medicine is not really addressed until late in chapter 7, and the book then tells a story about MR, but not *the* story.

The Pioneers of NMR and Magnetic Resonance in Medicine was written by James Mattson and Merrill Simon to commemorate the 40th anniversary of the Bar-Ilan University in Israel and to recognize that university's current research in MR. Simon is an engineer, writer and business consultant; Mattson is a professional technical writer. The book's content, up to chapter 8, is well researched and fascinatingly presented. Reference lists that follow each chapter are extensive and will prove useful in scholarly pursuits. This book is a "must read" volume for all serious students of NMR in chemistry, physics or bioscience for its early NMR biographies. However, it contains errors specific to scientific and technical ideas and misinterpreted nomenclature; the reader should beware. I also have serious objections to chapters 8 and 9, which purport to deal with the MRI story. These chapters appear astonishingly biased, as if written to sell a political candidate.

Seven of the early NMR scientists described in the book worked with atomic beams or small-sample magnetic resonance: I. I. Rabi, Norman Ramsey, Edward Purcell, Felix Bloch, Nicolaas Bloembergen, Erwin Hahn and Richard Ernst. All but Hahn are Nobel laureates, Bloch and Purcell for first measuring NMR signals directly. Hahn, Purcell, and Ernst have biomedical research experience, including MRI experience for Ernst. The other two scientists profiled in the book, presumably for their work on MRI, are Paul Lauterbur and Raymond Damadian. I personally know and like all of the principal scientists involved in the era of MRI breakthroughs, invited both Lauterbur and Damadian to give seminars and colloquiums at the University of Wisconsin in the early 1970s, and I stayed informed of their work. But Mattson and Simon's treatment of these two men and what they accomplished rather spoils this book for me.

There is wide agreement on the *real* story of MRI among scientists who attended advanced MR conferences in the 1970s, who heard and understood the exciting technical developments then being disclosed or who read conference papers and later refereed publications. Nuclear magnetic resonance was developed as a medical imaging modality, independently and nearly contemporaneously, at two universities. That work was done primarily by Lauterbur at the State University of New York at Stony Brook and, slightly later and in a different mode, by Peter Mansfield at Nottingham University in England; each of them worked with many of their immediate and now famous colleagues. Mansfield was knighted for that outstanding scientific achievement and was celebrated internationally at a special MRI conference organized at Nottingham in the spring of 1994, when he also opened the Centre for MRI Study Nottingham, the very first such institute in a department of physics.

Lauterbur had concentrated on developing the basic scientific principles for MRI (1971) and reduced those principles to a practical demonstration in an elegantly simple way. He later worked on full MRI systems with slow acquisition but greater flexibility for research, including MRI microscopy. He announced his results very early, at the Krakow, Poland, NMR conferences, with later fully peer-refereed publication in 1973. Mansfield followed Lauterbur, and his objective was more difficult: EPI, or echo planar imaging, which generates extremely fast "snapshot" MRI; it is a stop-motion mode that in the latest machines can acquire data for a full resolution slice in less than 45 milliseconds. Both Mansfield and Lauterbur used the modern method of post-excitation field-gradient encoding to Fourier sensitize holistic MR "echo-FID" data, but employed very different temporal sequences. Mattson and Simon seem to downplay all of this, including publication submission dates.

We get less than even half of the story of MRI in *Pioneers*. Lauterbur is conspicuously not listed in this book's prologue of scientists who read and approved chapters about themselves. Mansfield and his colleagues' roles are attenuated by their portrayal as quaint, tea-sipping Upper Midlands academic onlookers—at least some comic relief to those who know the old Nottingham gang. (Ironically, all MRI scans shown in chapters 8 and 9 were taken using Lauterbur–Mansfield–Ernst field-gradient modulation methods.)

Damadian, on the other hand, published a short but very novel NMR paper in *Science* (volume 171, page 630, 1971), about T1 (spm-lattice relaxation) in a category of fast-growing tumors, compared with healthy tissues. He implied that it would be desirable if one could perform *in vivo* scans of humans. The T1 results were seminal for oncology and widely cited for some time, but unfortunately, they did not apply to human cancers. It is truly ludicrous to propose, then, that Damadian's scientific contributions even remotely approach the achievements of Lauterbur, Mansfield and their colleagues.

Nor is there any evidence presented that Damadian had the slightest clue about how actually to build an NMR scanner until well after at least a dozen other labs were installing MRI units based on the Lauterbur–Mansfield–Ernst gradient modulation methods.

I am against Damadianizing the story of MRI; it is totally unwarranted. As was the case with Sonny Klienfeld, who wrote *A Machine Called Indomitable* (Time Books, 1986), we must assume that Mattson and Simon were not

personally aware of the deeper facts but, in good faith, simply believed what was convincingly presented to them.

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The Quantum Theory of Fields, Vol. II: Modern Applications

Steven Weinberg
Cambridge U. P., New York, 1996. 500 pp. $47.95 hc
ISBN 0-521-55002-5

The quantum theory of fields is the central tool in the study of physics at small distances and high energies. This theory also has important applications to many other areas of physics, including condensed matter physics, atomic physics, nuclear physics, astrophysics and cosmology. Continued development of quantum field theory will certainly be important for further progress in all of these areas. Supersymmetric field theories and superstring theories, which are outgrowths of quantum field theory that have achieved an independent status, may play an important role in some of these areas, but as yet, there is no definitive empirical support for these latter developments.

In volume I of this two-volume work, titled *Foundations* (See the review in PHYSICS TODAY, November 1995, page 78), Steven Weinberg, a Nobelist in physics for his contributions to the electroweak theory that partially unifies electromagnetism and weak interactions, gave a definitive account of the foundations of quantum field theory. In that volume, Weinberg emphasized the unique role that quantum field theory plays as the formalism that accommodates the requirements of both quantum mechanics and the special theory of relativity. He focused not only on how quantum field theory operates but also on why it has to be the way it is. Weinberg treated quantum electrodynamics, an Abelian or $U(1)$ gauge theory, in this first volume.

Weinberg devotes his second volume, *Modern Applications*, to non-Abelian gauge theories and their applications to the two central theories that make up the standard model of elementary particle physics: quantum chromodynamics, the theory of the strong interactions, an unbroken $SU(3)$ gauge theory; and the electroweak theory—a spontaneously broken $SU(2) \times U(1)$ gauge theory. He does not include supersymmetry or string theory, which would require another volume. The second volume can be read independently