

tentative—that this scenario is, in fact, a *current best guess*.

The editor and the members of the PPRG are to be congratulated on producing such an exciting book, which will no doubt stimulate much more thought and research. The book is recommended to all readers who are interested in the origin and evolution of early life on earth (and who isn't?).

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Spacelab: Research in Earth Orbit

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David Shapland and Michael Rycroft, Cambridge University Press, London, 192 pp., 1984, \$22.50.

Reviewed by Louis J. Lanzerotti

Spacelab, designed and built by the European Space Agency (ESA) to be flown on the space shuttle, provides a laboratory environment in space. Spacelab 1, the center of attention in this volume, was flown into earth orbit in late November 1983 on the NASA space shuttle *Columbia* and was truly a mission that accomplished "science around the clock, around the world." An ambitious technological undertaking by the Europeans, the building of Spacelab aroused at times considerable scientific and political passions regarding the directions of space and technological research. Spacelab 1 decisively demonstrated that a complicated project encompassing some 70 individual investigations could be designed, built, assembled, managed, and flown successfully to provide both new scientific and technological results as well as engineering information of the type required for future space research. That Spacelab 1 was a considerable success is amply testified by this volume, prepared by two British scientists who have been closely associated with European space science and technology programs for many years.

There is an enormous amount of information packed into somewhat less than 200 pages (many of which are filled with excellent diagrams and photographs): calculations of the orbital motion of spacecraft and of escape velocities, information on shuttle food and waste control systems, detailed weight and power characteristics of Spacelab—all are discussed. The assembly of the illustrations would appear to have been no small achievement in its own right for a book completed within 9 months or so of the end of the first mission. The volume is therefore very timely, even though the space age has rushed on, with the successful launches and science returns of both Spacelab 2 and Spacelab 3 now completed.

This volume is obviously directed toward a broad range of readers interested in the role of human beings in space and in the future of human-tended space experiments, particularly in the biological and life sciences, as noted in the forward written by Michel Bignier, the Director of Space Transportation Systems for ESA. The depth of detail provided for some of the physics and chemistry experiments will occasionally put off the casual lay reader, whereas those scientists who are most

familiar with shuttle-based science will find some of the technical discussions all too brief. Nevertheless, the book contains many items of interest for anyone interested in the future directions of earth-orbital and manned space research. The book should be especially informative for those U.S. space scientists who tend to have a somewhat jaundiced view of the uses of space for activities such as materials science and microgravity research. The number of such European experiments, plus those in the life sciences, was very large, constituting perhaps more than 50% of the total experiment payload objectives. These investigations were almost all related to special facilities installed in the Spacelab specifically for the science, such as a mirror heating furnace, an isothermal furnace, a low-temperature gradient heating furnace, and a special fluid physics module.

Approximately 20% of the book is devoted to the payload crew's views of their Spacelab experience and to discussions of orbiting laboratories of the future. As is obvious from these sections, the Spacelab experience is considered a precursor for future understanding of how a diverse set of technological and scientific objectives can be carried out in a future space station, an endeavor in which our European, Japanese, and Canadian friends and colleagues will be closely associated.

While the technical details of the experiments are interesting, the more sociological aspects associated with space flight, including experiment selection and integration and the comradery that arises from investigators collaborating and cooperating together to perform an optimum mission, are among the most engaging aspects of the volume. It is quite clear that much give and take occurs when some 70-odd investigators are each trying to optimize their own science return and, at the same time, are attempting to ensure that their colleagues also have an opportunity for scientific success. The give and take associated with Spacelab 1 ranged from such "simple" matters as weight and power allocations to major decisions concerning whether or not to proceed with the mission with only one tracking and data relay satellite (TDRSS) available for data transmission. Would a launch under nonoptimum conditions of lunar illumination prevent the maximum science return from some of the instruments and, if so, should the mission proceed? The ultimate consensus was yes to both.

In summary, this is an excellent volume with exemplary illustrations that conveys the excitement and enthusiasm associated with conducting a broad spectrum of scientific research activities in space. I thoroughly enjoyed reading it.

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Prophet—or Professor? The Life and Work of Lewis Fry Richardson

PAGE 28

Oliver M. Ashford, Adam Hilger, Boston, Mass., xiv + 306 pp., 1984, \$29.00.

Reviewed by Joseph Smagorinsky

This book focuses on a man who, in his lifetime, was scarcely known to the general

public. Yet within certain circles, Richardson has had enormous impact within recent years. Although there are many scientists and humanists who exercise influence in their own respective fields, rarely do they bridge disciplines. It is this combination that has made Lewis Fry Richardson a figure worthy of a full-length biography, not just to record his contributions to each field but to provide an analysis and understanding of what motivated his diversity. In another age, Richardson would have been counted as a Renaissance man. He has variously been referred to as a chemist, physicist, mathematician, psychologist, meteorologist, economist, and biologist. In retrospect, he clearly was well ahead of his time, whether the subject in question was his work in numerical weather prediction or in war studies.

With a background that somewhat parallels Richardson's, Oliver Ashford is an inspired choice as his biographer. Not only is Ashford a meteorologist, he is, like Richardson, a Quaker, and he is also a friend of the Richardson family. Soon after Richardson's death in 1953, his widow suggested to Ashford that he write a biography. In part, her recommendation seems to have been motivated by a sense of injustice, insofar as Richardson's contributions had not been fully appreciated in his own lifetime. Ashford had known Richardson and had even taken a course from him; eventually, some 30 years after Richardson's death and after his own retirement, he took up the challenge. Ashford discovered much unpublished and largely unknown material. He felt that he would set the record straight and tie up the loose ends, although meanwhile a great deal of recognition has been acknowledged in nearly every area of Richardson's work.

Numerous articles have been written since World War II on different focused aspects of Richardson's work, some of them by Ashford himself, but none of them have tried to capture the whole man in such a comprehensive work. Richardson's thoughts on mathematical modeling and turbulence, on peace and war, on factors bearing on intelligence, are just as relevant and vital today as they were when he first concerned himself with them. In everything, by Richardson's own admission, his Quaker upbringing was "a persistent influence, with its solemn emphasis on public and private duty."

The author states that his ultimate objective is to demonstrate that Richardson's life and work will surely continue to be a source of inspiration for many years to come. For a proper setting, Ashford has combed the records, published and not, to show by contrast that during Richardson's lifetime, his work was either not given full credit or ignored entirely. When his work was acknowledged contemporaneously, it was soon forgotten. Perhaps this is the inescapable plight of a man so far ahead of his own time. On the other side of that coin, there is much documented appreciation in the 30 years since.

Ashford meticulously tries to write for a broad readership, keeping technical detail well within bounds. His account of his idol's life unfolds chronologically. Just a few aspects of it will be touched upon in this review.

The geophysical reader will be interested particularly in Richardson's work on turbulence and his monumental opus "Weather Prediction by Numerical Process," which was

actually in a first draft in 1916 but was not published in its final form until 1922. It was a finite difference version of what the Norwegian physicist Vilhelm Bjerknes had first proposed to do graphically some years earlier, in 1904. Nevertheless, precedent aside, Richardson's proposal comes closest to what was ultimately realized when computers and atmospheric observations began to become adequate to the task. Richardson correctly anticipated a "forecast factory" in which the

electronic equivalent of "64,000 [human] computers" would be operating, thus, in the words of a 1923 review by Alexander McAdie in the *Geographical Review*, making forecasting "a science rather than an art."

Richardson spent a good part of his life in "peace research," trying mathematically to model the dynamics of arms races and of war moods in order to demonstrate the futility of war as a viable alternative. His models have even been used in recent analyses of the nu-

clear arms race. This would no doubt have left Richardson with mixed emotions: on the one hand, his work is being accepted; on the other, the problem of arms races is still with us. This book fills a gap in the existing literature on L. F. Richardson—the man and the scientist. It is written with understanding, compassion, and love.

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