ner plates to human shapes, are made up of combinations of straight lines and boxes. The more lines a machine can draw, the closer it can approximate to the subtle curves of nature. Today's graphics computers can generate several-hundred-thousand polygons per second. Impressive as that may be, no one is going to confuse those images with the outside world. "Reality", one expert estimates, "is 80 million polygons per second."

This does not stop Rheingold from speculating about what life will be like when the computers catch up. He devotes a chapter to "teledildonics", which one is to believe will be something like intimate one-on-one video teleconferences where the distant participants wear electric suits layered with sensors and transducers to simulate every caress. (A dirty limerick attributed to the computer pioneer John von Neumann suggests that such outfits should be easy to clean.) Just what a computer virus might mean in this context is left to our imagination.

Rheingold is at his best when chronicling the exploits of virtual reality's colourful pioneers. Jaron Lanier, president of VPL Research, is a dreadlocked "bear of a man" who lives in darkened rooms full of musical instruments and sells futuristic body sensors to both NASA and the toy company Mattel. And John Walker, a young man "with the kind of haircut you can still get at a barbershop for $5" who wears a pen-protector full of pens in the breast pocket, is the president of Autodesk Inc., a billion-dollar drafting-and-design software company on the verge of "going virtual".

Virtual Reality is written by an unabashed convert and fan. At his worst, Rheingold tends to romp through the world of technology in breathless first-person fashion: "The hand that floated in the virtual world was more than a hand. It was me." But in those passages where he manages to suppress his own awe and marvel for long enough to describe what the researchers in the field are actually doing, he generally gets his facts right, and his prose is clear enough to convey what the virtual-reality cast is really like. They are, in a word, eccentric (one should be rightly sceptical of any movement that has Timothy Leary, guru to the LSD generation, as a spokesman). But they seem to be on to something quite interesting indeed. □

■ Two other books on virtual reality have recently been published: *Cyberspace: First Steps*, edited by Michael Benedikt, contains essays on the theoretical and conceptual issues involved in the design, use and effects of virtual environments (MIT Press, $29.94, £24.95); and *Mirror Worlds, On: The Day Software Puts the Universe in a Shoebox. . . How it Will Happen and What It Will Mean* by David Gelernter (Oxford University Press, $24.95). Those who find the language of virtual reality impenetrable will find relief with *Technobable*, in which John A. Barry examines the new computer lexicon from an etymological, historical and anecdotal perspective (MIT Press, $27, £19.95).

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Group therapy

R. Bruce Martin

The Biological Chemistry of the Elements: The Inorganic Chemistry of Life. By J. J. R. Fraústo da Silva and R. J. P. Williams. *Clarendon: 1991. Pp. 561. £60, $75.*

THE cover of this volume features the theme of life, with Adam handing Eve a tile depicting the first element in the periodic table. Tiles for the biologically important alkali and alkaline earth metals, sodium, potassium, magnesium and calcium, nine transition metals, and the nonmetals phosphorus, sulphur, selenium, chlorine and bromine and iodine, form the backdrop to the scene. With the addition of silicon, the picture celebrates the elements emphasized in this rich and refreshing book. (No IUPAC-inflicted 1–18 group-numbering used here.)

Robert J. P. Williams, Royal Society Napier Research Professor at the University of Oxford, is arguably the world's most knowledgeable person on the comparative chemistry of the elements. While still a student he developed the well-known Irving–Williams stability series. At least a third of a century ago he pioneered the field of bioinorganic chemistry, well before the area became *de rigueur* in the United States. Because Williams's numerous publications cut a wide swath, it is useful to have this book where his breadth of knowledge, viewpoints and insights reside conveniently in one place.

In the preface, the authors state their intent:

> The strict environmental conditions that are required today by living organisms also point to the necessity of strict internal control and regulation of these processes, and this again means time and space organization of the biological substances, both large and small, and of their reactions. Much of this control is the now well-known classical treatment of the organic chemistry of life but, diverging from the classical tradition, we shall regard it in this book as the interplay of not just the great number of small and very large organic molecules but also of a group of about 25 chemical elements, free as ions, combined as complexes, or as precipitates, organized in biological space and time. Most of these elements are classified as 'inorganic'. We shall go on to insist that a proper appreciation of living systems and their evolution cannot be obtained without reference to these elements.

Thus not only carbon but many elements are judged central to life.

To carry out this promise, as well as for easy reading, the profusely illustrated book is divided into three parts, 22 chapters and sections within chapters. The seven chapters in the general first part cover uptake, speciation and compartmentalization of the elements in biology; kinetics and control; energy and hydrogen biochemistry; and the roles of biological macromolecules of all kinds. This broad overview is followed in part two by detailed discussions of individual elements.

The spirit of the 12 chapters in the second part may be captured by quoting the opening of the chapter on zinc:

> At the beginning of each chapter on a given metal in biology we should have in mind the question as to why it has been selected for its particular tasks. In the present case the question itself has two parts: (1) why zinc rather than another metal ion; and (2) why use a metal ion at all since zinc is only an acid catalyst comparable to the proton.

The first two parts of the book prepare the reader for the integration in the third part, which is composed of an opening chapter containing an interesting discussion of biological shape and the integration of the functions of different elements; a climactic chapter on the elements in homeostasis, morphogenesis and evolution; and a final chapter on what we, as successors to Adam and Eve, are doing with the elements in our Garden of Eden, and the consequences that this might have.

In addition to being a general resource, this engaging book provides an excellent text for an advanced course and should have much to teach both students and teachers. A small fault is that only short bibliographies (often mentioning lengthy reviews) at the end of each chapter have been listed, and that no specific references are given in any section within the chapter. For this omission, the authors offer a weak apology at the end of the preface.

Some years ago Williams noted that, as a group, physiologists were more aware of the importance of inorganic substances in biology than most biochemists. Recently, the imbalance has been lessening and many inorganic chemists have discovered biology. All these groups will gain by studying this book, in which their disparate viewpoints are so admirably synthesized. □

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Addendum

The full title of the book reviewed by John Durant on page 714 of the 24 October issue of *Nature* is: *Persuading Science: The Art of Scientific Rhetoric.* □