several sophisticated information-handling systems, including the genetic code and the immune system. Ordinary biochemistry is all that is needed for those two systems. Why should evolution have reached much further for the mind?

Penrose correctly argues that the discrete nature of the digital computer requires something to prevent degradation of accuracy—that is, to keep a 0 from drifting into a 1. He then argues that quantum mechanics, with its discrete states, is needed for that. He is not totally wrong; after all, we are in a quantum mechanical world and all of our technical machinery is quantum mechanical if examined in a sufficiently microscopic way. But computers do not need quantized spins. Starting with Charles Babbage and continuing through Konrad Zuse's construction in the 1930s of a computer built of punched pieces of sheet metal and interlocking rods, we have seen many computers that are no more intimately connected to quantum mechanics than is a rowboat or a screwdriver. Computers built out of relays, computers based on control of fluid flow, and many other examples can be added to the list. Indeed, a computer that acted in a totally coherent quantum mechanical way would be pathological. If its Hamiltonian had even a slight "manufacturing" error—if, for example, it deviated from the exact desired Hamiltonian—we would increase the admixture of erroneous states at every step in the computation. Such a computer could perform a very limited number of steps before its information content became useless.

I believe Penrose's only serious argument for why the mind is more than an analytic engine boils down to our self-perception, our sense of awareness and consciousness. But to invoke such an argument does not require subtle physics. Penrose is not likely to analyze that ancient argument definitively. (For that matter, neither am I.)

I have devoted most of this review to a critique of Penrose's main thesis. You may find yourself more in agreement than I did—or less. But you will not find *The Emperor's New Mind* a dull book.

Crystals in Gels and Liesegang Rings

Heinz K. Henisch
Cambridge U. P., New York, 1988. 197 pp. $54.50 hc
ISBN 0-521-34503-0

In 1970 Heinz K. Henisch of Pennsylvania State University published a slim volume entitled *Crystal Growth in Gels* (Pennsylvania State U. P.). I have treasured this volume, as no doubt have many others, because it is a useful summary of a field that is not too well known and it is written in an entertaining style. Studying it is an enjoyment—a rarity among technical books.

Eighteen years later, we now have the second modern book on the subject, *Crystals in Gels and Liesegang Rings*. This book is essentially a new treatment by Henisch, expanded from 111 to 197 pages, and is just as pleasant to read as its predecessor. Is it then worth purchasing this new volume? Given any interest at all in crystals or materials science, I believe the answer is a definite yes, whether one already owns the first book or not.

This volume, written by a recognized authority in the field, provides a thorough background on the practice as well as the theory of the growth of crystals in a gelatinous medium, be it

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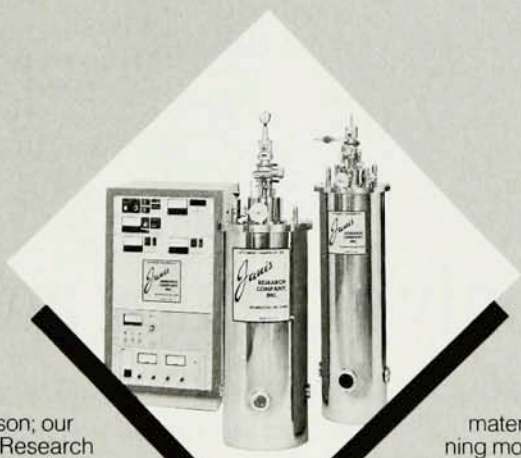

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silica gel, gelatin, jam or jelly. Such media can serve as "inert" crucibles that suppress nucleation and produce crystals that are frequently highly perfect. Convection is absent, much as it is under the gravity-free conditions in space.

Diffusion of several species, usually in more than one dimension, nucleation and growth kinetics, as well as an occasional re-solution stage, all control the sometimes surprising outcome of crystal formation. A most notable outcome is the well-known but still imperfectly understood Liesegang ring or disk phenomenon, a subject to which only a few pages were devoted in the earlier volume, but which here receives 60 pages. In his thoroughgoing fashion, the author starts this section with a portrait and brief biography of the incredibly versatile Raphael Eduard Liesegang (1969–1947), uses qualitative descriptions and fascinating photographs, works his way through extensive mathematical treatments and ends up with computer calculations that are able to duplicate qualitatively much of the observed phenomenology. Such simulations require many simplifying assumptions, and therefore a lot more remains to be done in order to obtain full insight into the mechanisms at work. Much of this work derives from studies by Henisch and Juan M. Garcia-Ruiz; they also make available (although it is not included with the book) a program disk IN VITRO VERITAS for computer simulations of Liesegang phenomena.

In his preface, the author states that the book "is intended as a guide to the literature, but it should not be taken as an encyclopedic or exhaustive evaluation of previously published material." While this statement is true (I noted the absence of reference to my own book on the gel growth of a variety of transition metal iodates), it is no defect, since a complete literature survey would bring in—together with some gold—much dull and indigestible dross, and would make the book much less fun to read. An hour or so in the library or at the computer terminal would meet anyone's specific needs in this respect. All important developments in this field are covered.

The book contains many drawings and well-reproduced photographs, and the text was well proofed. The 11 pages of small-print references are in alphabetical order (but without article titles, as is the modern practice). In a nice touch the author includes with each item the section number(s) where the citations occur. I for one hope that we will not have to wait

another 18 years for the next readable account of future developments in this fascinating field.

KURT NASSAU
Princeton University

Niels Bohr: Physics and the World

Edited by Herman Feshbach, Tetsuo Matsui and Alexandra Oleson
Harwood Academic, (Gordon and Breach), New York, 1988. $24.00 pb ISBN 3-7186-0484-1

In 1979, while compiling a volume dedicated to the centeniary celebration of Abram F. Ioffe, I asked Peter L. Kapitsa to take part. Kapitsa considered Ioffe his first teacher, and I was certain that he would write a paper for such a prestigious publication. To my astonishment, he declined my invitation. From his point of view a book of that kind made no sense: Nobody would read it, and papers devoted to different topics of physics usually have to be published in special journals. I tried to convince Kapitsa to change his mind, and as an example I pointed to the excellent book printed in the US in connection with Albert Einstein's 70th birthday. Unfortunately, Kapitsa was inflexible. Now I am sure that if I had had the Niels Bohr centenary volume, prepared with great care and love by Herman Feshbach, Tetsuo Matsui and Alexandra Oleson, I could have convinced Kapitsa to abandon his prejudice.

Nineteen American and West European scholars contributed to *Niels Bohr: Physics and the World*. It is a pity that Soviet physicists were unable to attend the Boston symposium held in November 1985. In the USSR Niels Bohr is revered, popular and beloved. During the mid-1960s the first two-volume collection of Bohr's scientific papers was published in the USSR in the series *Classics of Science*, and his 100th birthday was also celebrated in October 1985 in Pushchino (just outside of Moscow); the proceedings, entitled *Nil's Bor i Nauka 20 Veka* (*Niels Bohr and 20th-Century Science*), were published in Kiev in 1988.

The large number of papers included in the reviewed book precludes the possibility of detailed analysis in a short review; the articles are summarized by Feshbach in his foreword. Bohr (like Einstein, Heisenberg, Pauli, Schrödinger and other giants of 20th-century physics) made such an outstanding contribution to the development of physics that his influence is present in many fields, including, of course, quantum mechanics, nuclear physics, condensed matter physics, biology and philosophy. All of these fields, as well as the political ramifications of Bohr's work, are covered in the book. Victor Weisskopf and Abraham Pais, who opened the symposium with their papers, worked and kept contact with Bohr in the 1930s and 1940s, respectively. In their brilliant papers they present, side by side with physics and philosphy, vivid biographical and personal details. Arthur Miller, using a historical approach, analyzes Bohr's studies of the quantum theory of the atom and quantum mechanics. The "heroes" of Daniel Kleppner's paper ("Niels Bohr and Atomic Physics Today") are not the classical atoms of Bohr's theory, but hydrogen-like creations (muonium, positronium and more exotic atoms such as "high-Z hydrogen" and geonium), whose existence was not even suspected in the middle of the

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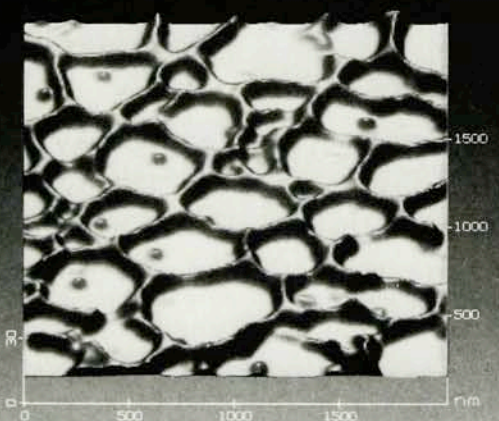

Image of a Web-like Voronoi Tessellation Pattern of a Polystyrene Coating on Silicon: Sample prepared by CIE, University of Minnesota, and scanned at Digital Instruments.

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