that some features of the universe are not easy to explain even when one can see them. For example, does one attribute the thickening of the disks in spiral galaxies (such as our own) to the effects of density waves, as Carlberg suggests, or to giant black holes in the halo, as Lacey suggests? In part, of course, it depends on whether there are any holes in the halo, so once more the dark matter problem raises its head. It raises it again when one tries to understand the origin of galactic and cluster rotation, as is discussed by Efstathiou and Barnes, and the formation mechanisms for different types of galaxies, as is discussed by Wyse and Jones.

The final section deals with the chemical evolution of galaxies. Considerable quantities of data have accumulated in the last few years concerning abundance anomalies in metal-poor stars, and, as is explained in Truran's fine review, one may thereby glean vital clues about the nature of the first stars. A particularly important anomaly concerns the apparent excess of oxygen in low-metallicity stars, which, according to Chiosi and Matteucci, suggests that the first stars may have been much more massive than the ones forming today.

It should be clear from the preceding discussion that this volume will not provide definitive answers to the questions that currently vex cosmologists. There are considerable differences of opinion on almost all the issues raised, and if the reader ends up disappointed by the lack of a clear-cut consensus and confused by the often contradictory conclusions of different papers that is no more than a reflection of the state of the art. For in the flurry of progress favored models come and go at an alarming rate. Only a year ago the simplest grand unified theory, SU(5), massive neutrinos, and inflation were the panacea of almost all cosmological ills. Now each of these remedies—at least in its most straightforward form—seems to have met its demise. Nevertheless, it would be inappropriate to end this review on a note of pessimism. For cosmology is a dynamic and rapidly developing field, and it is merely that the wealth of ideas sometimes appears confusing. Given the pace of development, it is inevitable that cosmologists will have to follow many false trails on the path to truth. We cannot yet see the end of the road, but we do have every reason to hope we are heading in the right direction.

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The Proterozoic Eon

Early Proterozoic Geology of the Great Lakes Region. L. G. MEDARIS, JR., Ed. Geological Society of America, Boulder, Colo., 1983. vi, 141 pp., illus. $28. Geological Society of America Memoir 160. From a symposium, Madison, Wis., May 1981.

Proterozoic Geology. L. G. MEDARIS, JR., C. W. BYERS, D. M. MICKELSON, and W. C. SHANKS, Eds. Geological Society of America, Boulder, Colo., 1983. viii, 315 pp., illus. $49. Geological Society of America Memoir 161. From a symposium, Madison, Wis., May 1981.

The Proterozoic eon is the unduly neglected middle half of geological time, separating the Archean (before 2.5 billion years ago) from the Phanerozoic (since about 0.6 billion years ago). A key controversy has concerned whether plate tectonics, the "dance of the continents," began near the end of the eon, near its beginning, or, in modified form, early in the Archean. This question is related to two other central issues in earth science today, the depth of mantle convection and long-term variation in the number and distribution of continents.

These two volumes stem from symposia held to discuss these and other issues in Proterozoic geology. Memoir 160 is specifically concerned with the Early Proterozoic (2.5 to 1.6 billion years ago) of the Great Lakes region, the Penokean orogen in particular. This belt evolved as the rifted southern margin of the late Archean Superior craton against which successive volcanic island arcs and microcontinents were apparently accreted, beginning about 1.85 billion years ago. The volume contains six papers on regional stratigraphic and tectonic synthesis, two on the geochemistry of igneous rock suites, and one on the sedimentology of siliciclastic rocks gradational with the "banded iron formations," for which the region is famous. Readers acquainted with Mesozoic-Cenozoic orogenic belts will find much that is familiar, although the state of knowledge is rather primitive, owing in part to poor bedrock exposure. Several important advances have been made since the symposium, notably in geochronology, structure, and geochemistry. As a result, none of the papers collected here should be considered definitive. Nevertheless, the volume may remain as the best overview on the subject until the Decade of North American Geology volumes on the Precambrian of North America are published in two or three years' time.

Memoir 161 is the more ambitious volume, consisting of 23 papers divided into sections on tectonics, magmatism and metamorphism, mineral deposits, life and oceans, and glaciation. The seven papers on tectonics present conflicting and, in some cases, eclectic views. Unfortunately, contributions concerning geophysics are limited to paleomagnetism. The section begins with a comprehensive and well-balanced paper by B. F. Windley asserting that plate tectonics operated throughout the Proterozoic, a view that all but one of the succeeding papers, more limited in scope, take issue with to varying degrees. J. D. A. Piper concludes from paleomagnetic data that all existing Precambrian shields were assembled into a single supercontinent throughout Proterozoic time, although his reconstruction requires such geologically unpalatable juxtapositions as the Arabian shield against southwestern United States. A. Kröner elaborates his idea that ensialic orogenic belts developed as the result of crust-mantle delamination. It has been proposed that the delamination and subsequent ensialic orogeny occurred in Cenozoic zones of lithospheric thickening due to plate convergence. Kröner attributes the delamination in the Proterozoic to the action of mantle plumes, though such a model is not consistent with the anastomosing geometry of Proterozoic orogenic belts. A. Y. Glikson updates his arguments for major Proterozoic global expansion, on the basis mainly of geochemical and isotopic evidence of an exclusively continental tectonic regime from 2.5 to 1.0 billion years ago. The analytical data presented are mainly from Australia and North America, where one suspects that the sample may be biased because the Archean crust is concentrated in the shields, which get sampled, and the juvenile Proterozoic crust is concentrated in the covered platforms, which do not. Proterozoic continentality is also stressed in another Australian contribution, by S. R. Taylor and S. M. McLennan, who report rare-earth element data for clastic sedimentary rocks. The global diachroneity Taylor and McLennan observe for the change from Archean to Proterozoic rare earth element signatures seems to refute their explicit assumption that such data represent world average compositions.

In the section on magmatism and metamorphism, J. L. Anderson compiles abundant new data on the enigmatic Middle Proterozoic "anorogenic" plutonism of the United States midcontinent, but the tectonic significance of the plutonism remains elusive. Perhaps the effects of thermal insulation of the man-

tle by a supercontinent assembled at about 1.8 billion years ago should be considered. R. C. Newton and E. C. Hansen, in a welcome marriage of experimental petrology, field geology, and comparative tectonics, conclude that 1.0- to 2.7-billion-year-old charnokitic granulites are best explained as products of continental collisions. The section on mineral deposits contains papers on tectonic controls (F. J. Sawkins), massive sulfide deposits (G. H. Gale), stratiform lead-zinc deposits (I. B. Lambert), sedimentary iron formations (M. M. Kimberley), and uranium deposits (F. F. Langford). Three rewarding papers make up the section on life and the oceans: a poetical overview by P. Cloud, a status report on the puzzling oxygen isotope data for Proterozoic sediments by E. C. Perry and S. N. Ahmad, and an informative summary of Proterozoic plankton by G. Vidal and A. H. Knoll. Two of the four papers on glaciation do not directly concern the Proterozoic, but one of them, by J. C. Crowell, concludes with the apt warning that globally dispersed Late Proterozoic glacial deposits are probably diachronous and that paleomagnetic evidence for low latitudes may result from rapid continental drift, possibly related to the breakup of a Late Proterozoic supercontinent.

In sum, Memoir 160 will be of interest to Great Lakes geologists and those wishing to follow progress in a "classic" field area. Memoir 161, although it contains some good material, lacks sufficient originality and foresight to impress as a research document and lacks the coherence and focus desirable in a textbook.

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Self-Revelations

A Slot Machine, a Broken Test Tube. An Autobiography. S. E. LURIA. Harper and Row, New York, 1984. x, 229 pp. $17.95. Alfred P. Sloan Foundation Series.

Among literary art forms, I suspect the autobiography is the most difficult to write. The novelist is free to create as vivid and memorable a personality as his or her imagination and talent will allow. A biography can describe, dissect, and analyze the anatomy of a life. However, an autobiography presents the reader not only with the story of a life but with the autobiographer as storyteller as well. I have found most autobiographies unsatisfying. Too often the story is not whole; the author seems intent on justifying some aspect of his or her life, or, in the case of many scientists, deals only with the science and leaves the scientist as person seemingly narrowly restricted, uninteresting, and unrevealed.

Salvador Luria, in the introduction of his autobiography, *A Slot Machine, a Broken Test Tube*, informs the reader that he is aware of this problem. In Luria's view, "An autobiography is valuable if it shares with the reader even those budding insights of which the writer is still uncertain. In fact, it ought to reveal the effort of self-creation through self exploration." In a word, the autobiographer should be immanent in the story. Given this objective (with which I agree), Luria has written a successful, and unusual, autobiography.

Luria, together with Max Delbruck and Alfred Hershey, was a founder of "the phage group" in the 1940's. Their research and, more important, their intellectual influence contributed greatly to the emergence of molecular genetics, a methodology, a paradigm really, that is now invading virtually every biological nook and cranny.

I was a latecomer to the phage group, and though I was close to Delbruck I do not know Luria, although I have met him on many occasions. Thus I approached his autobiography with interest and innocence. I left it with a sense of coming to know him in the same way I grow to know my close personal friends. Indeed, the form of the book itself resembles a developing friendship.

At first rather distant and guarded, Luria recounts the major events of his life. A lower-middle-class Jew who grew up in Fascist Italy, he became a physician, but his dissatisfaction with the practice of medicine turned him to research. The rise of anti-Semitism in Italy before World War II led him to leave Italy for Paris. Before the advancing German armies, he fled Paris on a bicycle. In the south of France, he managed to obtain a visa, ending up in the United States, one of the numerous Jewish scientists rescued from the clutches of Fascism who contributed to the postwar development of American science.

In a more personal vein, Luria then describes what he perceives to be his most satisfying scientific accomplishments. I found especially fascinating his account of the role of metaphor (a slot machine) and serendipity (a broken test tube) in shaping his major discoveries, the mode of mutant formation in bacterial populations and the phenomenon of host-induced modification. The former discovery marked the beginnings of bacterial genetics, the latter led to the discovery of restriction enzymes and thus to genetic engineering.

The second half of the book increasingly reveals the "inner Luria"—his attitudes and opinions about science and the academic life, the importance of politics and political action to his life, his conscious efforts to expand his appreciation and understanding of the arts. In the last chapter he describes his long ordeal with bouts of depression and his bitterness with what he experienced as the ineffectuality of psychotherapy.

Luria writes well, and with wry humor. His personal approach allows the reader to learn, without judgment, of his opinions and attitudes about science, politics, philosophy, and art. They are presented as aspects of a man, a man whose formative years occurred in a time and place of great social evil. He reveals himself as a discerning immigrant who actively and consciously embraced many of the American ideals. Yet he is an avowed existentialist and socialist. This book helped me to appreciate how these philosophies could allow one who lived through that bitter time to grasp the present and, through the efforts of self-creation, move toward wholeness and affirmation.

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Pioneering Space Research

Origins of Magnetospheric Physics. JAMES A. VAN ALLEN. Smithsonian Institution Press, Washington, D.C., 1983. 144 pp., illus. $19.95.

The last three decades have witnessed dramatic advances in our knowledge of physical phenomena throughout the universe. Especially significant has been the radical transformation of physical understanding—and, indeed, the dramatic extension of concepts—in the geophysical sciences. From global plate tectonics, with its vast implications regarding the structure of the earth (and other planets), to the earth's radiation belts, which would not exist if there were no geophysical magnetic dynamo, many basic ideas have undergone complete revolutions. The discovery of the radiation belts at once linked concepts of plasma physics to those of terrestrial geophysics; the linkage is now found in many other aspects of the solar system, as in the case