with each side ignoring the work of the other. Weyl learned both sides. He emphasized the global groups and their algebraic topology, and he introduced a new tool: the finite group generated by reflections that we now call Weyl group. He also made an important contribution to the theory of finite dimensional representations of simple Lie groups (including the famous character formula). In the preface of his *Classical Groups, Their Invariants and Representations*, Weyl states: "It is high time for a rejuvenation of the classical invariant theory which has fallen in an almost petrified state." I find Borel's study of Weyl's work on invariant theory, presented in historical perspective and also from a modern point of view, a genuine masterpiece.

One can enjoy these three brilliant lectures just as one enjoys going to a good concert. But if one wants to know more about Weyl's scientific achievements in other domains of research than those dealt with by Borel, one will have to read other contributions celebrating Hermann Weyl. Some of them will undoubtedly come from another centenary celebration, held in Kiel, near Weyl's birthplace.

LOUIS MICHEL
Institut des Hautes Etudes Scientifiques, 91440 Bures-sur-Yvette, France

Elementary Particle Physics

The Particle Hunters. YUVAL NE'EMAN and YORAM KIRSH. Cambridge University Press, New York, 1986. xii, 272 pp., illus. $49.50; paper, $13.95. Translated from the Hebrew edition (Givatayim, Israel, 1983).

It is a good time for popular accounts of the recent developments in elementary particle physics. The accomplishments of the past two decades have led to a quite concise and unified picture, one that is easily summarized. Nevertheless this synthesis is not easy to appreciate fully without knowing how we got to now from then. And the storyteller has to decide where to begin: when is "then"? Almost invariably the tale begins no later than the end of the last century, if only to introduce the reader to basic concepts of relativity and quantum theory. This book is no exception. Of its 260 or so pages, about one-third are devoted to the oft-told prehistory of Bohr, Einstein, Heisenberg, and their associates. And given this breadth of scope, the writers must opt either for a weighty, comprehensive tome (which this book, mercifully, is not) or selectivity of coverage—or at least of emphasis.

The Particle Hunters emphasizes developments peaking in the early 1960s, culminating in the identification of quarks as basic building blocks of matter. During this period many new states of matter were discovered. They are now interpreted as quantum states of three quarks (baryons) or of a quark and antiquark pair (mesons), analogous to nuclear or atomic levels. The need for their classification and the development of the tools for doing so were paramount. The key was the identification of conservation laws and the symmetries underlying them. A principal tool was the mathematics of Lie groups. And one of the important contributors to all this was Yuval Ne'eman, coauthor of this book. It is no surprise therefore that the chapters dealing with this material are the heart of the book.

The basic format of *The Particle Hunters* is historical narrative. After the aforementioned introductory sector and a sequel on the experimental developments of the prewar and early postwar periods, the authors recount the history of the discovery of strange particles and the hadronic resonances, along with the theoretical response. There is a splendid chapter on symmetries, including the discrete symmetries of parity, charge conjugation, and time reversal, and the discovery of their violation in weak interactions.

Quarks do not arrive on the scene until the last quarter of the book. Thus the developments of the 1970s and early '80s, though adequately covered, get somewhat less emphasis. One consequence of this is that what is to me the climax of the story, the emergence of theories of the forces and their description in terms of the symmetry principle of local gauge invariance, is muted. One feels, instead, the steady but inconclusive progress in penetrating layers of structure of matter, as implied by the present compact, yet uncomfortably large, "periodic table" of quarks, leptons, and force carriers.

An excellent feature of the book is its emphasis on the experimental side of the subject, including the development of particle accelerators. Another is the series of marginal notes, anecdotal in character, that add the all-important human element to the narrative. Ne'eman's own story is there, and an interesting one it is. And in general the coverage of material is complete and accurate. Kirsh is a specialist in popular exposition, and the introduction and management of jargon are skillfully done. The book should be accessible to most readers of this journal. There do exist flaws. For example, the authors fall into the not uncommon trap of asserting that the gluon-mediated strong force between quarks weakens at short distances and grows at long distances. (It is roughly inverse-square at short distances and constant at long distances.) And there is a zinger in their discussion of neutrino physics, where it is claimed that "experiments have been carried out in the United States in an attempt to exploit neutrino beams as a method of communication with submarines. . . . Since this method has only military implications, the results of these investigations are being kept secret." It must be noted that Ne'eman has been deputy director of Israeli intelligence. However, high-energy neutrinos are needed to achieve such communication, and all research with them is unclassified: proposals on neutrino communication have consistently been rejected as unfeasible.

There is a curious omission in the index. The most quoted person in the book is Alfred Nobel. There are at least four dozen references to The Prize in the text but no citation in the back of the book. I would have preferred it the other way around. After all, the unsuspecting reader might get the idea that high-energy physicists feel the real reward for their labors is that trip to Stockholm. That's no reason to build the Superconducting Super Collider.

JAMES D. BJORKEN
Fermi National Accelerator Laboratory, Batavia, IL 60510

Minicourses

Intersection between Elementary Particle Physics and Cosmology. T. PIRAN and S. WEINBERG, Eds. World Scientific, Singapore, 1986 (U.S. distributor, Taylor and Francis, Philadelphia). x, 220 pp., illus. $42. Jerusalem Winter School for Theoretical Physics (Dec. 1983), vol. 1.

Physics in Higher Dimensions. T. PIRAN and S. WEINBERG, Eds. World Scientific, Singapore, 1986 (U.S. distributor, Taylor and Francis, Philadelphia). x, 236 pp., illus. $44. Jerusalem Winter School for Theoretical Physics (Dec. 1984), vol. 2.

The Jerusalem Winter School was first held in December 1983 and has since met annually. Each year a distinguished faculty has been assembled to give a set of intensive minicourses covering an important, rapidly developing area of theoretical physics. By all reports the venture has been outstandingly successful.

The two volumes under review are collections of written versions of lectures given at the first two winter schools.

The first volume deals with the intersection between elementary particle physics and cosmology. This area had an impressive infusion of new ideas in the late 1970s, notably including a possible microphysical