cated ways) and presents the elements of the subject in a simple, sensible form. Now that he has done it, we can only wonder why the book was so long in coming.

The book begins by examining the simple model of a finite-state machine (a machine which can have only a finite number of states). After carefully defining his mathematical model and explaining some of the relationships between it and reality, Minsky proves that a finite-state machine can add arbitrarily long sequences of binary digits of two binary numbers provided the lowest-order digits are presented to the machine first, but that a finite-state machine *cannot* do the corresponding multiplication.

Neural nets and the McCulloch-Pitts models are shown to be equivalent to automata made up of simple parts and then to be equivalent to finite-state machines. Some logical systems such as Kleene's theory of regular sets are also shown to be equivalent to finite-state machines; thus the idea of finite-state machines is shown to provide a unifying view of a number of originally diverse topics.

The second part of the book treats infinite-state machines. It begins with the development of the classic Turing machine and effective computability, demonstrates the usual universal Turing machine, and passes on to the surprising limitations of effective computability, such as the unsolvability of the "halting problem" and some decision problems. Special attention is given to the interesting consequences of computable numbers.

Just as finite-state machines were shown to unify some diverse topics, so infinite-state machines are shown to be related to recursive-function theory and Post's theory of productions, and the normal-form theorem is proven. The book ends with some specially simple Turing machine models such as the four-symbol, seven-state Turing machine.

These topics, many of which were until quite recently considered to be advanced and abstruse, are treated with a commonsense attitude, a simplicity of presentation, and a style that make much of this material accessible to the "average person" interested in the field. Thus the book is a significant contribution.

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Cool Stars

Colloquium on Late-Type Stars. Trieste, June 1966. MARGHERITA HACK, Ed. Osservatorio Astronomico, Trieste, 1967. 465 pp., illus. Paper, 10 L.

The term "late-type" is astronomical jargon for stars of low temperature. The idiom arises from a long-dead theory of stellar evolution that held that stars began their lives as objects with very high surface temperatures and then simply cooled down. To this day we call hot stars "early-type" and cool stars "late-type." The spectral sequence is similarly ordered, and the designation "early" or "late" refers to the position of the star in the sequence. More particularly, "late-type stars" refers to stars cooler than the sun, with surface temperatures ranging downward from about 5000°K, although no precise definition has ever been adopted. A number of objects are cooler than the reddest stars visible to the eye. Such objects are detected by infrared devices and are now often called "dark-brown" stars.

Cool stars are of astrophysical interest for a variety of reasons: At low temperatures, compounds form. Isotope effects in molecular bands of carbon compounds such as CN are readily observed, for example. Only from molecular spectra has it been possible to get information on stellar isotope abundances. The spectra of cool stars are very sensitive to the ratio of carbon to oxygen. Titanium oxide bands dominate the spectra of cool stars with solar composition, whereas if carbon exceeds oxygen in abundance all the oxygen disappears as carbon monoxide and carbon bands dominate the spectra. Giants and supergiants represent stars in late stages of evolution; cool representatives sometimes show remarkable abundance anomalies and even the presence of short-lived technetium. Hence these objects are of enormous interest in connection with theories of element building and stellar structure. A great advantage in their study is offered by the fact that the astrophysicist can approximate their temperatures in the laboratory.

This excellent symposium volume brings together a number of valuable papers on the spectral classification, high-dispersion spectra, chemical and isotopic composition, atmospheres, internal structures, and evolution of these remarkable stars. As mentioned above, some of them are very luminous giants and supergiants; others are dwarf stars much fainter than the sun and show no evolutionary effects, but attempts have been made to find planet-like companions among them. Perhaps the greatest value of this information-packed book is the stimulation it will certainly bring to a rising generation of physicists, chemists, and astrophysicists to engage in one of the most exciting fields in astronomy.

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The Views of a Physicist

Erwin Schrödinger. An Introduction to His Writings. WILLIAM T. SCOTT. University of Massachusetts Press, Amherst, 1967. xvi + 175 pp. $6.50.

In his later years Erwin Schrödinger was deeply concerned that physics was cutting itself off from its historical background. He considered much in quantum mechanics, particularly the statistical interpretation of the wave function, to be a break with the scientific tradition of over two millennia. Schrödinger argued as forcefully as he could against this trend, going so far as to compare quantum jumps and virtual transitions with the circles and epicycles of medieval astronomy. But this was the same Schrödinger who had created wave mechanics in 1926 in a series of articles about which Max Born later remarked, "What is there more sublime in theoretical physics?" Schrödinger had indeed felt that same way then, being confident that his new theory "struck deep into the nature of the quantization rules" because it made atomic quantum numbers as *natural* as the number of nodes of a vibrating string. He had never liked "this damned quantum jumping," as he called it, and had found the essentially discrete and algebraic matrix mechanics to be "forbidding, not to say repulsive." He did not find in it what he prized most—an intuitive clarity.

William T. Scott has written the first book on this remarkable physicist. It is, in his own words, "a modest introduction" which deals only with some of the major themes in Schrödinger's writings and very briefly with his life. (His publisher does him a disservice by misadvertising the book as a "comprehensive study.") One of these major themes, strange in view of Schrödinger's attitude toward quantum mechanics, is the

importance of statistical concepts in physics. Schrödinger referred to Boltzmann's ideas as "my first love in science," and wrote some 30 or 40 papers in statistical mechanics in the course of his career. Scott manages to refer to most of these papers, giving a definite impression of the range of Schrödinger's interests in this field. I think, however, he might have done better to analyze a few of them at enough length to demonstrate Schrödinger's way of handling a problem or developing an idea. Scott is not at his best in treating historical questions. His discussion of the development of wave mechanics is only a chronicle, in which one paper after another is described briefly. He does not convey much sense of just what problems these papers were written to solve, or why Schrödinger's contemporaries should have found them exciting or puzzling or disturbing.

When Scott turns to an analysis of Schrödinger's views on the interpretation of quantum mechanics he has more to contribute. He tries to disentangle the essentials of Schrödinger's position from some of the more extreme and inadequately qualified statements that Schrödinger sometimes made in semipopular articles. Scott traces Schrödinger's criticisms of the theory over a period of 20 years or more. He gives a very fair analysis of those points where Schrödinger was refuted by Born and Heisenberg, who were spokesmen for the viewpoint of the overwhelming majority of theorists, and those points that are still unresolved. No attempt is made to deal with most of the large literature on these problems.

Schrödinger had a lifelong interest in philosophy but, as Scott remarks, "his writings reveal relatively few *formal* points of contact between physics and philosophy; . . . the principal connection is in the person of Schrödinger himself." Scott provides a physicist's introduction to those brilliant but tantalizing little books in which Schrödinger touched on a great variety of issues, from the nature of life to the Greek presuppositions of science, offering insight, challenge, and sometimes mystification.

Scott has succeeded in providing a useful introduction to some of Schrödinger's main concerns. Let us join him in hoping that someone will now go further and give us a full-length picture of Schrödinger, that "glittering, many-sided man," in a style incisive and vigorous enough to match Schrödinger's own.

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Quantifiable Data for Anthropology

Ethnographic Atlas. GEORGE PETER MURDOCK. University of Pittsburgh Press, Pittsburgh, Pa., 1967. vi + 128 pp. $4.95.

This is an atlas without a single map. But the 862 societies of concern—tribes and ethnic groups—are listed according to precise geographical location. Murdock is well known for his pioneering in the problems of comparative cross-cultural research. At Yale he organized the Human Relations Area Files, a summary codification of the content of human cultures across the world, and at Pittsburgh he founded the journal *Ethnology*, in which sections of the data brought together in this atlas have appeared.

The purpose of the atlas is to provide a summary overview of societies for which detailed ethnographic descriptions exist. The materials are coded so that the anthropologist interested in cross-cultural comparison can obtain a quick insight into the kinds of clustering of institutions which the various societies listed exhibit. Murdock considers both the individual societies themselves and the general area to which each belongs, a necessary safeguard since there may be contact or diffusion of cultural elements among societies placed closely together. Murdock divides the world into 412 culture areas, or cultural clusters, seeking thereby to encompass the entire ethnographic universe. The various societies are listed according to cluster and then summarized both as to location and cultural content. Coded tables relating to the content of the various societies make up most of the volume.

To illustrate the kind of data which the atlas contains, one may select a fairly familiar people, the Navaho of the southwestern United States. They, like each of the other groups summarized, are assigned a code number and a coded location. There follows a series of topical columns covering a wide range of data about the group. Topics considered include, among others, subsistence, type of family and social structure, patterns of authority and politics, inheritance, linguistic affiliation, settlement and demographic pattern, games, and house type. Thus for the Navaho it may be noted that they possess a modified dependence on gathering, give some attention to hunting, none to fishing, a fair amount to agriculture and to sheep raising. The codes show a small and extended family, with strong emphasis on the matrilineal clan, and preferential matrilateral cross-cousin marriage. They practice no genital mutilations, do not segregate their males, lack a belief in a high god, have an uncomplex but well-defined political structure. Add to this considerations of Navaho material culture, with such occupations as weaving and basket-making, not to mention a complex house type, and it may be clear that Murdock has succeeded in bringing a great deal of material together. Nor can the atlas be regarded as complete; additional categories can yet be appended. To find data on a particular society means, it is true, a rather unhandy riffling back and forth to see what the column numbers and codes mean, but it is evident that no other arrangement would permit the compression of such extensive information into so little space.

Considerable research is now being done in anthropology that involves the testing of cross-cultural hypotheses with the use of quantifiable data. In the Human Relations Area Files and in this atlas there is a ready source of materials susceptible of statistical review and computer analysis. For such endeavors the atlas may prove most useful, and one must compliment Murdock on the prodigious amount of work he has done in assembling this vast body of data.

Comparison of human behavior has always been implicit in cultural anthropology and ethnology. Murdock in this regard offers a refined approach. Yet there is a dimension which his scheme must inevitably miss, since it must limit itself to formal structure and content. The imposition of categories can be misleading; "matrilineal institutions," for example, overtly similar, may function quite differently in different social systems. Treatment of form and content alone reveal little of the depth or intensity of institutions among different groups of men.

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