of a relatively timeless quality or suggest ideas that are still stimulating, for example, John A. Hannah on "Motives for the participation of American universities in international education," Robert M. Macy on "The need for guidelines to political development," and Jerome Bruner on "Educational assistance for developing nations: techniques and technology." But in general one is impressed that the pace of change in this field, as in others, is so rapid that mimeographed documents prepared for conferences and committees should be put into print quickly or not at all.

EUGENE STALEY
School of Education, Stanford University, Stanford, California

Techniques in Chemistry

High Resolution Nuclear Magnetic Resonance Spectroscopy, by J. W. Emsley, J. Feeney, and L. H. Sutcliffe (Pergamon, New York, 1965. vol. 1, 733 pp., illus.; vol. 2, 542 pp., illus. $17.50 each), is a bold attempt "to provide a detailed account of the basic theory underlying high resolution nuclear magnetic resonance (nmr) spectroscopy and also to present a survey of the major applications in physics and chemistry." That it succeeds in its purpose to a remarkable degree is testimony to the abilities and thoroughness of the authors. That it is less than definitive and falls short of being truly comprehensive reflects the ever-increasing vastness of the subject and the heterogeneous interests and backgrounds of the practitioners of the art.

Twenty years ago two communications reported the first observations of nuclear magnetic resonance in bulk matter. Useful applications of the new techniques to physics and chemistry soon followed, as did the discovery and characterization of new nmr phenomena, such as the "chemical shift" in 1949, the electron coupling of nuclear spins or indirect spin-spin interaction in 1951, and the spectral averaging effects of chemical exchange in 1953. These three phenomena were found to govern the detailed fine structure which appears in the high-resolution nmr spectra of liquids and gases and which is a very sensitive indicator of molecular structure, including some of the most subtle conformational changes and differences. Thus it soon became clear that nmr was a field of great promise for chemical research.

The promise has been realized during the past 10 years by the design and commercial availability of nmr spectrometers of increasingly higher sensitivity and resolution and by their successful application to an astonishing range and number of chemical problems. The success of nmr as an aid to research is shown in quantitative terms by the present publication rate, greater than 450 per month, of papers referring in a more than incidental way to some aspect of nmr. Most of the current papers involve the use of high-resolution nmr to solve structural problems in chemistry. Many of these applications are empirical in nature and require little more than comparing the spectra for compounds of known and unknown structure. Others require detailed analysis and understanding of the spectra, and some even need to use or extend the basic theory relating the spectral parameters to molecular structure.

The first volume of Emsley, Feeney, and Sutcliffe's book is directed toward the latter needs. It treats the basic theory of nmr, especially of the phenomena governing high-resolution spectra and the relation of these phenomena to molecular electronic structure. The practical aspects are covered in a chapter on instrumentation principles and another on the operating procedures and lore employed to obtain usable spectra. Strong emphasis is placed upon the analysis of a complex spectrum to obtain the chemical shifts and scalar coupling constants which, after all, are the basic spectral parameters related to molecular structure. Initially the authors planned a single volume, but the exponential increase in nmr determinations of molecular structures led to the publication of their survey of such applications as a second volume. This volume includes separate chapters on proton and fluorine resonance and a third on other nuclei. Many useful tabulations of chemical shifts and coupling constants are given and many typical spectra are reproduced.

It is not surprising that there is some unevenness in such a lengthy monograph by several authors, and each reader will no doubt find his own points to carp about. In my case, although Erwin Hahn's studies of the indirect spin-spin coupling were by spin-echo rather than high-resolution methods, I feel that his contributions to this area should have been cited, as should have been his addition of chemical exchange terms to the Bloch equations. Moreover, with the general availability of high-speed computers, I believe that a 5-page discussion of computer methods for analyzing spectra would have been much more useful than 25 pages of appendices listing frequencies and intensities of A_mB_n spectra. Also, I wish that volume 1, besides being a comprehensive reference for the theory and practice of high-resolution nmr, were more critical or were better suited for students. But in any case, the authors are to be congratulated for having fitted such a large and diverse field into one book. Practitioners of the art will find that the usefulness of the monograph makes it well worth its high price.

H. S. GUTOWSKY
W. A. Noyes Laboratory of Chemistry, University of Illinois, Urbana

Ratios and the Celestial Spheres

Nicole Oresme, speculative mathematician and natural philosopher, translator of Aristotle's *Ethics* and *De coelo* into French, friend and protégé of the King of France, opponent of astrology, schoolman extraordinary, was without question one of the most original thinkers of the 14th century. His **De proportionibus proportionum** and **Ad pauca respicientes**, now published together in a definitive edition (University of Wisconsin Press, Madison, 1966. 488 pp., illus. $10.75), with English translation, commentary, and notes by Edward Grant, set forth one of his most original pieces of thought: an analysis of the quantitative relations of ratios that is equivalent to the introduction of fractional and irrational exponents, and an anti-astrological application of this analysis to the motions of the planets.

To understand this achievement of Oresme, one needs to recall the nature of ratio as conceived in Euclid's *Elements*: a relation with respect to size

between magnitudes of the same kind. In the famous Definition 5 of Book V, Euclid (following Eudoxus) gives us a definition of *same* ratio, or the necessary and sufficient conditions for four magnitudes, which need not be commensurable, to be proportional. This definition runs almost exactly parallel with Dedekind's definition of real number; yet we cannot say that a Euclidean ratio is essentially the same as a real number. In the Euclidean context, ratios are never added or subtracted; this happens only to the magnitudes composing the ratio. One ratio can be greater or less than another, but the occasion never arises for saying that one ratio is a multiple or submultiple of another. In fine, the ratio continues to be thought of primarily as a relation rather than as a quantity in its own right. However, there is one further quantitative relation of ratios dealt with in the *Elements*: if $A : B :: B : C$, then $A : C$ is said to be the "duplicate" of $A : B$, and $A : B$ the "subduplicate" of $A : C$. Triplicate and subtriplicate ratios are correspondingly defined. This type of relation serves as a basis for the Oresmean development.

Oresme's *De proportionibus proportionum* takes its start from the medieval discussion of velocity of motions. Following Aristotle, it was assumed that the velocity V of a motion depends in some way on the ratio of the moving power F to the resistance R, and Bradwardine in 1328 proposed a specific form for the dependence which can be translated into modern symbolism as $F_2/R_2 = (F_1/R_1)_n$, where $n = V_2/V_1$. Thus if $n = 2$, F_2/R_2 is the duplicate of F_1/R_1. In a lengthy analysis, Oresme generalizes the discussion of this function by allowing n to take on any value, integral, fractional, or irrational, while the original magnitudes F_1, R_1 and F_2, R_2 may also be commensurable or incommensurable. Throughout, the ratios are treated as continuous quantities in their own right. And what is perhaps most astonishing is to see this detailed analysis of mathematical possibility carried out verbally, without benefit of algebraic symbolism.

There is one more remarkable result in *De proportionibus proportionum*: proceeding in a surprisingly modern direction, Oresme applies probability considerations to the relations of ratios and concludes that if two unknown ratios be selected at random, it is probable that they are "incommensurable" or related by an irrational exponent. From this conclusion Oresme infers that the motions of the celestial spheres are probably incommensurable with one another. Therefore, quite aside from the inevitable problem of observational error, no celestial conjunction, opposition, or other aspect is exactly predictable, and astrology becomes impossible. *Ad pauca respicientes*, the second treatise published here, is explicitly concerned with rational celestial kinematics, the study of the predictability of conjunctions, oppositions, and other such relations between celestial bodies moved with various conceivable circular motions.

In these two treatises one sees a first-rate mathematical mind working within a traditional context in a most novel way. Grant's decipherment, analysis, and translation of the texts is admirable for its clarity. This book should be of interest not only to historians of science but to all who are concerned with the nature and development of mathematical thought.

CURTIS WILSON
Department of History, University of California at San Diego, La Jolla

Climate and Man's Future

A nation that had comfortably adjusted itself to the innocuous weather of earlier years, England has been troubled since World War II by an abundance of cold winters and dank summers. If at first this turn of events was shrugged off as a statistical accident, the arrival of the winter of 1962–63, which surpassed all modern records for snowiness in Britain (and for persistent cold on the continent), at last raised the specter of a systematic deterioration of climate with its ominous implications for the future. Such was the motivation for the 2-day symposium held in October 1964 at the Royal Geographical Society in London out of which has sprung an unusual little book, **The Biological Significance of Climatic Changes in Britain** (C. G. Johnson and L. P. Smith, Eds. Published for the Institute of Biology. Academic Press, New York, 1965. 232 pp., illus. $7).

Whatever Britain's climatic fate, in this book one can find an illuminating and authoritative assessment of the impact of weather and climate on the productivity of her farmlands and her fisheries. From many different vantage points, the 14 contributors (and another score of discussion participants) have addressed themselves in this volume to the vulnerability of food resources to the elements and to what reasonably can be done to lessen it in the future.

The book is clearly written, carefully edited, well illustrated, and handsomely produced. It contains good bibliographies, 13 pages of tersely paraphrased discussion, an author index, and a subject index. Of four sections into which the text is divided, the first consists of a comprehensive account, by H. H. Lamb of the Meteorological Office, of the facts and statistics of Britain's enviably well-documented climatic history. Lamb traces in some detail the fluctuations of temperature, rainfall, and atmospheric circulation during recent centuries and notes their relevance to the overall problem of planning for the future. The second section contains seven contributions on a variety of topics relating to the implications of climatic change, most of these in the fields of marine biology and agronomy. Several authors draw a clear distinction between the effects of long-term climatic change and those of relatively rapid climatic fluctuation, and attach great importance to both. Much attention is given to climatic and hydrographic change in the oceanic environs of Britain and its relationship to historical trends in fish catch.

In the third section, three papers are devoted to genetic and environmental factors (other than climate) and to the means by which present knowledge of these can be exploited to offset the effects of unfavorable climatic change on horticulture, livestock productivity, and forage grasses. The final section (two papers) is concerned in part with the agronomic benefits that would accrue from the availability of accurate long-range weather forecasts and in part with the effects of climatic variability on farming practices in Britain. Concerning the latter topic, a more rigorous examination of existing climatological data—as distinct from bona fide forecasts of future climate—is viewed as a promising means of eliminating several kinds of economic waste now prevalent in farm operations.

Owing to the very different complexion of our food resources and to the much greater diversity of climates