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.

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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

in America than in Britain, it is rather too much to expect that the wealth of information to be found in the pages of this book can be transferred lock, stock, and barrel across the Atlantic to our own benefit. Be that as it may, the book is well worth a close scrutiny by American readers: agriculturalists, horticulturalists, marine biologists, naturalists, climatologists, economists, and geographers. The problem of climatic change and its manifold effects on food supplies presents a challenge to all mankind. It is no exaggeration to say that man's ability to understand it better and to deal with it foresightedly could appreciably slow his inexorable retreat to the great Malthusian wall.

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Beryllium

A. A. Beus's **Geochemistry of Beryllium and Genetic Types of Beryllium Deposits** (translated by F. Lachman. Freeman, San Francisco, 1966. 411 pp., illus. $15) is an excellent review of the state of knowledge of the geochemistry and crystal chemistry of beryllium and the mineralogy and structure of beryllium deposits in the U.S.S.R. as of 1960, the year the original work was published. The translation editor, Lincoln R. Page, notes with regret the unavoidable omission of some recently discovered types of deposits, for example, the Spor Mountain deposits.

After an introduction summarizing the history of the study and utilization of beryllium, the author devotes a short chapter to the atomic structure and consequent crystal chemistry of beryllium, especially in minerals. Chapter 2, the longest in the book, is devoted to the mineralogy of beryllium. For each mineral are given the physical and optical properties, unit cell data, and structural details where available, and for most, many analyses drawn from both Russian and foreign literature. The author does not hesitate to disagree with accepted ideas of crystal structure for some of the minerals, and he offers interesting suggestions for further structural work. Regrettably, *d*-spacing data from x-ray determination are not furnished. Chapter 3 discusses the peculiarities of the isomorphous entry of beryllium into the crystal structure of minerals. The author recognizes four well-defined types of beryllium isomorphism: (i) with substitution of beryllium together with high-valence cations such as rare earths, zirconium, and titanium for silicon, (ii) with substitution of beryllium for silicon together with substitution of fluorine and hydroxyl for oxygen; (iii) with substitution of beryllium and hydroxyl for silicon; and (iv), isostructural isomorphous series of beryllium compounds.

The second section of the book begins with a summary of genetic classifications: "All known beryllium deposits are post-magmatic formations genetically related to the late stages of the pegmatitic process or to the various stages of hydrothermal-pneumatolytic or hydrothermal processes. The overwhelming majority of these deposits, including all industrial deposits, are related to acid intrusive rocks and are the products of pneumatolytic and hydrothermal separations of the granitic magma." In the ensuing chapters the three classes are considered in more detail.

Chapter 4 deals with pegmatic deposits, on which the author is a recognized expert. Seven types are recognized and examples, taken largely from the Russian literature, are described in great detail, with numerous clear maps and diagrams and well-reproduced photomicrographs. Deposits described before 1941 are identified with some precision; those described since then are identified much more vaguely, as is usual in the Russian literature. The zonal classification used in the U.S.S.R. is apparently even more detailed than that developed in this country during World War II. Some space is devoted to the economically unimportant but interesting desilicated and alkaline pegmatites, both unfamiliar to most American geologists. Suggestions for prospecting for rare elements in pegmatites are included. Chapter 5 is devoted to the hydrothermal-pneumatolytic deposits, including greisens and skarns. (Greisens are becoming economically important in the U.S.S.R.) Chapter 6 considers the hydrothermal deposits, including the famous Colombian emerald deposits.

Chapters 8, 9, and 10 consider the chemistry of the solutions from which the beryllium minerals are deposited in magmatic, pegmatitic, and hydrothermal-pneumatolytic processes and offer a wealth of information on the distribution of beryllium in rocks and rock-forming minerals of the U.S.S.R. Chapter 11 considers beryllium in the hypergene (supergene) processes and in sedimentation and furnishes much statistical information. Chapter 12 concludes that the beryllium clarke in the earth's crust is 3.5 parts per million, approximately equal to the concentration in the crust in the U.S.S.R.

The translation is in nearly idiomatic English, and the number of misprints is moderate. The translation editor has annotated some errors and peculiarities of usage. Seventeen pages of references conclude the volume.

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Fine Particles

Richard D. Cadle, the author of **Particles in the Atmosphere and Space** (Reinhold, New York, 1966. 234 pp., illus. $10), formerly chairman of the atmospheric chemical physics department at Stanford Research Institute and now a program scientist at the National Center of Atmospheric Research, has excellent qualifications for writing a book on this subject. Cadle says in the preface that his book "is intended to be intermediate in scope between an introduction to the subject and an exhaustive treatise," and in this he has succeeded admirably. He writes in a lucid style and has managed to include a great deal of information in 196 pages of text.

Cadle discusses particles in the troposphere and in the stratosphere and mesosphere; radioactive fallout; interplanetary dust; the moon; and planets, comets, and galactic dust. The longest chapter deals with radioactive fallout and the next longest with dusts of diverse origins in the troposphere and with cloud physics. Although, as Cadle himself writes, "no attempt has been made to provide an exhaustive review of the literature," there are 344 references conveniently placed at the ends of the chapters, with a separate index of their authors at the end of the book. The book is well illustrated with photographs, line drawings, and graphs.

I once considered writing such a book as this. It is a pleasure to find that someone else has accomplished a better