Book Reviews

A Philosopher Contemplates Cosmology

John D. North has had the interesting and very useful idea of studying the literature of cosmology as an impartial spectator who is also a man trained in mathematics, philosophy, and astronomy. The task must have been an enormous one, to judge from the number of references that are quoted in his book, **The Measure of the Universe: A History of Modern Cosmology** (Oxford University Press, New York, 1965. 464 pp., $11.20), and North, who is a Nuffield Fellow at Oxford, is to be congratulated on his achievement. It is a most remarkable one for a man who is about 30 years of age. He writes well, in a pleasant ironical vein, as he contemplates the heated controversies to which the subject has given rise. Indeed, as my contributions to cosmology passed under his cool and critical eye, I had the impression that I was reading my own professional obituary written by a kindly but perspicacious critic!

North's starting point is the state of astronomy in Herschel's day, and he continues with a brief account of the puzzle that the "nebulae" presented in the 19th century. Then comes a discussion of the difficulties that arose when Newtonian gravitational theory was applied to the universe as a whole, the attempted solution of Charlier, the paradox of "why the sky is dark at night." During the 19th century many attempts were made to modify or replace the Newtonian theory by electromagnetic or hydrodynamic analogies, or by simply modifying Newton's inverse square law of gravitation. In chapter 4, North describes Einstein's ideas and the principles of general relativity, and this is followed by a long chapter on the Einstein and de Sitter universes and on Weyl's principle. It is fascinating to see how hard it was to understand the physical meaning of the de Sitter universe in terms of the original statical form of the line element combined with the prediction from the geodesic equations that free particles were in motion. The redshift effect was deduced, but there was incomplete agreement about the correct formula.

With chapter 6 we enter into the present era which, as North rightly says, began in 1930. The work of Friedman and of Lemaitre was rediscovered and was placed on a sound theoretical basis by Robertson and A. G. Walker. The different kinds of uniform model universe are described by North in terms of the nonstatical line element, and the modern redshift formula is obtained. The stability of the Einstein universe came in for a good deal of attention in those early days, presumably because cosmologists were looking for a "cause" for the expansion. Meanwhile, astronomers were showing that the red shift in the spectra of galaxies could be regarded as an exemplification of the theories that were being developed out of general relativity, which is the subject of a brief chapter 7.

An Oxford man would naturally be interested in the ideas of E. A. Milne, that stormy petrel of cosmology in the 1930's. Milne himself presented his ideas in such a voluminous form, with so much emotional fervor, that their importance tended to be overlooked in the "noise." North has performed a useful service in analyzing Milne's contribution to the theory of time, to that of distance, and to the meaning that is to be attached to the notion of coordinates. Even if Milne's kinematical relativity has not proved to be as fundamental as he had hoped, he forced all cosmologists to examine their basic ideas and to realize that everyone was using a "cosmological principle" of one kind or another. North also devotes attention to the Newtonian hydrodynamical cosmology that Milne and McCrea invented, even if he concludes that this theory contains too many conceptual difficulties to compete with the cosmology of general relativity. Chapter 9 contains an account of the theories of Birkhoff and of Whitehead, and they too receive a somewhat cool reception.

The steady-state theories of Bondi, Gold, and Hoyle, and the analogous conceptions of Dirac or of Pascual Jordan, are the subject matter of chapter 10. I was unaware that the notion of continual creation had a history going back to 1918. Chapter 11 brings the first part of the book to a close and is devoted to an account of the methods by which cosmological theory can be compared with observational results.

North brings out very well the hesitant and, all too often, confused steps by which this was achieved. It seems obvious today that the best way of solving the problem is to set up relations between pairs of observable quantities (red shifts and apparent magnitudes, number of galaxies and apparent magnitudes, and the like), but, as North points out, this was not so obvious 30 or even 20 years ago. The breakthrough came when "distance" ceased to be regarded as a primary quantity given by observation and when it was realized that "velocity of recession" was a confusing way of describing the observed red shift.

This brief account hardly does justice to the many questions discussed by North in the first part of the book. The problem of the time scale, Mach's principle, McCrea's "zero point stress," horizons, Milne's equivalences of observers, and many other topics of interest in cosmology are all discussed and appraised.

Chapters 12 to 18 form the second part of the book, which is entitled "Philosophical Issues." An astronomer or applied mathematician without formal training in present day philosophical ideas will find this the hardest part of the book. Such matters as the meanings that can be given to the terms "fact" and "universe," the notions of generality and simplicity in science, cosmological principles, "absolute" and "relative," infinity, creation, and the age of the universe, all come under scrutiny. There is also an interesting chapter 15 on distance and on coordinates; my own early struggles to assign an a priori meaning to coordinates in general relativity come in for attention here. I agree with North that

they led to unsatisfactory conclusions, and I have long since decided that, on the analogy of generalized Lagrangian coordinates in classical mechanics, only a posteriori meanings can be found.

The exposition is mainly verbal, but mathematical formulas are quoted as needed, usually without detailed proof. There are also 22 notes at the end of the book that expand in detail points raised in the text. It is clear from his comments that North understands the underlying mathematical theory very well. Nevertheless it must be recorded with regret that the formulas contain a quite unusual number of misprints. Plus and minus signs are interchanged, indices are omitted or incorrectly printed, capital letters become lower case in successive lines, brackets are misplaced, and so on. The misprints are merely a source of irritation to the expert reader, but they might well prove to be a serious obstacle to a student. It is also surprising to see Oxford University Press allowing, in the text, so many misprints of the "fron" for "from" variety. I believe that the book is of permanent value, and it would be highly desirable to correct all misprints before further printings are made. I have also noticed two places where I cannot follow the mathematical argument. On page 108, I am unable to deduce equation (30) —in which "sin" is misprinted for "sinh"—from (29) and the information contained in equations (27) and (28). If τ (or should it be T?) and R are independent coordinates, the derivation cannot be made. There must be some unstated condition about the relation between τ and R. On page 346, I do not believe that the attempt to prove the transitive property for luminosity distances is legitimately made from equations (17)—here R^k is misprinted for R_2. Luminosity distances are applicable to a set of luminous sources viewed at the same instant of time by a single observer. North wants to combine luminosity distances calculated by observers located at different places and at different times. I would say that this is an illegitimate use of the concept of luminosity distance. Nevertheless, in spite of these defects, the book can be heartily recommended to all students of cosmology.

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Science and Technology and the Less-Developed Countries

Science and Medicine in Central Africa (Pergamon, New York, 1965. 1008 pp., $30), edited by George J. Snowball, is a collection of papers that were presented at the Central African Scientific and Medical Congress held at the College of Further Education (Lusaka, Northern Rhodesia) in August 1963. The Congress brought together scientists of widely divergent interests in the manner of the United Nations Conference on the Application of Science and Technology for the benefit of the less-developed countries.

The subject matter covers the physical, biological, social, and medical sciences. Some of the papers are presented in full, others in abstract form only. At the beginning of most papers there is a short explanatory statement which will assist the reader in selecting the papers of particular interest to him; these statements will also enable the reader to understand the overall complexity of attempting to change cultural patterns.

There is a fascinatingly wide range of information in this book for anyone interested in the problems of newly emerging nations. The authors represent a judicious mixture of scientists steeped in African affairs and scientists from the wider world.

Agricultural education is discussed in an opening paper, with emphasis on a three-tier system of agricultural education in Britain, the needs of the fundamental research worker, the critical gap between the research scientists and the farmer, the educational needs of the farmer, and the need for some degree of specialization. The lessons of Britain have meaning for Rhodesia.

The need to teach the fundamental sciences to all school pupils is stressed in another paper. The planning of medical care services is discussed in relation to lessons learned from the mistakes of the National Health Service planning in Britain: namely, that the need for medical care does not decrease, but increases and becomes more expensive.

There is an article on airframe icing on a scheduled flight over the Sudan; geological and ground water research is discussed. A novel method of waterborne sanitation appropriate to much of Africa is presented—a combination of aqua privy and stabilization pond. The sands of Kalahari-type are analyzed and discussed in relation to their origin.

A standard method of vegetation classification is put forward for consideration—a method that does not involve specialist knowledge and will be a boon for all those working in vector-control, for example. Even the dragon fly, and its role as an economic factor, comes in for discussion. Did you know that crocodiles eat adult dragon flies? Or that termite mounds may be partly created by the erosion of the surrounding land surface, not necessarily by the addition of material from above?

The impact that a changing cultural environment makes on the individual and the stresses engendered by living in two worlds, old and new, is presented. Papers on medicine occupy one fourth of the book.

In toto, this volume attempts to equate the reader with the interaction of the sciences, education, and economics. It presents the need for research in applied science and pure science. Education is a constant theme. But the greatest lesson that this Congress teaches is the interrelationship of the various disciplines, that Africa needs men of broad vision, as well as the specialist, who can relate the contribution of science to the betterment of human life. It is a must for those interested in Africa. More such interdisciplinary conferences are required; but they should be convened with defined objectives and a strictly limited series of papers.

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Respiratory Physiology

Cerebrospinal Fluid and the Regulation of Ventilation (Davis, Philadelphia, Pa., 1965. 456 pp., $16.50), the proceedings of a symposium held at the Downstate Medical Center, State University of New York, in April 1964, has been published under the editorship of Chandler McC. Brooks, Frederick F. Kao, and Brian B. Lloyd. The symposium brought together scientists, from western Europe and the United States, who were interested in the role of the cerebrospinal fluid (CSF) in regard to respiratory physiology. Fourteen papers presented at the con-