cussed here particularly in Islamic countries) serve to define and redefine the positions of individuals and groups within both national and transnational political arenas. The dynamic process of being "born again" adds a further dimension and is shown here to operate within both organized religion (Islam and Hinduism) and the nation state (Malaysia, Pakistan) to gain increasing privilege and exclusivity. Readers may conclude with this reviewer that it is to be regretted, perhaps, that case studies of cultural pluralism in the United States are not under consideration. Barth is surely wrong when he argues that U.S. ethnicity is "a very special kind of case" (p. 85). The seminal paper of the symposium, Leo Kuper's "International protection against genocide in plural societies," poses at the outset the field of study: destructive conflicts between ethnic and other groups *in the successor states to the colonial empires* (p. 207; emphasis added). Ethnohistorians would not consider this challenge met in this otherwise informative and thought-provoking volume. Perhaps not until cultural pluralism and genocide are studied in empires—political and economic—will they be understood in nation states.

JOAN VINCENT
Department of Anthropology, Barnard College, Columbia University, New York 10027

Relativity and Other Issues

Understanding Relativity. Origin and Impact of a Scientific Revolution. STANLEY GOLDBERG. Birkhäuser, Boston, 1984. xviii, 494 pp., illus. $24.95.

Goldberg's book has several clear and worthy objectives: to provide a self-contained exposition of special relativity "primarily for a lay audience" (p. xi) that will serve "to *demystify* the substantive content" (p. xiii) of the theory (part 1 and six appendixes, totaling over 300 pages); to provide a comparative account of the reception of special relativity during the period 1905 to 1911 in Germany, France, Great Britain, and the United States (part 2, totaling some 85 pages); and to describe how special relativity was assimilated in the United States from 1912 up to (almost) the present (part 3, totaling some 60 pages). In addition, Goldberg has a fourth—for me, much more problematic—objective having to do with analysis of how science is related to other aspects of culture and society. Among Goldberg's statements along these lines are the following: "The glib claim that it is necessary to do science in order to fuel the fires of technological progress will be scrutinized and found wanting" (p. xii); "There is no special kind of thinking that is 'scientific' " (p. 2); "The fate of ideas like the theory of relativity is as much a function of culture as is the fate of any other product of the human intellect" (p. 325). Since I found Goldberg's remarks on these and similar topics vague, largely programmatic, and hence difficult to evaluate, I shall say no more about them.

Let me begin, then, with Goldberg's own interpretation of special relativity—an interpretation that colors much of the discussion in all three parts of his book. Special relativity, Goldberg holds, is "a theory of measurement" that "says nothing about the nature of the world" (p. 103); and, he goes on, the two postulates of the theory (the principle of special relativity and the constancy of the velocity of light in vacuo) "could never be justified *a posteriori*" (p. 108). As for the relation of special relativity to Newtonian mechanics, Goldberg holds that Einstein's theory "did not replace Newtonian mechanics. It replaced the Newtonian theory of measurement" (p. 103). In other words, what is usually thought of as special relativity mechanics is for Goldberg simply Newtonian mechanics with a new theory of measurement (primarily, for time), for "the basic premises of Newtonian mechanics are unaffected" (p. 103).

Now, I find calling special relativity merely a theory of measurement more mystifying than illuminating, but, quite apart from terminological matters, to maintain that special relativity says nothing about the world seems to me just false. The easiest way to see this is to look at the actual structure of Einstein's 1905 paper. The first two sections of the paper deal, as Einstein explains, with the kinematics of a rigid body. The position of a material point is taken to be directly determinable by means of rigid measuring rods and Euclidean geometry. The motion of a material point is more problematic because it involves the unclear idea of time. To clarify this idea Einstein proposes his famous definition of clock synchronism (or simultaneity), which stipulates that oppositely directed light rays along the same path move at identical speeds. But, and this is crucial, Einstein adds that one must assume that the proposed definition is consistent, applicable to any number of points, symmetrical, and transitive. These four assumptions say some things that are presumptively true about the physical properties of light rays. In other words, though Einstein's definition of clock synchronism may be a sheer stipulation, it is a usable definition only because of the contingent behavior of light rays. This—the empirical—side of Einstein's definition Goldberg simply ignores (see his discussion of the definition on pp. 110–113), as he also ignores Reichenbach's more explicit presentation of the empirical aspects of special relativity in his axiomatization of the theory (1924). (It is difficult to make out Goldberg's attitude toward Reichenbach's work; he first quotes, without challenging, Reichenbach's claim that his logical analysis of special relativity coincides very closely with Einstein's own interpretation of that theory and then dismisses the work of Reichenbach as having "confused logic with history" [p. 307].)

In his legitimate concern to dispel the air of paradox often associated with the relativity of time and space Goldberg places insufficient emphasis on the larger goal of Einstein's thought experiments with clocks and rigid rods, which was to formulate a new relativistic kinematics to replace Newtonian kinematics. These two kinematical theories, it must be stressed, represent objectively different and incompatible space-time structures, so that no more than one can characterize the world. In this sense, at least, special relativity certainly does say something quite definite about the world.

With respect to Einstein's own understanding of the epistemological basis of special relativity, Goldberg says that Einstein's popular writings on relativity often do not "reflect his views on the nature of good theories" (p. 109); and yet he claims his own exposition of special relativity will "follow Einstein's account in his fine, albeit parsimonious, popularizations" (p. 110). In any case, I should like to cite what I consider to be one of Einstein's most important writings on the nature of physical theories in general; it was first published in the London *Times* in 1919, and in it Einstein draws a distinction between physical theories of two kinds: constructive theories (like the kinetic theory of gases) and principle theories (like thermodynamics). Special relativity is said to be of the latter kind, namely a theory whose "elements" are "not hypothetically constructed but empirically discovered . . . general characterisitics of natural processes" and whose "postulates" are "powerfully supported by experience."

Goldberg's exposition of special rela-

tivity seems to me not notably different from many elementary expositions now in print. Occasionally, though, he says misleading things. Thus, owing apparently to his insistence on treating special relativity as a mere theory of measurement, Goldberg writes that rotational motions "fall outside the realm of discourse of the special theory of relativity" (p. 71). But special relativity, exactly like Newtonian mechanics, can deal perfectly well with rotations; either theory would be cripplingly impoverished if it could not. (It is true that if one chooses, in either theory, to use rotating, and hence non-inertial, reference frames one has to introduce so-called fictitious forces.)

More original and more interesting than his exposition of special relativity is Goldberg's history of the reception of special relativity in Germany, France, Great Britain, and the United States in the years 1905 to 1911. Briefly, what Goldberg contends is that each response was a function of "social custom and fashion" within the respective national physics communities. Thus, leading German physicists debated the paradoxes that seemed to inhere in special relativity (such as the difficulty of defining a rigid body and the possibility of velocities exceeding that of light in vacuo); French physicists, following the lead of Poincaré, ignored Einstein's theory altogether; British physicists reworked Einstein's main results so as to make them compatible with the traditional concept of an ether; and American physicists—or at least the few who paid any attention to the theory—either attacked it as metaphysical speculation or interpreted it as based on empirical generalizations, "consistent with the pragmatic experimental emphasis prevalent within the American scientific community" (p. 256). This last theme is pursued in a long chapter entitled "Relativity in America, 1912–1980."

Goldberg's evidence for American interpretations of special relativity from 1912 to 1980 is drawn primarily from physics textbooks—graduate, advanced undergraduate, and introductory—widely used in the United States during the period in question. He favors such evidence because "textbooks prove to be one of the few places where physicists are willing to discuss, if only implicitly, the meaning of theories and their concepts of how evidence supports theories" (p. 276). He concludes, "The American interpretation of the meaning of the theory of relativity is based on the belief that the theory is correct because both the postulates and the predictions of the theory are in agreement with measurement and observation. Such an interpretation is more easily integrated into traditional American views about the relationship between evidence and theory than is Einstein's view that theories are the free creation of the human spirit" (p. 318). To me there is nothing inconsistent about holding both views referred to in the latter of the sentences quoted; I believe, furthermore, that Einstein himself held both views. A theory may be freely created, but once formulated it can be subjected to observational and experimental tests. (A point of logic: Goldberg appears to hold that the "conclusions" of a theory but not the "premises" must be "tested and demonstrated" [p. 293]; but if the conclusions, or predictions, of a theory are testable, then its premises, or postulates, are also, at least indirectly, testable—which seriously reduces the force of Goldberg's intended distinction between conclusions and premises.)

One test of whether there is anything peculiarly "American" about the interpretations of special relativity found in the textbooks studied by Goldberg would be to compare those interpretations with ones found in European textbooks of the same period. Without such a test Goldberg's historical thesis remains a suggestive, but hardly cogent, finding.

ROBERT PALTER

Trinity College,
Hartford, Connecticut 06106

Climate

Theory of Climate. BARRY SALTZMAN, Ed. Academic Press, New York, 1983. xiv, 505 pp., illus. $64. Advances in Geophysics, vol. 25. From a symposium, Lisbon, Oct. 1981.

The theme of this volume is that in the last decade scientists in the disciplines concerned with the climate system have increasingly come to appreciate the connections between the various components of the climate system and the hazards of overly narrow viewpoints.

The eight chapters in the volume are illustrative of the "bringing together" of areas of expertise in the search for a fuller understanding of the theory of climate. I particularly appreciate the tutorial nature of almost all the chapters. Particularly notable in this respect is Golitsyn's chapter, "Almost empirical approaches to the problem of climate, its variations and fluctuations," in which basic physical concepts and order-of-magnitude estimates are used to demonstrate the power of climatic processes. Also notable is the final chapter, by Oort and Peixóto, who present a global picture of the general circulation of the atmosphere and of its thermal structure from observational data. Their meticulous analysis of data from 10 years of observation illustrates that such data are very much harder to come by and considerably more difficult to interpret than the ever-flowing streams of output from global climatic models. It does not seem too strong to claim that validation and, hence, fully successful parameterization in climate models will not be achieved until as much money, computer time, and scientific effort are devoted to the improvement, careful checking, and analysis of observational data as are currently devoted to climate modeling. In this respect a chapter by Ohring and Gruber devoted to the analysis of the scanning radiometer data from the National Oceanic and Atmospheric Administration's polar orbiting satellites and the application of these data to climatology is a valuable contribution to the literature.

One of the few difficulties with this excellent volume is that chapters are grouped under somewhat contrived headings. For example, a section entitled Radiative, Surficial, and Dynamical Properties of the Earth-Atmosphere System encompasses the papers by Ohring and Gruber and Oort and Peixóto as well as an excellent review by Dickinson of the considerable difficulties faced by the very few of us concerned with incorporating land-surface processes into global-scale climate models. Dickinson's paper covers topics as wide-ranging as stomatal resistance and modeling of regional-scale albedos in the cryosphere. However, it should not have been positioned between the strongly observational chapters of Ohring and Gruber and Oort and Peixóto. Grouping chapters by Shutts and by Saltzman under the heading Statistical-Dynamical Models tends almost to diminish the wide-ranging nature of both.

A paper by Manabe on carbon dioxide and climatic change seems rather familiar. Perhaps this is simply a reflection of a jaded academic's oversaturation with results of increased CO_2 on global climate modeling sensitivities. The tutorial nature that is so strong in other chapters is missing here. My favorite chapter is the opening review, by Smagorinsky, of the beginnings of numerical weather pre-