technology symbiosis has any significance, it is in conceptually dissolving the old boundaries.

The author's remarks on the structural relations that may exist between art and natural language are perhaps his most provocative. At one point he writes, "For instance, computers cannot handle natural language, and this fact is held by some (rightly in my view) to be very relevant to a provisional definition of human creativity." In his chapter "The implications of linguistics," Benthall makes some far-reaching speculations on the systems approach to ecology and the applicability of the same principles to other language and sign systems. One wishes that he would push these a bit further. Probably the average art-lover will find little of comfort in Benthall's book. But for the serious reader who has lost patience with the antics of avant-garde art, this introduction into one realm of it will prove a clarifying experience.

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Coming to Grips with Time

Time in Science and Philosophy. An International Study of Some Current Problems. JIŘÍ ZEMAN, Ed. Elsevier, New York, 1971. 306 pp., illus. $17.75.

The Study of Time. Proceedings of a conference, Oberwolfach, West Germany, Aug. 1969. J. T. FRASER, F. C. HAVER, and and G. H. MÜLLER, Eds. Springer-Verlag, New York, 1972. 550 pp., illus. $20.30.

Temporality is so pervasive that a thorough understanding of it would seem to be a prerequisite for success in any philosophical or scientific investigation whatsoever. Yet, like all such pervasive and general features of experience and of the world, it resists direct characterization in general terms and is involved in so many diverse disciplines that a complete and unified analysis based on these is all but impossible. By bringing together writers from diverse disciplines to deal with problems in which time plays a central role the two volumes here reviewed attempt to overcome the difficulties which the lone investigator would encounter in attempting such an analysis.

Failure to achieve the rather ambitious goal of a complete and unified analysis of time would by no means render these books unworthy of note. Each of them will be found useful, if not indispensable, for many purposes, some of which are pointed out below. Certainly no major university library or special collection dealing with the philosophy of science, philosophical problems of physics, or philosophical problems pertaining to time can afford to be without either volume.

A crucial question in examining these works is whether these heterogeneous writers succeed in speaking the same language to a sufficient degree to communicate with each other or with a common audience. Only to the degree that this goal is realized will it be possible to progress toward a deeper, more encompassing, and more unified understanding of time.

Ironically, of the two books, it is the one which deals primarily with a narrower range of topics, *Time in Science and Philosophy*, that is the less successful in this. It seems that the "philosophy" followed by the editor has been to include selections from as many viewpoints and approaches as possible, and the contents of the book are grouped under the headings Astronomy and Physics; Geology, Biology, and Psychology; Philosophy; and Time Measurement. Yet the bulk of the material is devoted to philosophical issues related to the physical sciences and such allied fields as information theory and probability theory. Some of the articles, including the opening one, are so technical that potential readers are limited to those knowledgeable in these fields. If the book has a common audience it would thus have to be a subclass of those persons knowledgeable in the physical sciences. Yet, very few such readers—indeed very few readers at all—are likely to profit from an exposure to the barrage of highly specialized technical jargon encountered in one of the psychologically oriented articles. Still less likely is it that a reader with a scientific background will gain new insight into the nature of time by being told, in another article, that in positing the notorious thermodynamic or "heat" death of the universe modern science has unwittingly stumbled upon a fragment of the wisdom of the ancient Vedic sages, who, through special powers of intuition and cosmic insight which modern man lacks, came to know of the great World Cycles, the largest of which lasts 3.1104×10^{12} years and begins and ends with an undifferentiated formless state of pure consciousness or energy. Some of the other selections pose similar problems. Thus, neither the problem of specialized technical vocabularies nor that of incommensurable methodological and epistemological commitments seems to have been dealt with satisfactorily.

In contrast, in *The Study of Time*, although the problem of technicality persists in discussions in which the concepts and findings of physics play an important role, a more consistent effort seems to have been exerted to make the gist of arguments and issues clear to the reader who lacks the technical background to follow the details. In the life sciences and humanities surprisingly uniform success is achieved in dealing with the problem of technical jargon. Since *The Study of Time* contains large sections devoted to the life sciences (primarily biology and psychology), philosophy, sociology, cultural and intellectual history, drama and art criticism, as well as a special section on flight dysrhythmia, this achievement is all the more remarkable. Incommensurable epistemological and methodological commitments are also much less of a problem, largely because the basic viewpoints taken by the authors are all Western and empirical. Conceptions of time from other philosophies and cultures are discussed, but from a Western, empirical viewpoint. Within these limits epistemological and methodological diversity is present, however, and can be expected to surface in any sustained probing of the philosophical issues involved in the problems presented. In some cases basic philosophical commitments and their consequences are very much in evidence, as is the case, for example, with the surprisingly virulent—for the 1970's—logical positivism of David Park in "The myth of the passage of time."

Taken as a whole, however, *The Study of Time* seems to succeed in providing the necessary conditions for the development of a deeper and more unified conception of time. Thus it might serve very well as a text for an interdisciplinary course on time, provided the instructor is prepared to provide appropriate supplementary material from the physical sciences for those whose background in them is inadequate. All factors considered, however, both volumes here reviewed are likely to see the most service as resource and research references. Each will be of special interest to those concerned with philosophical problems closely related to the physical sciences. The problem of "the direction of time" in its various forms and connections receives perhaps the most attention in both volumes, being treated in several excellent papers and review articles. Ontological questions concerning the reality of time and of temporal becoming also receive considerable attention, as do the various philosophical problems and paradoxes associated both with the theory of relativity and with the various field theories of contemporary physics. The methodological problems of time perception and measurement (in physics, biology, and psychology) are also considered in both volumes. Both devote space to differing conceptions of and attitudes toward time. *Time in Science and Philosophy* features the article on time in Indian philosophy already mentioned. *The Study of Time* contains several psychological, sociological, historical, cultural, and philosophical studies of a range of time concepts and their intricate interconnections with other factors, as well as the fascinating and readable selection of articles, also already mentioned, on the disrupting and disorienting effects of long transmeridian flights.

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Neutralists vs. Selectionists

Proceedings of the Sixth Berkeley Symposium on Mathematical Statistics and Probability. Vol. 5, Darwinian, Neo-Darwinian, and Non-Darwinian Evolution. LUCIEN M. LE CAM, JERZY NEYMAN, and ELIZABETH L. SCOTT, Eds. University of California Press, Berkeley, 1972. xvi, 370 pp., illus. $13.50.

Do not be deceived by the title of this book. It contains little about statistics and almost nothing about Darwin. It does, however, give an excellent sample of the recent arguments about molecular evolution, written in a manner intelligible both to biologists and to mathematicians.

The debate has been heated, and there has been a tendency for each side to ignore the arguments of the other. The issues have become clouded rather than clarified. The book is therefore particularly valuable for allowing us directly to compare the different points of view.

The comparison is not very flattering to either party, and the reader may be forgiven if occasionally he throws down the book in disgust and says "a plague on both your houses."

Yet the issues are important, theoretically and practically. Has the greater part of our evolution been the result of random substitutions, effectively neutral in selective value? Are the many enzyme polymorphisms in human populations merely "evolutionary noise"? If they are not, they must affect—or have affected—our survival or reproduction. These are matters of concern.

Even in matters of concern it is depressing how easily myths and misconceptions can become accepted as scientific truths. Once they get embedded in the literature, it is difficult indeed to winkle them out. Nonetheless the attempt must be made.

I will start with a personal but illustrative example. In 1957 Dobzhansky and Pavlovsky published an experiment purporting to show the interaction between random genetic drift and natural selection. Shortly thereafter, Williamson and I published in the same journal a note pointing out (albeit timidly, for we were young then and Dobzhansky was already a great man) that their data appeared to be clumped, that their statistical test was therefore inappropriate, and that their results seemed to be statistically insignificant. We were correct but, from that time to this, Dobzhansky and Pavlovsky's paper has been quoted without qualification in virtually every textbook of population genetics and nearly every discussion of genetic drift. It appears again in Crow's introduction to this symposium, quoted with approval and without reserve.

There are more serious cases. A new and popular misconception is that, for individual classes of proteins, evolutionary rates are constant. Kimura and Ohta's contribution to the book makes much of this "constancy" despite the fact that their own data show significant variations between different lines of descent, and despite the fact that the averages within lines are calculated for such long periods that the differences between them would permit very large changes of rate (even by orders of magnitude) over shorter intervals. Kohne *et al.*, in another paper, report that the rates of evolution in nonrepetitive DNA are variable and appear to be related to generation time. Nevertheless Jukes, in the same book, baldly states that "the evolutionary clock ticks slowly in proteins, independent of speciation, generation time or gene duplication." After this, he goes on to accuse the selectionists of fitting all molecular changes in evolution to "the Procrustean bed of pan-selectionism."

Three papers (by Crow, Kimura and Ohta, and King) reproduce a neat example of circular reasoning. Each of them expresses pleasurable surprise that Fitch's "covarions," studied in cytochrome c, hemoglobin α and β chains, and fibrinopeptide A, seem to evolve at nearly equal rates. These covarions were postulated following Fitch's attempt to define two exclusive types of sites within proteins (variable and invariant). When it became apparent that the data were not consistent with this dichotomy, the concept was refined to include the hypothesis that the array of variable sites (covarions) changes with time. Disregarding the doubtful business of imposing a system of strict alternatives on variation that is clearly continuous, it is important to recognize that slowly evolving proteins are supposed to have relatively fewer covarions and faster-evolving proteins are supposed to have relatively more. The inevitable result of this arrangement is that the evolutionary rates of the covarions will be much more alike than the rates of the proteins themselves. Their similarities should be no source of surprise, and cannot be construed as evidence of neutrality, or of anything else.

Another popular misconception, pointed out by Stebbins and Lewontin in a thoughtful essay, is the "fallacy of omniscience"—the assumption that if we cannot immediately see the function of an organic system it is therefore functionless. This fallacy has raised its muddled head many times during the development of evolutionary theory. Newly discovered genetic variation is immediately hailed as neutral, a view that persists for a length of time directly correlated with the degree of our ignorance. This has happened for industrial melanism, for mimicry, for nonmimetic color polymorphisms, and now for enzyme polymorphisms.