physical] science which had called them forth [pp. 45–46].

That Kuhn had described something fundamental is clear from the loud noise generated by critics and admirers alike. The 1965 London Colloquium in the Philosophy of Science (published in 1970 as *Criticism and the Growth of Knowledge*) devoted to his views and those of Karl Popper gave vent to feelings of tragedy among many philosophers and to battle cries for pedagogical reform. As Popper wrote,

> In my view the "normal" scientist, as Kuhn describes him, is a person one ought to be sorry for. . . . The "normal" scientist, in my view, has been taught badly . . . all teaching on the University level (and if possible below) should be training and encouragement in critical thinking [*Criticism*, pp. 52–53].

Another critic, John Watkins, picked up some of the more dramatic phrasing in *The Structure of Scientific Revolutions*, in which normal scientific education is compared to orthodox theology in its narrowness and rigidity, and suggested that, by analogy, the relatively rare periods of extraordinary science must correspond to "a period of crisis and schism, confusion and despair, to a spiritual catastrophe" (*Criticism*, p. 33). Nothing expresses better what distinguishes Kuhn's sociopsychological approach from the approach of the Popperians than Watkins's comment that

> From a methodological point of view, something rare in science—a path-breaking new idea or a crucial experiment between two major theories—may be far more important than something going on all the time [*Criticism*, p. 32].

With such an assumption, one wonders how philosophers of science could ever see the history of science as relevant to their concerns. To Margaret Masterman, on the other hand, normal science exists as "the crashingly obvious fact which confronts and hits any philosophers of science who set out, in a practical or technological manner, to do any actual scientific research" (*Criticism*, p. 60).

Whatever the disagreements among Kuhn's supporters and critics and whatever the ambiguities in his early formulations of the paradigm concept, his conceptualization of science has clearly urged serious attention to the following question: What place do shared elements—elements such as language and meaning, values, educational training, metaphysical presuppositions, theories, methodologies, and attitudes toward criticism—have in scientific inquiry? Kuhn's position is clear. From early on, as the essays in this volume reveal, he has tried to characterize science (as demarcated from other kinds of knowledge) by its high degree of consensus. Its strength and novelty notwithstanding, this perspective is not without difficulties. Many philosophers have pointed to the relativism implied by Kuhn's account of paradigms (now replaced by "disciplinary matrices") as closed systems of premises with no transparadigmatic juries to adjudicate disputes. Kuhn now concedes that the problem of translation and incommensurability between paradigms cannot be handled in the way he has attempted to handle it in the past, and he promises future thoughts on the matter (p. xxiii). Even descriptively, however, it is not clear that consensus-bound research is quite as pervasive as Kuhn has supposed. Consider a favorite case of Kuhn's, the "Copernican Revolution." Early reactions to the Copernican theory showed a strong methodological consensus among its *opponents*, who nevertheless borrowed heavily from Copernicus's planetary models. The scientific community of the time did not act as though it were choosing between different ways of doing science, nor did its members live in totally different universes of meanings. The first "textbook" of Copernican astronomy, written by Kepler and appearing some 75 years after Copernicus's *De revolutionibus*, was read and understood by opponents and supporters alike. One cannot help wondering whether Kuhn's concern, manifested as early as 1959 in the essay that gives the present collection its title, with epitomizing "*the nature* of education in the natural sciences" (p. 228, my italics) is itself time- and culture-bound—characteristic, that is, of his own education in postwar America. The description of his own "conversion" to the history of science and his account of the difficulties encountered by his philosophy graduate students in reading a text historically and by history students in dealing sympathetically with the analytic clumsiness of early thinkers reveal Kuhn's rich sensitivity to the problem of how we make contact with different frames of meaning and experience. That problem is a universal one, no more specific to scientists than to parents trying to understand children or men struggling to understand the experience of women or Americans the life-style of Europeans or anthropologists a foreign culture. If Kuhn has failed thus far to solve the problem of what demarcates science from other forms of knowledge, that is more than compensated for by the increase he has brought about in our hermeneutic sensibilities. No one who studies his writings will come away unchanged.

ROBERT S. WESTMAN
Department of History, University of California, Los Angeles 90024

Atmospheric Phenomena

Environmental Aerodynamics. R. S. SCORER. Horwood, Chichester, England, and Halsted (Wiley), New York, 1978. 488 pp., illus. $49.50. Mathematics and Its Applications.

Richard Scorer is a keen observer. He has greatly distinguished himself by explaining many visible phenomena by ingenious uses of physical principles. About 20 years ago, Scorer produced a well-received book called *Natural Aerodynamics*. In it he explained, in fairly qualitative terms, such atmospheric structures as mountain waves, plumes, clouds, and thermals.

In *Environmental Aerodynamics*, Scorer has retained much of the material of the first book, added some sections, and made his argument considerably more rigorous and mathematical. His introduction implies that "mesoscale" phenomena—meteorologists define mesoscale as those scales of motion that are too small to be seen on weather maps but yet contribute to weather—are emphasized more than in the first book.

Scorer deals primarily with those mesoscale phenomena that interest him and that he or his colleagues and students have investigated. The book includes chapters on secondary vorticity, the rotating earth, waves in a stratified fluid, billow mechanics, turbulence, clouds and fallout, and dispersion of pollution. Scorer does not discuss mechanisms and models of such important phenomena as sea breeze and thermally driven mountain-valley circulations.

The types of phenomena of interest to Scorer are discussed with clarity and ingenuity. But he limits himself to analytical solutions of linearized equations and does not mention the considerable progress achieved by the use of numerical models. He has a general bias against such models, which, in the reviewer's opinion, is only partly justified.

Scorer is a scientist of strong opinions, which makes the book provocative yet irritating. Some of what he states categorically is really controversial. He also dislikes much of the work of other meteorologists and often criticizes them on the basis of his own incomplete understanding. This tendency is particularly evident in the discussion of turbulence. Certain ideas on turbulent structure and turbulent dispersion are much more amenable to practical use in the atmosphere than he supposes.

Finally, many developments in the last 20 years that are relevant to the subjects Scorer discusses are not referred to in the book. Almost nothing is said about Briggs's work on plumes, which has proven valuable in practical pollution predictions. Neither does he refer to Deardorff, whose experiments and theoretical analysis of convective boundary layers have made the physics of this region tractable.

In spite of these faults, the book is a provocative treatise of certain atmospheric phenomena, and it should be of interest generally to physical scientists and engineers.

H. A. PANOFSKY
Department of Meteorology, Pennsylvania State University, State College 16801

Evolutionary Mechanisms

Endopolyploidy and Polyteny in Differentiation and Evolution. Towards an Understanding of Quantitative and Qualitative Variation of Nuclear DNA in Ontogeny and Phylogeny. WALTER NAGL. North-Holland, Amsterdam, 1978 (U.S. distributor, Elsevier, New York). xiv, 284 pp., illus. $54.50.

Chromosomes have evolved in higher cells as a successful mechanism to achieve two cellular functions: the precise passage of genetic information from generation to generation and the expression of this information during the cell's lifetime. Usually, chromosomes in somatic cells are identical with those in the germ line. However, there are numerous instances in which there are somatic variations in the chromosomes, usually as polyploidy, an increase in the number of copies of each chromosome within the nucleus, or as polyteny, an increase in the number of chromatids, and hence DNA strands, per chromosome.

Endopolyploidy and Polyteny in Differentiation and Evolution also appears to have two functions. The first is to assemble the information on the occurrence and functions of polyploid and polytene nuclei. The second is to bring this information together with our current understanding of chromosome organization to explain some aspects of speciation and cellular differentiation.

The current interest in molecular approaches has led many researchers away from much of the cytological literature. Nagl does a great service in his remarkably complete review of the cytology of polyploid and polytene nuclei. Much of the book concentrates on the varied processes that give rise to polyploidy and polyteny in animals, protists, and plants. Indeed, many of the better examples of polyploidization events are from plants, and considerable attention is paid to this often neglected branch of biology. Applications of polytene chromosome cytology, especially gene mapping, are outside the author's aim and so are omitted. A number of photographs are included, some of them very fine and some of them almost impossible to interpret.

The increase in DNA content by polyploidization or polytenization that occurs during differentiation is seen by Nagl as an analogy for changes in DNA that take place in evolution. He presents evidence that cells have an optimum DNA content that can be reached by either a somatic or a generative DNA increase. Further, nuclear DNA content is a phenotype subject to rather strong selective pressure. As the nuclear DNA content changes, so does the number of repeated DNA sequences. Because repeated DNA sequences are suspected to be involved in regulation of gene expression, Nagl concludes that a change in DNA content may result in alterations in the patterns of genetic activity. Thus, new species may arise abruptly as a consequence of a change in these regulatory patterns, independently of any major divergence of structural genes.

This scheme is certainly interesting, but its vagueness and reliance on broad assumptions limit its utility and testability. That some repeated DNA sequences are involved with genetic regulation seems quite likely, but most of the repeated DNA, especially the highly repeated or satellite DNA, probably is not. Unfortunately, Nagl fails to distinguish between the satellite DNA and those repeated sequences which are interspersed among structural genes. Another problem is that Nagl views phyletic evolution and speciation as distinct processes, each with its own causal mechanism. Thus phyletic evolution is the result of structural gene mutation, and speciation is the result of changes in control elements. There are certainly many instances of saltatory speciation that do not require substantial change in structural genes, but it is simplistic to expect to find any single process of speciation.

We are left with a very thorough review of chromosome structure and somatic DNA variability and a somewhat tenuous but interesting model of the effect of quantitative DNA change on evolution. As the title might indicate, the book is not easy reading. The short glossary is helpful, but a reader without a background in chromosome cytology will have slow going. Nevertheless, those interested in the diversity of nuclear organization may find the time well spent.

BRIAN B. SPEAR
Department of Biological Sciences, Northwestern University, Evanston, Illinois 60201

Books Received

Aging. Geraldine M. Emerson, Ed. Dowden, Hutchinson and Ross, Stroudsburg, Pa., 1977 (distributor, Academic Press, New York). xvi, 374 pp., illus. $25. Benchmark Papers in Human Physiology, vol. 11.

The Aging Reproductive System. Edward L. Schneider, Ed. Raven, New York, 1977. xii, 280 pp., illus. $27.50. Aging Series, vol. 4.

Air Photography and Coastal Problems. Mohamed T. El-Ashry, Ed. Dowden, Hutchinson and Ross, Stroudsburg, Pa., 1977 (distributor, Academic Press, New York). xviii, 428 pp., illus. $32.

Alcohol Intoxication and Withdrawal—III. Proceedings of a symposium, Lausanne, Switzerland, June 1976. Milton M. Gross, Ed. Plenum, New York, 1977. Two volumes. Vol. 3a, Biological Aspects of Ethanol. xviii, 652 pp., illus. $59.50. Vol. 3b, Studies in Alcohol Dependence. xviii, 646 pp., illus. $49.50. Advances in Experimental Medicine and Biology, vols. 85a and 85b.

American Political Science Research Guide. Vol. 1. George W. Johnson, Ed. IFI/Plenum, New York, 1977. xvi, 226 pp. Paper, $20.

Ancient Continental Deposits. Franklyn B. Van Houten, Ed. Dowden, Hutchinson and Ross, Stroudsburg, Pa., 1977 (distributor, Academic Press, New York). xiv, 368 pp., illus. $28. Benchmark Papers in Geology, vol. 43.

Animal Health Yearbook, 1976. FAO, Rome, 1977 (U.S. distributor, Unipub, New York). iv, 204 pp. Paper, $13.50.

Chloramination Reactions. Stephen E. Frazier and Harry H. Sisler, Eds. Dowden, Hutchinson and Ross, Stroudsburg, Pa., 1977 (distributor, Academic Press, New York). xvi, 230 pp., illus. $28. Benchmark Papers in Inorganic Chemistry, vol. 6.

Communicative Structures and Psychic Structures. A Psychoanalytic Interpretation of Communication. Proceedings of a conference, Brooklyn, N.Y., Jan. 1976. Norbert Freedman and Stanley Grand, Eds. Plenum, New York, 1977. xiv, 466 pp., illus. $35. Downstate Series of Research in Psychiatry and Psychology, vol. 1.

The Conquest of Smallpox. The Impact of Inoculation on Smallpox Mortality in Eighteenth Century Britain. Peter Razzell. Caliban Books, Firle, Sussex, England, 1977. x, 190 pp. £8.