gen and antibodies. A meandering and diffuse scientific development had become, in reconstruction, a straight and goal-directed process, the result of clear individual intentions. This, Fleck suggests, is how memory works. The socially constructed character of a scientific fact had become submerged in a recollected account of clear individual goals. When the new thought style has developed, everything that preceded it is necessarily reprocessed in terms of the new Gestalt. This is how thought styles leave their imprint on scientists' sense of history.

Even more interesting is Fleck's account of the relationship between what he calls "journal science" and "vademecum science." Journal science, while a poor indication of actual scientific practice, nevertheless represents findings as provisional and dubitable. Journal science is the science of the esoteric core of participants; it makes a plea for the findings to become collectively accepted facts. As the findings are communicated to the exoteric periphery, and as the periphery then represents findings to a wider audience, the results become vivid, self-evident, and given. They are made into hard facts. Fleck is not offering merely an account of the "popularization" of science. He claims that "every communication . . . tends to make any item of knowledge more exoteric and popular." That is to say, the act of transmitting findings is what makes scientific facts acquire their apodictic character. The history of the Wassermann reaction exemplifies the process whereby journal science was made into vademecum science. The development of any scientific fact is an artifact of the social processes of communication.

In general terms, what Fleck was aiming for was a picture of the connection between "active" and "passive" elements in knowledge. The passive component of knowledge is what we call "existence" or "reality"; it seems independent of us and compels us to accept it. On the other hand, what Fleck calls the active components of knowledge rest upon particular dispositions, assumptions, and goals actively adopted by the thought collective. Fleck does not, however, use the distinction between active and passive to place limits on relativism. In his account, active and passive are "inevitably united." For example, if we actively adopt 16 as the atomic weight of oxygen, then it will "inevitably" (passively) follow that the atomic weight of hydrogen will be 1.008. Yet this passive feature will itself be a function of the assumptions and goals adopted by a particular thought collective and is, therefore, explicable in terms of cultural history. What appears passive and a function of "reality" in one set of circumstances may appear actively constructed in another. One cannot isolate purely passive features of knowledge. Hence, there is nowhere that cultural history (or, as we would now say, "sociology of knowledge") cannot go.

Fleck slyly suggests that scholars have a tendency to regard as hard and immutable those areas of culture with which they are unfamiliar. The philosophers of the Vienna Circle, trained in the natural sciences, maintained that ideal human thinking ("logic") was fixed and absolute whereas empirical facts were relative. Humanistically trained philosophers, contrarily, tend to treat human thought as relative and empirical facts as given. Might it not be possible, Fleck asks, to manage without the notion that anything is fixed?

Genesis and Development of a Scientific Fact is a flawed book; it is poorly organized and repetitious. Its empirical materials are a messy jumble, ranging from anecdotes of the author's own scientific experiences, through patchy extracts from histories of medicine, to snippets from the journal literature of early-20th-century serology. It is also a work of transparent brilliance: one of the most significant contributions toward a thoroughly sociological account of scientific knowledge.

For all that, it is difficult to know what role Fleck's book ought to play in the history and sociology of science. Certainly, it ought to be read and seriously discussed; there is no doubt that we still have much to learn from Fleck. There is no reason to regard him merely as a precursor of Kuhn, for all the striking resemblances noted by Kuhn and others. In many respects Fleck's relativism and his search for a social epistemology are more vigorous than Kuhn's. On the other hand, the style of research into the nature of scientific knowledge has, at last, caught up with Fleck. While relativism and advocacy of a sociology of scientific knowledge are by no means dominant positions, they are steadily gaining in academic significance. Moreover, empirical work predicated upon orientations similar to Fleck's is growing in quantity and persuasiveness.

Fleck's truest legacy may be his passionate conviction that we will never be in a position to understand scientific culture scientifically if we persist in an egocentric attitude toward it. Whatever is known has always seemed indubitable to the knower; equally, whatever is alien has seemed fanciful and arbitrary. If we do not find the courage to examine science sociologically and comparatively, we will remain like the 18th-century French philologist Fleck describes. "*Pain, sitos, bread, Brot, panis* were," the savant claimed, "arbitrary, different descriptions of the same thing. The difference between French and other languages . . . consisted in the fact that what is called bread in French really was bread."

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Oxygen Metabolism

Oxygen Free Radicals and Tissue Damage. Papers from a symposium, London, June 1978. Excerpta Medica, Amsterdam, 1979 (U.S. distributor, Elsevier, New York). viii, 382 pp., illus. $52.75. Ciba Foundation Symposium 65 (new series).

The product of the limit reduction of molecular oxygen is water, and therein lies the greatest advantage of using the oxygen molecule as the terminal electron acceptor in bioenergetic systems. Indeed, the electron transport systems of aerobic organisms are designed to produce water as the sole product of the reduction of O_2, thereby avoiding the large-scale formation of superoxide radical (O_2^-), hydrogen peroxide (H_2O_2), and hydroxyl radical ($OH^\cdot$). However, it is now clear that finite quantities of these reactive intermediates are produced in aerobic organisms by minor pathways of oxygen utilization, and the possibility of hazardous consequences arising from the generation of these species has to be considered. *Oxygen Free Radicals and Tissue Damage* is a collection of papers presented at a symposium on the subject. Starting off with Hill's paper on the chemistry of dioxygen and its reduction products, the book deals with the biological mechanisms by which reactive intermediates of oxygen reduction are produced, their possible roles in the generation of tissue damage, and the roles of certain enzymes as defensive mechanisms against oxygen toxicity.

Several of the papers discuss the possible mechanisms of cytotoxicity produced by oxygen radicals. The data of Bielski and Shiue on the reactivity of O_2^- with amino acids appear to preclude significant damage to proteins as a result of the formation of that radical. On the other hand Fridovich gives compelling evi-

dence for its toxicity and for the role of superoxide dismutase in providing protection against it. One of the more fascinating aspects of the biology of oxygen radicals is the accumulating evidence that they are necessary intermediates in the utilization of oxygen. Several of the papers deal with the beneficial and perhaps obligatory roles of oxygen radicals in such processes as prostaglandin synthesis, vitamin-K-dependent synthesis of prothrombin, and the bacteriocidal action of phagocytic cells. The fact that many of the papers are reviews rather than limited discussions of a few experimental data make the book especially useful.

This is not to say that only well-established findings are presented in the book. The question whether hydroxyl radicals are generated in vivo appears, on the evidence of the paper by Willson, still to be unanswered. The relative roles of superoxide and hydrogen peroxide in the bacteriocidal action of phagocytes are discussed at length in several papers. Though the book does present differences in points of view, it also contains many superb discussion sections in which the participants attempt to reach as much accord as possible. The book serves the useful purpose of bringing together in one place a variety of approaches to the study of oxygen metabolism, and it is strongly recommended to all who are engaged in research in this field.

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Environmental Carcinogens

Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. JERRY M. NEFF. Applied Science Publishers, London, 1979. xii, 262 pp., illus. $42.

Polycyclic aromatic hydrocarbons (PAH), although structurally quite dull, are biologically interesting because some of them cause cancer when applied to the skin of animals, including humans. Although their structures were not known, their effect was first observed over 200 years ago when it was correctly suggested that scrotal cancer among London's chimney sweeps was due to exposure to soot and its associated organic compounds. It was not until the 1930's that the structure of one of the most carcinogenic PAH, benzo[*a*]pyrene, was elucidated.

Like soot, PAH are produced by the combustion of a great variety of fuels under fuel-rich conditions. Therefore, until recently almost all studies of their environmental occurrence focused on the emissions of combustion sources and their dispersion in the atmosphere. Within the last several years, however, there has been a realization that they can come from sources other than combustion and can reside in environmental compartments other than the atmosphere. This book is a review of much of this recent information, with emphasis on PAH in water, sediment, and the associated biota.

We learn that PAH have several sources. These include direct and indirect biosynthesis, fossil fuels, and natural and anthropogenic combustion. PAH move from these sources to the aquatic environment by a variety of transport mechanisms, and Neff has estimated the magnitude of the inputs of PAH by these mechanisms. He concludes that the input of benzo[*a*]pyrene is 100 metric tons a year from land runoff, 500 metric tons a year from atmospheric fallout and rainout, and 80 metric tons a year from other sources (such as petroleum spillage and biosynthesis). These input rates are nothing more than gross estimates, but they indicate that airborne transport is an important mechanism for the introduction of PAH into the aquatic environment.

Neff points out that the fates of PAH are dependent on their physical distribution and on their chemical transformations. Their distribution in sediment as a function of depth is a historical record that indicates that their major source (at the locations studied) is the anthropogenic combustion of fossil fuels. Information on their chemical transformations suggests that "PAH may persist indefinitely in oxygen-poor water basins or in anoxic sediments." Clearly, PAH can serve as conservative markers of human activity.

The effects of PAH on aquatic organisms have not been throughly studied. We do know that many aquatic organisms accumulate PAH; the extent of this effect is dependent on species, temperature, and salinity. In addition, PAH may induce tumors in fish.

Neff has been exhaustive but not critical in gathering data. The book contains 89 separate tables, many of which are undigested data presented with excessive significant figures. Long sections of the book consist of abstracts of paper after paper. A reader's ability to comprehend this great bulk of information is limited by the lack of chapter or subchapter summaries. A three-page summary does appear at the end of the book, however, and it is excellent. The book has been carefully prepared; the literature coverage seems to be complete through 1977 and spotty for 1978. Assembling the existing data on PAH in the aquatic environment is a truly useful endeavor, and it has been done well. Marshaling these facts into a unified picture would have been even more useful.

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Neurophysiology

Sensory Mechanisms of the Spinal Cord. W. D. WILLIS and R. E. COGGESHALL. Plenum, New York, 1978, x, 486 pp., illus. $35.

This book has appeared at a most opportune time. The last 10 to 15 years have been a period of rapid and exciting advances in our knowledge of spinal cord mechanisms concerned with somesthesis. During this time the microelectrode, which has continued to be the most useful research tool, has allowed the functional organization of the dorsal horn to be clarified; the more recent trend toward working with identifiable neuronal systems has paid off handsomely in understanding of ascending systems taking origin in the cord (spinocervical, spinothalamic, and spinoreticular paths) and of control of access to these pathways by segmental and descending systems; many new techniques have appeared, including a number for tracing anatomical pathways and for injecting dye intracellularly, and these, combined with a second flowering of silver staining and degeneration methods, have allowed a new understanding of structural-functional relationships; finally, the great interest in pain mechanisms has focused attention on the dorsal regions of the spinal gray matter where the first central operations on nociceptive information take place. The book is the first to treat the subject in detail, and it provides a comprehensive and up-to-date account together with an extensive bibliography up to early 1978.

The authors adopt a most successful approach to the many complex problems thrown up by modern work. Each subject is developed clearly and concisely. Initially, helpful definitions are given, and these are followed by descriptions of the peripheral apparatus (receptors and afferent fibers), the structure and func-