degree of public involvement in all of them. As to the first, scientific, decision, there seems to be no alternative to the autonomous processes of the scientific community. These, of course, need not necessarily be based on the same kind of autonomy as that which prevails in Britain or anywhere else today, and I agree with many of the authors' criticisms of the ways academic and scientific communities conduct themselves. The second and third types of decisions are technological or operational ones. They can be and have to be taken according to the same criteria that are applied in economic and political decisions and by the people who deal with economic and political affairs in general. As there is now abundant evidence that technological devices, and especially how they are used, have very far-reaching consequences, there is a good case for more public control and planning of such developments.

In the more concrete part of their discussions the authors are perfectly aware of these differences. But they try to dismiss them by the argument that in effect

> many scientific developments are allowed to proceed from the point where they are nothing but a gleam in a research director's eye to that at which they are so technically sweet that they are virtually impossible to rescind without their *ever* being subject to public scrutiny.

These things undoubtedly happen in technological as well as other kinds of decisions. The dangers that result from insufficient alertness about the possible consequences of all kinds of actions are probably greater in an increasingly crowded, interdependent, and fast-changing world than they were in the past. But this problem is not particular to science, or even to technology; it pertains to public and international life in general. To keep mankind alive today requires greater moral responsibility and a greater degree of political rationality than at any other time in history.

This being the case, the recommendations—in this book and in many parts of the scientific community in general—about the need of greater political control of science and technology, as the principal means of preventing total disaster for mankind, are dangerously misleading. Science in this way of thinking is conceived of as an omnipotent force that somehow failed its mission. It not only failed to redeem mankind but has actually turned into "an instrument of man's destruction." This way of thinking places the blame for the state of the world on some impersonal thing, instead of facing the commonsense truth that man alone is responsible for his deeds. For our most grievous difficulty there is no remedy short of finding ways of dealing with conflicts without violence and war. It is difficult to bear the idea that mankind may have to continue walking on a precipice for who knows how long and to avert disaster only by the day-to-day efforts of fallible politicians and their advisers. One can understand that people tend to lose their nerve in such a situation and seek scapegoats, but the idea that the danger can be averted by controlling science is an attempt to exorcise the evil spirits by magic.

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The Fluoride Saga

Water Fluoridation. The Search and the Victory. FRANK J. MCCLURE. National Institute of Dental Research, Bethesda, Md., 1970 (available from the Superintendent of Documents, Washington, D.C.). xii, 304 pp. + plates. $3.25.

This book is an attempt to prepare a simple, straightforward account of the historical developments that led to the sequential recognition that mottled enamel was caused by excess fluoride ingestion during tooth development, that an optimal intake of fluoride resulted in a highly significant, indeed spectacular, reduction in tooth decay, and that the water engineer could inexpensively, safely, and efficiently either increase the fluoride concentration of a deficient water supply to an optimal level or reduce an excess fluoride concentration to an optimal one.

McClure points out in the preface the Jekyll and Hyde aspects of fluoride and the ultimate recognition and subdual of Mr. Hyde and survival of Dr. Jekyll. The fact that a single element in excess can be harmful but be beneficial in lesser amounts still bewilders many laymen and is the root of the controversy whenever the subject comes up for discussion in political campaigns.

The first seven chapters are devoted to the toxic manifestations of excess fluoride ingestion and the processes by which water was identified as the carrier of the toxic principle and by which fluoride was (in 1931) identified as the toxic agent. Early descriptions of mottled enamel are given, such as the one in 1901 by Eager, a Public Health Service physician who was stationed in Naples, Italy, to examine emigrants embarking for the United States. McKay's work in Colorado Springs and elsewhere in the United States and Italy is described in detail to show the background for his hypothesis that the source of water during tooth development was pivotal in the determination of whether an individual would have mottled enamel. Changing water supplies in several communities established this concept, and then years later several investigators reported within months of each other that fluoride was the active agent. A full-color foldout plate is included to show the various degrees of mottled enamel (dental fluorosis). This plate was reprinted from a recent report on the epidemiology of fluorosis in Denmark (I. J. Møller, *Dental Fluorose og Caries*, Rhodos, Copenhagen, 1965). The systemic toxicosis in domestic animals and man occurring at still higher levels of fluoride ingestion than those associated with endemic dental fluorosis is documented with good references to pertinent literature.

The next section of four chapters is devoted to the recognition of the relationship of fluoride ingestion during tooth development to reduced incidence of dental caries in areas where the water contained fluorides and then to the testing of whether a comparable benefit could be obtained by the adjustment of the fluoride concentration of low-fluoride water supplies. McClure meticulously documents the procedures and the results in the four earliest water fluoridation trials in Newburgh, New York, Grand Rapids, Michigan, Brantford, Ontario, and Evanston, Illinois. Another chapter is devoted to alternative means of administering fluoride to achieve dental benefits.

The third major portion is devoted to evaluation of the safety of fluoridation at the recommended level of approximately 1.0 part of fluoride per million, which is to be varied according to the climate and other contingencies in the community. These studies occurred in abundance between the recognition of dental benefits and the initiation of fluoridation trials. Many other factors continue to be examined

in various parts of the world to determine the applicability in local situations of water fluoridation or fluoride provision through some other vehicle. McClure justifiably affirms the safety of fluoride ingestion at recommended levels with regard to all aspects of health. The reproducibility of the dental benefits around the world without even the complication of esthetically undesirable levels of dental fluorosis in various cultural scenes is becoming increasingly clear.

The last part of the book is devoted to the winning of approval for the initiation of fluoridation in the first trial communities, the extension of fluoridation throughout the United States and the world, the various legal tests through which fluoridation has received approval, and the questions and problems raised by those opposed to fluoridation on various grounds. Some interesting thoughts are included on the views of political and social scientists on the nature of the fluoridation controversy at the polls. Fluoride ingestion by man, and particularly fluoridation of public water supplies, have become subjects of intense debate, fear campaigns, and acrimony whenever and wherever the public is confronted with the opportunity to elect or reject the adoption of water fluoridation at a referendum. On these occasions, such considerations as the ubiquity of fluorides in soils, foods, and water supplies, the identity of the fluoride occurring natively in water supplies with that added in water processing plants, and the high efficiency of the human body to excrete fluoride are often forgotten. The vast amount and the varied types of research that have been conducted on fluorides and human health tend to be submerged by rhetoric under vague allegations of potential danger to many facets of health.

The author of this volume was a pioneer in the field of fluoride metabolism and did or supervised much of the analytical work on fluorides at the National Institute of Dental Research throughout approximately three decades. His tenure as chief of the laboratory of biochemistry spanned the time from the early recognition of the dental benefits of optimal fluoride ingestion to his retirement in 1966, when fluoridation of public water supplies had been demonstrated to be safe and had been widely accepted in the United States and was being adopted in many countries of the world. He knew many of the pioneers in dental epidemiology, biochemistry, and physiology who were responsible for the development of our current knowledge about fluorides. His personal warmth is very evident throughout the book. It is almost a diary made up of quotes, figures, and tables from key letters and scientific papers written over a 70-year period interlaced with comments about the import of the data and how they related to events past and yet to come. In addition, numerous vignettes are included of the men who made history through their participation in the development of the fluoride saga.

This book is good scientifically both for its textual content and its references. More than that, McClure portrays the human side of science by recording his insights about the enthusiastic, dedicated men who in the face of opposition and controversy persevered until overwhelming supporting evidence of benefit and safety had been obtained.

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Aerial Surveying

Remote Sensing in Ecology. Proceedings of a symposium, Madison, Wis., June 1968. PHILIP L. JOHNSON, Ed. University of Georgia Press, Athens, 1969. x, 246 pp., illus. $8.

Remote Sensing. With Special Reference to Agriculture and Forestry. National Research Council Committee on Remote Sensing for Agricultural Purposes. National Academy of Sciences, Washington, D.C., 1970. xvi, 424 pp. + plates. $12.95. NAS Publication No. 1723.

These two symposia bring together a wide variety of papers on uses and techniques in remote sensing and results of projects using different techniques. Johnson, in his résumé, stresses that ecological study is necessary for the solution of the real and extensive environmental problems facing mankind and mentions four phases of ecological study that can profit from the use of remote sensing techniques. To survey the potential of aerial surveys for answering specific environmental questions was the goal of the study of which the National Research Council volume is a result.

Inventory and mapping of environmental resources can be done economically and rapidly with remote sensors. A few features that lend themselves to assessment by remote sensing are crop acreage and yields, land use, pest and disease infestations, water quality, forest inventory, and some aspects of wildlife management. Remote sensing is no panacea, and many contributors to these volumes emphasize the need for "ground truth." Ground truth pertains to the identity of the image and to the relationship of the subject to the environment. Both of these entities are revealed solely by study on the ground.

Remote sensing has come a long way since the first aerial photographs were taken from a balloon during the Civil War. Black-and-white photography remained the only technique available until just a few years ago, but recent advances in infrared and color photography, electronics, and optics have now provided a wide range of sensors. Different kinds of infrared film, black-and-white and color film, radar, very-short-wavelength radiation, ultraviolet imaging, multispectral sensing, and nonphotographic scanners are some of the new developments useful in obtaining synoptic compilations of study areas.

Because plants are the primary subject of interest, or at least are a large part of the image, in agriculture and ecology, properties of plants that affect imagery need study. Several such properties have been studied in both the laboratory and the field; these are reflectance, transmittance, and absorptance of radiation. Findings of these studies aid in establishing the accuracy and significance of image analyses.

Several papers in both symposia deal with results obtained by means of remote sensing techniques, suggesting that the methods can be used in a wide range of environmental studies. Crop vigor, moisture stress, and disease are but three characteristics of plants that have been sensed with photography. Infrared sensing, using both film and nonphotographic scanners, has proved invaluable in inventorying large animal populations. Infrared photography also is being used successfully to detect hot areas at the ground surface caused by geothermal activity. Such patterns often go unnoticed on the ground, and their detection facilitates the selection of study sites. With airborne scanners, the distribution of visible light from the sea makes possible the rapid identification of water masses. Aerial photographs also have been used successfully to map bottom biota, sediments, and topography in shallow bodies of water.