substitution in the central nervous system and his finding of greater extracellular distances in normal tissue, especially in unmyelinated axon fields. The book also deals with the extensive literature on experimental studies using "extracellular" indicators, although the most recent studies defining the "sink" effect of cerebrospinal fluid on the steady-state concentration of certain substances in brain have not been included. This is the natural hazard of publication in a rapidly evolving field.

It was a pleasure to read Van Harreveld's lucid account of this intriguing biological subject. It is particularly useful to have his own work brought together in a single volume and to have his concise, personal synthesis of the current status of the problem of the magnitude of the extracellular compartment of the central nervous system.

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Analyses of Materials

Archeological Chemistry. Papers presented at a symposium held in Atlantic City, N.J., September 1962, sponsored by the Division of History of Chemistry, American Chemical Society. MARTIN LEVEY, Ed. University of Pennsylvania Press, Philadelphia, 1967. 365 pp., illus. $8.50.

Although this reviewer ordinarily takes a dim view of books made from "proceedings" because of their miscellaneous content and their uneven quality, he must admit that this selection contains much information that is useful. The authors are persons well known within this small field; most of the authors, who include industrial chemists, college professors, and research scientists, pursue archeological chemistry as a subordinate occupation, but some are museum staff members and conservators. Because many are well known to the reviewer he would like to mention all by name and subject, but regrettably this is impossible within the confines of this review. Collectively the papers illustrate how well modern analytical techniques, both chemical and physical, can assist in the full interpretation of the material cultures of the ancients. Nearly the whole range of modern techniques is employed. In the lead paper it is told how infrared spectrophotometric analysis made possible the identification of dyes used on 1800-year-old woolen textiles recovered from caves in the Judean desert. There are two papers on ancient glass, one reporting many wet chemical analyses on glass from central Asia, the other giving spectrochemical analyses on early glass objects from the Middle East, that lead to conclusions about raw materials of glass manufacture, including colorants and opacifiers. There are eight papers that deal primarily with metals; they show how wet chemical analysis, x-ray fluorescence spectrophotometry, x-ray diffraction, electron microbeam probe analysis, radiography, metallography, and even hardness testing can all contribute to knowledge of how the ancients won and worked metals. One paper deals with cement mortars of Poland, another with ceramics of India, and finally there is one on the pigments, natural and artificial, used over a span of 2000 years by painters of Japan.

This fine collection of reports, useful as it is, brings to focus a matter that has long disturbed the reviewer. Chemists for well over a hundred years have published many hundreds, even thousands of quantitative chemical analyses made on ancient objects of all kinds. Unfortunately, many of these are of limited value, or have no value at all, because of failure to describe the exact provenance or source of the objects, to describe their condition, or even to illustrate them. More seriously, the analyst often has not troubled to mention the method of sampling, the size of the sample taken, or the method of analysis (although this can often be inferred from the data or the context). In spectrochemical analysis there is often failure to mention limits of detection or elements sought and not found. Seldom is mention made of the accuracy claimed. Averages of multiple analyses are sometimes listed without giving the range of the data averaged; hence the data are not statistically meaningful. The result is that many times the analytical data of different investigators, even where they employ the same general method, cannot be compared. These oversights not only annoy later investigators who want to make use of the data but, more seriously, they lead archeologists or other nonprofessional users of the data into pitfalls. The latter are inclined to believe that analytical chemistry is an exact science—even to the third doubtful decimal place—which is not the case. Analytical chemistry is still an art based on scientific principles. The cautious analytical chemist speaks of his findings as an "estimate." If the archeologists were better acquainted with indirect methods of analysis based on "standards" they would accept analytical findings with more reserve.

Among the papers in this book nearly all the sins possible in reporting analytical data are illustrated. (The paper of Sayre and Smith on glass analysis is an exception.) Editors must share some of the blame. They should recognize such deficiencies and require of authors additional detailed information about procedures. Among these papers a few short footnotes could have provided all the missing information. Let us suggest that the next symposium on archeological chemistry choose as its theme "The Presentation and Interpretation of Analytical Data in Archeological Chemistry."

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The Color Center

F-Centers in Alkali Halides. Solid State Physics, Supplement 8. JORDAN J. MARKHAM. Academic Press, New York, 1966. 412 pp., illus. $16.

More than a century ago Kirchoff and Bunsen, each of whom was much better known for other things, found that ordinary salt took on a beautiful color when heated in sodium vapor. Pohl, who at Göttingen in the '20's and '30's saw the connection between Bunsen's coloration and the electronic properties of photoconductors and phosphors and fathered a whole new field of research, named the principal colored species the *Farbenzentrum*, or "*F* center." Thanks to magnetic resonance we now know that this center is just an electron trapped in a negative-ion vacancy.

Even in this age of specialization, it is not often that one comes across a book so unabashedly specialized as Markham's *F-Centers in Alkali Halides*. Although the number of known color centers is now well over 20 and the *F* center has many interconnections with the others, Markham sticks to his title and concerns himself primarily with what an *F* center *is*, rather than with processes in which *F* centers are involved. Readers expecting to learn, for example, how *F* centers migrate together to form *M* centers or how *Z* centers are made from *F* centers and impurity atoms, or to inform themselves

about proposed mechanisms of the creation of F and V centers by x-rays, will be disappointed. Rather, the optical absorption, luminescent emission, photoconductivity, and magnetic properties of F centers are covered in detail. The theory is treated in two parts: the calculation of wave functions, and the electron-phonon interactions.

The theory of F centers is still evolving. Markham points out that although most methods give acceptable values for the energy of maximum optical absorption, no method has been particularly successful for calculating other observable properties of the F center. He begins by describing the method of Slater for treating imperfections; this method cannot, however, be rigorously applied to F centers. Of the methods for calculating the absorption-band location, that of Simpson is considered in quantitative detail. A brief comparison with the methods of Gourary and Adrian and of Kojima is given. Questions of recent interest, such as the lifetime of the excited state, and transitions to higher states (to produce the K or L bands perhaps) are not treated.

The book suffers from two drawbacks. First, as with all books dealing with lively research matters, the early cutoff date for new material (mid-1963) creates a feeling that parts of the book are out-of-date. Markham's preoccupation with the prewar work at Göttingen, important though this work is, and his omission of some significant developments in the period 1957–1963, contribute to this feeling. Second, there are many inelegancies in writing and some mistakes that detract from the pleasure of the reader. A careful editor could have been of assistance here.

In spite of these shortcomings, the wealth of information in this book should make it of value to anyone interested in the behavior of electrons in insulators.

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On Information on Information

Annual Review of Information Science and Technology. Vol. 1. CARLOS A. CUADRA, Ed. Interscience (Wiley), New York, 1966. 401 pp. $12.50.

Through the combined efforts of a federal agency, a professional society, a nonprofit corporation, a publishing house, and a number of dedicated individuals, a first sample of a much-needed review series has come into existence. Although the editor admits that "at the present time there is no clearly defined and well-understood field of information science and technology," this book nevertheless provides a quite reasonable mapping of that field onto a dozen carefully written review chapters. These chapters, in turn, provide a total of more than a thousand references to the current literature.

Prior to this book, the best tour guide to the field had been the National Science Foundation's series *Current Research and Development in Scientific Documentation.* Unlike such a compilation, this book attempts the difficult task of reviewing in a critical fashion both a technical field and a body of literature. I found the result strongest as a coherent descriptive survey of recent work in the field. Most chapters also provide credible discussions about current status and trends. However, actual criticism of specific endeavors or specific references is rather infrequent and usually gentle; it would have been refreshing to find an occasional admonition to burn a book or to skip a particular field of endeavor, but in this respect the reader will be disappointed.

Three key chapters address, respectively, content analysis, file structures, and the related issues of natural language research. It is interesting to observe that all three chapter authors visualize considerable human participation in the computer handling of information. In the chapter on content analysis, Phyllis Baxendale concludes that "It is entirely predictable, for example, that computer-aided human indexing and interrogation will be qualitatively and economically superior to fully automatic methods." Still later in the book, Jordan Baruch, talking about information system applications in fields such as medicine, similarly concludes that "man has gradually crept back into the interpretation and control loop."

Although extensive citation of the literature leads to occasional slow reading, the excitement of a burgeoning field and the intensity of national interest is clearly transmitted. This review volume should be a useful reference for the expert and an excellent appetizer for the serious novice.

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Radioactivity in the Sea

Radioecology of Aquatic Organisms. G. G. POLIKARPOV. Translated, with revisions by the author, from the Russian edition (Moscow, 1964), by Scripta Technica. Vincent Schultz and Alfred W. Klement, Jr., Translation Eds. Reinhold, New York, 1966. 342 pp., illus. $16.50.

The Russian edition of this work was reviewed in *Science* **154**, 995 (1966). The volume has much to recommend its translation. It is the first short summary of a very large field, and it provides an extensive introduction to Soviet work in radioecology, which Polikarpov defines broadly as being concerned with the interaction between a radioactive medium and living organisms.

The present revised and updated volume, prepared with the author's active cooperation, is expanded about 20 percent over the Russian edition and has recast tables and a more detailed mode of citation of the literature. There is still no index. The previously criticized "accumulation factors" are still based on the table (except for cesium) for elemental composition of sea water as given by Krumholz, Goldberg, and Boroughs, which is largely derived from older data and is badly out of date. One of the authors of the table (Goldberg) has published several revised estimates since the first compilation appeared in 1957. The translation is accurate and clear, with the exception of a few blue notes (for example, p. 53, "Complexing agents, which are also known as complexons and addenda. . . ."; p. 60, "The total exchange fund of calcium, strontium and some other elements in marine algae is made up of a large number of microfunds"). The price, though stiff, does not approach the exorbitant levels of some translated volumes which have appeared in recent years.

Readers will appreciate that aspects of radioecology lie close to sensitive areas of national nuclear policy and international politics. With due allowance for this and an understandable national orientation, Polikarpov's treatment seems fair and often agreeably candid. Only on one main question does one detect the possible intrusion of dogma: this is the repeatedly stressed view, coinciding with the official Soviet government position, that further addition of any kind of radioactive product to the oceans is inadmissable.

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