cellent way to supplement the main body of information and warn readers against many pitfalls earlier workers in the field fell into.

It is a worthy decision on the part of the author to devote as much as eight pages, of less than 100 total text pages, to sialic acids. These acids are the most important glycosyl residues of sphingoglycolipids, and much progress has been made in the study of them since the publication of Gottschalk's classic book (*The Chemistry and Biology of Sialic Acids and Related Substances*, Cambridge University Press, 1960).

The last chapter of Shapiro's book deals with synthetic procedures, concerning which enough details are given so that presumably syntheses can be carried out without further reference. Many new, previously unpublished improvements have been incorporated. It will be interesting to see how useful these accounts of synthetic procedures will be for biological scientists who are not familiar with organic synthesis in general. It would have been ideal if isolation and purification procedures for natural sphingolipids had also been given here. Practicing biologists and biochemists would perhaps like to see chromatographic data and analytical procedures included.

As the author states in the preface, there is a strong need for "a closer cooperation between chemical and medical research," and this book will undoubtedly serve to fill the gap between the two fields.

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Spectrum Analysis: A History

Nineteenth-Century Spectroscopy. Development of the Understanding of Spectra, 1802–1897. WILLIAM MCGUCKEN. Johns Hopkins Press, Baltimore, 1970. xiv, 242 pp., illus. $11.

Spectroscopy has played so prominent a role in the development of modern physics that it is surprising that so few historians of science have paid serious attention to it. William McGucken's addition to the sparse literature on the history of this field should prove valuable and informative, not only for the professional historian of science but also for chemists and physicists interested in the roots of their subject. The scientists might find particularly intriguing the different conceptions and purposes chemists and physicists have had for the terms "atom" and "molecule," which kept these two fields at odds through much of the last century.

McGucken presents some significant original material, including his coverage of the predecessors of Bunsen and Kirchhoff, his short portion on band spectra, and his elaboration of the kinetic theory and its place in early spectral theory with its dominant analogy to acoustics. Also, his development of the contributions of Plücker, Hittorf, Wüllner, and Salet in establishing the existence of multiple spectra for a single chemical substance, contrary to the previous fundamental principle of spectrum analysis, demonstrates the complexities and types of controversies, both experimental and theoretical, which haunted spectroscopy for decades. The difficulties arising for spectral theory from the work of Kundt and Warburg on specific heats based on the kinetic theory of gases provide another example of such controversy.

McGucken contrasts the dominance of the vortex atom model in Britain during the last decades of the century with the endurance on the Continent of more "traditional" atomic-molecular models for spectra, demonstrating the vibrant national competition in this area. Likewise, the search for spectral series formulas, culminating with Balmer, Rydberg, Kayser, and Runge, is handled briefly but adequately.

The establishment of the electron, the first subatomic particle of modern physics, by J. J. Thomson in 1897 was a watershed in the history of physics. G. E. Owen and I have maintained that Zeeman's discovery of the effect of magnetism on spectral lines had a direct influence upon Thomson's proposal several months later of a subatomic "corpuscle." McGucken now joins the support for this view, offering not only additional evidence but a further interpretation of how this may have come about. His conjectures strike me as highly plausible and completely in accord with the evidence at hand.

In addition to augmenting our knowledge of the history of spectroscopy, this fine volume is a substantial addition to the growing literature on the history of the atomic theory. McGucken observes correctly that spectroscopists predominantly were atomists. They opposed the anti-atomistic trends of the 19th century. The prolonged weak theoretical state of spectroscopy through much of that century was a source of embarrassment for atomistic theorists, but then the successful spectral theory of the early 20th century reinforced faith in a modified atomic hypothesis.

McGucken strictly limits himself to developments occurring during the 19th century. This limitation has a number of unfortunate consequences. For one, it terminates his story just at the point where the study of spectra was, owing to the new electron atomic models, becoming exciting and profitable for modern physics. For another, it distorts the role of J. Norman Lockyer and his dissociation theory of the elementary chemical atoms. McGucken makes a fine presentation of Lockyer's earlier conceptions, which were almost universally rejected when Lockyer's allegedly coincident "basic lines" in various elementary spectra proved spurious. However, Lockyer's later "enhanced lines," which played a significant role in the first successful resolution of the spectral puzzle in the early 20th century through the work of Niels Bohr and Lockyer's younger assistant Alfred Fowler, are completely neglected. But then these are far from fatal defects. At least two of the secondary sources listed in McGucken's bibliography cover this later period for those who are interested.

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Groundwater Hydrology

Flow through Porous Media. ROGER J. M. DE WIEST, Ed. Academic Press, New York, 1969. xiv, 530 pp., illus. $22.50.

This volume is an outgrowth of an Institute in Hydrology for College Teachers sponsored by the National Science Foundation and held at Princeton University in 1965. The editor has included updated, and in some cases expanded, versions of those lectures dealing with flow of subsurface fluids.

De Wiest commences with a discussion of the fundamental principles of groundwater flow, presenting major governing theories without delving into either well mechanics or specific examples of flow analysis. Davis follows with a thorough review of porosity and permeability of natural media. Inclusion of this material is laudable, for the analytical material of the volume can

be related to the real world only through pertinent data on those physical parameters of geologic materials which influence fluid flow. Much of the material in these two chapters is covered in earlier texts by the authors: *Geohydrology* (1965) by De Wiest and *Hydrogeology* (1966) by Davis and De Wiest. Nevertheless, their inclusion is welcomed, for they serve as an introductory and unifying background for ensuing chapters.

Rumer discusses the hydrodynamics of resistance in chapter 3, developing a macroscopic force-balance equation which is shown to transform to Darcy's law for low velocities. A truncated version of the series expression for resistance coefficient is comparable to the "Forchheimer equation." The special problem of upward flow and fluidization is also analyzed. In each case resistance is related to permeability, Reynolds number, and parameters dependent upon the geometry of pore systems or on physical properties of fluids and particles.

Bear presents in chapter 4 a clear, concise summary of hydrodynamic dispersion, followed by comparative description of the principal theories of dispersion, discussion of dispersion parameters (dispersivity, coefficient of dispersion, relation of permeability to dispersion), and solution of the differential equation of dispersion for various initial and boundary conditions. Decay and adsorption of transported chemical species are considered. Solved problems illustrate application of developed theory. Simpson (chapter 5) follows with a shorter discussion of the role of molecular diffusivity of chemical species in longitudinal dispersion as a function of flow velocity.

Chapters 6 (Swartzendruber) and 7 (Dicker) deal with unsaturated flow and transient free-surface flow through porous media. Dicker introduces a revision of classical theory which removes a heretofore undiscovered mathematical anomaly in the derivation. Chapter 8 (Verruijt) discusses elastic storage properties of aquifers in terms of the Biot theory that geologic materials act as perfectly elastic materials which may undergo three-dimensional consolidation. Biot's theory is shown to reduce to Jacob's theory, assuming only vertical deformations.

Chapters 9 and 10 deal with mathematical concepts for the description of fluid flow through porous media. De Josselin de Jong discusses generating functions for the specific discharge vector for incompressible homogeneous fluids that obey Laplace equations of the type $\nabla^2 \mathcal{F} = 0$ and for inhomogeneous situations that fit equations of the type $\nabla^2 \mathcal{F} = G$. De Wiest expounds the role of Green's functions in solving partial differential equations for given boundary and initial conditions. The final chapter (Morel-Seytoux) introduces the groundwater hydrologist to subsurface two-phase flow, primarily in terms of the immiscible liquids water and oil.

Although important to groundwater hydrology, the topics covered for the most part do not warrant full volumes, and existing advanced texts do not deal with them in the depth and breadth of this volume. Consequently, the book seems well suited to be a reference or text for an advanced graduate course in groundwater hydrology, particularly if the course approach is to consider individual problems. It is recommended reading for practicing groundwater hydrologists and will find use as a standard reference work for some years to come. Some might consider the volume to be worthwhile for Bear's discussion alone, which fills a long-felt need for a comprehensive discussion of hydrodynamic dispersion.

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Books Received

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Catalytic Processes and Proven Cata-

(Continued on page 662)