force. But the essential truth, as understood by Mayer, certainly calls for *energy.* Again, for example, in the great paper of Helmholtz on the "Conservation of Energy," Professor Magie's own translation would be preferable to that of John Tyndall who, though thoroughly *au courant* with the best physics of his day, was nevertheless using the imperfect nomenclature of 1853. Thus (p. 219) when Helmholtz proceeds to quantify Faraday's discovery of 1831, the first sentence of the translation is "when a magnet moves under the influence of a current, the *vis viva* gained thereby must be furnished by the tensions consumed in the current." Here *vis viva* is Tyndall's rendering of *lebendige Kraft,* a translation which leaves the English reader in doubt as to the factor "1/2": "kinetic energy" would have certainly carried the "1/2" with it. In the phrase "tensions consumed in the current," Helmholtz could scarcely have had in mind anything but what we call "E. M. F. drop." A correct translation depends partly upon the words of the writer, partly upon the vocabulary of the reader, and is therefore a function of time. Owing to rapid changes in scientific nomenclature, a translation which fits one generation may be quite inapt for the next.

A fine perspective is displayed by the author in bringing closely related papers into immediate juxtaposition and in his allotment of space to individual investigators. Ten pages is none too much for Black's account of the phenomena which lead up to the ideas of *specific heat* and *latent heat,* a masterpiece of scientific description. Thirteen well-deserved pages are assigned to Ampère's fundamental work. Seven pages, devoted to the law formulated by Ohm, show us how far he was from our present conception of that law—the one which Weber and Kirchhoff gave us—and yet how skilfully he treated his data and how clearly he expressed his imperfectly understood results in terms of two numerical constants a and b.

In these days, when research has become a powerful educational instrument, one might expect a disregard for earlier work and a lack of respect for the past; but the reverse of this appears to be the fact. As one bit of evidence, compare the prices to-day with those of fifty years ago when it comes to acquiring some of the "sources" which are reproduced in this volume.

A few trifling inadvertencies which ought to be considered before a new edition is issued are the following: In the first sentence in the book, Professor Magie has many excellent authorities, such as the Ninth Edition of the Encyclopedia Britannica (corrected in the eleventh), for saying that Galileo was born on the 18th of February. The late Professor Antonio Favaro has, however, established the fact that Galileo was born on the 15th of February and that citizens of Pisa were so anxious "to make the dying of Michelangelo coincide with the borning of Galileo" that they deliberately added three days to this latter date and accordingly engraved the "18th of February" on the marble slab which marks the house where the great Italian is "supposed" to have been born.

On page 398, six years should be added to the date given for du Fay's birth; and in the first line of page 447, ten years should be subtracted from the date given for Ampère's most celebrated paper. A slip of the pen has substituted *Padua* for Pavia in the third line of the biographical sketch of Volta on page 427.

The controlling idea of this volume is identical with that of "Harper's Scientific Memoirs," edited by Professor Joseph S. Ames a generation ago; but here the number of papers reported is much larger and the unimportant details are omitted; nevertheless, the book is one which historians would describe as "abundantly documentated." The collection is one upon which the verdict of scholars has already been passed. For the student who wishes to build upon "the solid ground of nature," its significance is no longer open to question.

HENRY CREW

X-RAYS

X-Rays in Theory and Experiment. By ARTHUR H. COMPTON and SAMUEL K. ALLISON. D. Van Nostrand Company, 1935. vii + 828 pp. $7.50.

X-RAYS in medicine, in crystallography and in engineering are all dependent on x-rays in theory and experiment, and it is in theory and experiment that Compton and Allison have made their great contributions. A book by them devoting all its 835 pages to this field, as indicated by its well-chosen title, is therefore most welcome.

Originally this book was going to be a second edition of Compton's "X-Rays and Electrons," which appeared in 1926, but the rapid progress of x-ray research since that date made it practically a new book. On the theoretical side the greatest changes were of course those due to the new quantum mechanics, while the experimental side was changed partly by the advent of new theoretical predictions to be tested, but at least as much by improvements in technique. Old experimental apparatus, such as Wilson's fog tracks and Robinson's magnetic velocity spectra, were improved and turned to new uses, and among new types of apparatus were Ross's differential filters for spectrum analysis, double-crystal spectrometers, thin targets and x-ray diffraction gratings.

To be sure, even with all these influences for growth, the changes in the science of x-rays in this decade, its fourth, were not nearly so revolutionary as those in its first decade or even in its second; and there is a

disconcerting air of finality in the regularity with which the present book records agreements between the new experimental data and the new wave-mechanical theories. This, however, is not the fault of the book nor a peculiarity of x-rays as distinguished from other branches of the physics of electrons. The question whether we now know all that is very exciting about electrons may or may not be worth discussing elsewhere. Here the outstanding fact is that x-rays have been one of the most fruitful sources of evidence about electrons, not only in earlier decades but also in this last, and they probably have plenty more to tell us.

The authors' main objective, however, is not the ephemeral one of outlining the next research problems to be studied. Rather, as stated in their preface, "the main objective of "X-rays in Theory and Experiment" is to present a comprehensive view of the whole field, to call attention to those aspects which seem of most fundamental physical significance, and especially to discuss the theory of the phenomena in sufficient detail that their meaning can be appreciated." And very wisely, they do not go into all this detail at first. Instead, they make their first chapter an excellent preliminary of the whole field. Then for six chapters they go into details in a sort of life-history order, starting with the production of x-rays and following them through scattering, refraction and reflection to their photoelectric absorption. Finally there are two chapters on the interpretation of x-ray spectra and recent refinements in accuracy of measurements, and some mathematical appendices.

Throughout the book, the style is clear and logical. In the first chapter, the survey, the authors use practically no calculus, but they need none, because their objective there is simply to introduce the student to unfamiliar phenomena by qualitative descriptions. This chapter can be read with interest and understanding by any student who has done well enough in first-year physics to want more. From there on, however, free use is made of calculus, but only of such parts of it as a good student acquires in his first year in that subject; and the authors show remarkable consistency in subjecting the student to this much calculus on the slightest provocation but never letting themselves be tempted to overstep this limit.

Necessarily, this restricts the discussion of wave-mechanical theories very seriously. In many cases the less mathematically inclined students might get the impression that wave mechanics is like pulling rabbits out of a hat, and they might fail to appreciate the existence of wave functions that can be visualized and used for qualitative understanding of the theory and for intuitive thinking about what effects to look for next. But this will not happen to students who really want to learn. The fundamental principles of wave mechanics are stated and discussed early in the book, in connection with the production of x-rays, so the better students can see there that the next thing they need is more mathematical study and that the rewards for such study are great. Likewise in discussing the Compton effect (which by the way, the authors modestly call by other names), it is clearly proved that wave mechanics handles the free-electron case very simply and that for any quantitative explanation of scattering by bound electrons wave mechanics is absolutely essential. So even if it seems later to play the rôle of deus ex machina in decreeing queer absolute values for the angular momenta in atoms emitting spectral lines, the students who have the ability to learn more mathematics will be in no danger of lapsing into contentment with vector-model theories. No matter how strongly a reader may want wave mechanics to be carried further, therefore, he probably must admit that the place for that is in books primarily on wave mechanics rather than on x-rays, even as restricted to their place in theory and experiment, and that the choice of material in the theoretical discussions here is really excellent.

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SPECIAL ARTICLES

CONCANAVALIN A AND HEMAGGLUTINATION[1]

HAVING identified the substance in the jack-bean which agglutinates the red cells of certain animal species as the crystallizable globulin, concanavalin A,[2] we have attempted to explain the mechanism by which hemagglutination is brought about.

It has been found that neutral suspensions of higher fatty acids and of coconut, linseed, olive, almond and jack-bean oils are agglutinated by adding concanavalin A dissolved in salt solution. It therefore appeared possible that the lipids in the surface layers of erythrocytes might be similarly affected. However, suspensions of butter, castor oil, lecithin and cholesterol acetate are not agglutinated by concanavalin A and suspensions of lipids extracted from erythrocytes are only incompletely agglutinated.

We have observed that suspensions of rice starch,

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[2] J. B. Sumner and S. F. Howell, *Jour. Immunology*, in press.