

of the subject. In the case of the present book the unevenness, though not entirely absent, is scarcely apparent. It takes the form of slight inadequacy on the mathematical side, appearing in the brief and not entirely unmisleading account of the measurement of sensation intensities, and more prominently in the long and otherwise excellent chapter on "The Interrelations of Mental Function," where the important method of correlation now in general use for the measurement of these interrelations is not mentioned, and is only referred to indirectly by the quotation, in one sentence, of a research somewhat out of date and certainly not representative.

In other respects, Prof. Pillsbury has written an exceptionally useful and effective book, for which one can safely predict a high degree of popularity among students. The earlier chapters are devoted to a very interesting analysis of the general characteristics of consciousness, such as attention, retention, and association, and the descriptions of perception, memory, reasoning, &c., are all based upon this earlier account, and form the later chapters of the book. The discussions of attention, memory, and imagination, reasoning and work, fatigue and sleep, are exceptionally good, and sum up concisely a great many of the results of modern experimental work on these topics. Perception is not so well done. It is surely incorrect to say that "perceptions always involve centrally aroused sensations or memories, as well as sensations" (p. 157). Evidence from pathology and animal psychology makes dead against this view. Inherited structure of the nervous system, as Prof. Stout suggests, "explains" the function better in such cases, and even in normal human psychology these additional mental images and ideas are largely mythical and unidentifiable by introspection.

Another small point: in the chapter on cutaneous sensations no mention is made of the distinctness of sensations of warmth, coolness, and light touch from those of heat, cold, and heavy touch respectively, although this result, based upon the work of Drs. Head, Rivers, and Sherren, is now three years old and well authenticated. A reference to it would not have conflicted with the elementary character of the book. This is one instance among several of the tendency to ignore important work done by English psychologists, which is more pronounced than it might be in some American and Continental writers.

At the end of each chapter of the book there is a series of "exercises" in experimental introspection, for which one is grateful. They add considerably to its value for class-work. W. B.

NUMBER AND QUANTITY.

Grandeurs et Nombres—Arithmétique Générale. By Prof. E. Dumont. Définitions et Propriétés fondamentales des Grandeurs géométriques et de leurs Mesures; Nombres Naturels, Qualifiés, Complexes, Ternions et Quaternions. Pp. xvii+275. (Paris: A. Hermann et Fils, 1911.) Price 10 francs.

IN mathematics, as in other affairs, a great movement happens now and then which is a kind of revolution; and whenever this occurs there is sure to be a body of stalwart veterans, who refuse to budge

from their old position, however untenable or worthless it may be.

M. Dumont's book is an illustration of this familiar fact. So far is he from accepting the modern view of mathematical science that it stirs him to a passionate revolt; he invokes the shades of the old masters, from Archimedes down to Hamilton, and denounces the logicians as conspiring to make mathematics a barren pastime, instead of the instrument of the natural philosopher.

In order to justify his protest, he has attempted to give a theory based on the definition of a number as the ratio of two quantities. As might be expected, he constantly begs the question, and makes a variety of tacit assumptions, far more complicated than those really necessary in applying mathematics to physical phenomena. For instance, he says (p. 7), "To multiply a quantity G by the number A_1/A is to apply to G the same treatment which, applied to A , produces A_1 ." What is "the same treatment"? G may be a length, and A, A_1 volumes or masses; how can "the same treatment" be defined without begging the whole question at issue? A little further on we read that "it is not always possible to multiply a quantity (*grandeur*) by a number, as we shall see in the theory of quaternions." Here our Don Quixote betrays some sense of discomfort in his antiquated armour; the reason appears subsequently. Length is defined (p. 114) as "*une grandeur linéaire relative et orientée . . . qui se développe dans deux sens opposés, à partir d'une origine arbitraire, et dans une direction variable.*" On p. 195 we read, "the ratio of two vectors or of two angles, thus conceived, is called a quaternion or quaternary number"; after this it is not surprising to find a treatment of quaternions quite needlessly complex, with definitions stated as theorems, and formulæ of the most repellent kind; moreover, we have a separate chapter on "ternions," which are only special cases of quaternions. To make confusion worse confounded, the author writes (a, b denoting vectors) a/b as the equivalent of $b^{-1}a$, and calls it "the ratio of a and b ," while $a:b$ is the equivalent of ab^{-1} , and is called "the quotient of a by b ." Almost immediately before this we read: "*Quant à a/b , on écrira aussi volontiers $a/b=b^{-1}a$ que $a/b=ab^{-1}$* "!

M. Dumont expressly denounces the views of his distinguished countrymen Jules Tannery and M. Hadamard; they need no better justification than is unconsciously given by this attempt to prove them wrong. At the same time, some of us will partly sympathise with M. Dumont, although entirely disagreeing with his doctrine. It would indeed be lamentable if mathematics were to be entirely divorced from its physical applications, and simply cultivated as an intellectual game. Fortunately, there is no reason to fear that this will ever be the case; electrical theory alone will continue to attract many of the ablest mathematicians of the time. And however fully we may admit that arithmetical analysis is independent of measurement, we cannot ignore the fact that measurements must precede any physical theory of a mathematical kind. Moreover, the data properly belonging to any physical science are not themselves

mathematical; the business of the mathematician (as Kirchhoff and Pearson have so well pointed out) is to provide, if possible, a descriptive scheme, such, for instance, as the so-called "law" of gravitation and its mathematical consequences, which reduces a complex group of phenomena to an intelligible system. Anything beyond this is metaphysics, and outside the domain of physical science and mathematics as well.

G. B. M.

APPLICATIONS OF PHOTOGRAPHY IN SCIENCE AND TECHNICS.

Angewandte Photographie in Wissenschaft und Technik. Edited by K. W. Wolf-Czapek. In vier Teilen. Pp. xvi+100+37 plates; pp. 119+41 plates; pp. 95+42 plates; pp. 98+37 plates. (Berlin: Union Deutsche Verlagsgesellschaft Zweigniederlassung Berlin, 1911.) Price 20 marks.

THERE is scarcely a science to-day wherein photography is not employed in one form or another, and even our industries make use of it in a host of different ways. So universal has become the adoption of this form of obtaining permanent records of things living and inanimate that specialists have sprung up in all directions who are able to bring to bear a great amount of experience, not only in how to apply photography to the particular case in question, but the most appropriate apparatus and methods to be adopted to secure the best results.

If, for instance, one wishes to launch out in the domain of photomicrography the first step is to find out what has been written on the subject, and then secure a book which is recommended as containing the best methods to be followed. Or, again, the special field of photographing fast-moving objects, like rifle bullets, is one that requires a good deal of attention before satisfactory results can be obtained. It often happens that one wishes to tackle one branch of photographic work which is outside the domain of that to which one is accustomed, and hence there follows an inquiry into the methods, special apparatus, and material required.

Now the work under review is a veritable *vade mecum* in this respect, for it deals, and deals exceedingly well, with the application of photography in practically every important aspect, both in science and the technics. It is only natural that for such a volume to be of value it must necessarily be the work of numerous men, for no one man can have had experience in all the multitude of applications. Herr K. W. Wolf-Czapek has done well therefore in gathering round him a number of workers who are authorities on the branches about which they write, and the result is one that is eminently satisfactory. The book itself contains 407 pages and 159 plates, with 470 illustrations on them, so that the reader will at once gather the fact that both methods and examples are amply illustrated and described. The contents are divided into four parts under general subheads, namely (1) inorganic physical sciences, such as physics, chemistry, astronomy, &c.; (2) organic physical sciences, such as botany, zoology, &c.; (3) technical science, such as photography applied to war,

engineering press, &c.; and lastly (4) social problems, as anthropology, criminal statistics, &c. The list of coworkers is too numerous to be given here, but when it is seen the reader can rest content that the text was in good hands. It is interesting to note that the volume was inspired by the International Photographic Exhibition held in Dresden in 1909, and that Herr Wolf-Czapek took the opportunity to utilise the exhibits as the groundwork for the volume.

In addition to a very carefully prepared table of contents, a subject-index and a name-register, the value of the work is considerably enhanced by the large number of references to the literature of the various subjects treated.

AGRICULTURE AND SOILS OF KENT, SURREY, AND SUSSEX.

Board of Agriculture and Fisheries: a Report on the Agriculture and Soils of Kent, Surrey, and Sussex. By A. D. Hall, F.R.S., and Dr. E. J. Russell. Pp. viii+206+56 figures. (London: H.M. Stationery Office, 1911.) Price 2s. 6d.

A BRIEF introductory account is given of the geological features of the area under consideration. This is followed by a concise account of the agriculture of the three counties as practised at the present day, chief reference being made to the cultivation of hops and fruit, for which this part of England is famous. Attention is also directed to the most important breeds of live stock found in the districts, the Southdown and Romney Marsh sheep receiving special notice.

The latter portion of the report is devoted to the authors' work upon the soils of the three counties. This section contains a valuable record of analyses—both mechanical and chemical—of the soils of the different localities. Messrs. Hall and Russell have taken the geological formations as a basis of work, and find that the analyses of the soils upon each formation exhibit certain common features which mark them off from those of other formations.

By a careful study of the results, it is seen that the mechanical analysis is, in a general way, indicative of the power of the soil to grow particular crops successfully, and a knowledge of the character and proportion of the component particles is frequently sufficient to enable the expert to predict with certainty the suitability of the soil to the cultivation of hops, fruit, roots, wheat, and other cereals. The chemical analyses in many instances also clearly indicate the need for particular fertilisers, and practical recommendations are made for the manuring of the various farm crops when grown on land situated on the different geological formations.

The authors modestly suggest that the report is incomplete and fragmentary. It is, however, one of the most valuable contributions made to the study of soils in this country, and it is to be hoped that some effort will be made to secure a continuance of similar work in other areas and on an extended scale. We should like to see the analysis of soils undertaken in conjunction with carefully planned experiments upon the actual fields from which the samples are drawn,