

agree, however, that chance is nothing but the very thing which emerges to some of us in his X-entity, just some complex of conditioning factors not yet known.

Finally, the book before us is pedagogically nearly ideal, and it may be that its teleological philosophy is one of its strong points in this regard. As the author will assuredly agree, scientific research is one thing and the teaching of science quite another; the elementary teacher does not try to tell the whole truth, but only those portions which may best lead on to such a state of mind in the student as will some time, perhaps, enable him to understand a large portion of the truth. Now, considering that physical causation is far too complex a subject even to be thought about adequately, until the thinking person has accumulated a vast store of accurate scientific experience, it may well follow that a perfectly monistic philosophy would not serve at all in an elementary treatise, and that a somewhat *devitalized* dualism is the only sort of inclined plane by which the scientifically untrained mind may be led toward the highest and clearest altitudes of scientific philosophy.

In conclusion, the book we have been considering is one of the American Nature Series, is bound in green cloth with a gilt-ornamental back, and is about 4 centimeters thick. It will always be read lying on the table. The paper stock is very heavy, clay-coated and highly surfaced, so that the numerous half-tone illustrations are exceedingly satisfactory. It is, however, also true that the position of the book and reader must be properly chosen to avoid dazzling high lights where the midnight lamp is reflected in the mirror-like surface of the paper. As with all such coated papers, a distinct odor of glue is perceptible throughout the reading; spattered water will play havoc with the pages.

B. E. LIVINGSTON

*Studies in Luminescence.* By EDW. L. NICHOLS and ERNEST MERRITT. Published by the Carnegie Institution of Washington, 1912. Royal 8vo, vi + 225 pp.

The memoir represents the results of investigation extending over a period of nine years. In large part it gives the experimental observations made by the authors; but in it are also observations on one or another phase of the general subject, made by other observers, mainly, however, under the guidance of the authors. The work has been aided by occasional grants of money from the Carnegie Institution of Washington, and the memoir is published by the institution. The material has been published previously in separate articles, most of which have appeared in the *Physical Review*; but it has now been given such continuity of form and (in the last two chapters of the memoir) such valuable theoretical discussion as to make the present publication one of unusual interest and value.

The authors, during these years, have evidently kept steadily before themselves the intention of using the spectrophotometer to the farthest possible extent. The success with which they have held to such intention, in investigations of a dozen or so of luminescent substances, is nothing short of remarkable. Measurements of intensities have been carried out far toward the edges of fluorescent and phosphorescent bands. In the cases of nearly all substances investigated, measurements were made to determine the exact form and extent of absorption bands corresponding to given luminescence bands. The dependence of the intensities of luminescence upon the wave-length of exciting light, and the distribution of intensities for some substances when excited by Röntgen rays and by cathode rays, have been studied. More remarkable still is the extent to which the spectrophotometer has been used in following the decay of phosphorescence at various wave-lengths in chosen bands. When one considers how weak the illuminations in the comparison fields of this instrument are, at the limits of a band or after some time of decay, the range of application which the method finds is surprising. Numerous settings were made with intensities in the comparison fields so small as to convey to the observer no sensation of color. The concord-

ance of results, obtained under widely varying conditions, bespeaks the care and patience with which unavoidable errors in individual readings have been ironed out by the law of averages.

In following the decay of phosphorescence there is obviously a stage beyond which the spectrophotometer, on account of its wastefulness and dispersion of light, is no longer applicable. In working beyond such limits with apparatus adapted to these researches from the methods of ordinary or gross photometry, Professors Nichols and Merritt took every care to excite only that band with which they were at the time concerned. Where in a few cases this precaution could not be observed, great care was exercised to insure the desirable uniqueness of significance for the results. Two very important laws, established from the spectrophotometric measurements, add much to the significance of such measurements as were of necessity made by gross photometry. The laws express the individuality of behavior of a given luminescence band as a whole, throughout a wide range of conditions of excitation, and, in the case of phosphorescence, during decay. A band maintains measurably the same relative distribution of intensities and the same wave-length of maximum intensity. As the authors express it "the band behaves as a unit." It is, now, not unreasonable to assume that, beyond the limits of availability of spectrophotometric methods, a given luminescence band still behaves as a unit, and that the measurements made thereafter on the band as a whole should indicate with fair certainty how the intensities at the individual wave-lengths decay.

Stokes's law of photo-fluorescence, namely that the fluorescent light is of greater wave-length than the exciting light, is verified in its gross sense. But since in a large number of instances, the corresponding luminescence and absorption bands overlap, and since the whole of a given band may be excited by light of any wave-length within the region of absorption, it follows that, considered in detail, the law frequently fails.

To these three important laws, and another

concerning the absence of polarization in the luminescence spectrum even when it is excited by polarized light, the authors add, from their own results and from those of other observers, some general "facts connected with the decay of phosphorescence." These are—the form of the curve of decay; the hysteresis effect or the dependence of the form of decay curve upon the previous excitation to which the substance has been subjected; the effect of red and infrared rays (ingeniously used to restore a substance to a standard condition after each excitation); and the effect of high temperatures.

Much work was done in the study of electrical properties of fluorescent solutions. This and the efforts of other investigators in the same field has led generally to negative results in the search for change in electrical resistance of solutions during fluorescence.

Important also is the work done to reduce the initial observations, made by spectrophotometer with diffused light of the acetylene flame as a comparison standard, to the fundamental basis of energy curves, and that which was done to determine the specific exciting power (intensity of fluorescence excited per unit of absorbed energy) of various wave-lengths of exciting light.

The last two chapters of the memoir are devoted to the consideration of theories by means of which the experimental data thus far gathered may be related and explained. The discussion is notably interesting and lucid throughout. Chapter XIV. gives an outline of the dissociation theory of Wiedemann and Schmidt, and shows that it has already been applied with considerable success to the explanation of fluorescence in gases. In Chapter XV. the authors add such other hypotheses as would seem necessary to make this theory specifically applicable to the problem in hand, and deduce therefrom laws which follow experimental results with surprising success—remarkable, indeed, when one considers how complex must be the processes which occur in luminescent solutions, solid and liquid.

One of the valuable things accomplished by a memoir such as the one in review, collecting

in orderly form and discussing as it does a vast amount of material of observation, is the pointing out of gaps in available data. The pages of these "studies" raise numerous questions which must be settled in order that the whole fabric of luminescence theory may be further extended. Undoubtedly many of the questions so raised will be worked out in the same laboratories from which the present researches have been issued.

Even thus far the work represented in the present memoir constitutes a most noteworthy series of researches in the general field of luminescence. Not only the care and patience with which the observations have been made, but much more the experimental acumen with which the methods and materials have been chosen and the illuminating discussions of theoretical character, all contribute to give these researches a place beside those of the middle of the past century by which E. Becquerel blazed the way into this wonderfully interesting region. Recent developments in physics attach much more of importance to the phenomena of luminescence than could possibly have been foreseen in those earlier years, and it seems certain that further developments, in this and allied branches of physics, will greatly enhance the value of the region as a field for research.

F. E. KESTER

#### SPECIAL ARTICLES

##### NON-ELECTROLYTES AND THE COLLOID-CHEMICAL THEORY OF WATER ABSORPTION

THE colloid-chemical theory best explains at the present time the absorption of water by protoplasm under various physiological and pathological conditions. The laws governing the absorption of water by such simple protein colloids as fibrin and gelatine, are point for point identical with those which we have known to govern the absorption of water by cells, tissues, organs, or the organism as a whole. Thus fibrin and gelatine swell more in any acid solution than in distilled water, while protoplasm does the same. The addition of any salt to the acid solution reduces the amount of this swelling, and this the more the

higher the concentration of the salt. The same holds for protoplasm. At the same concentration different salts arrange themselves in a characteristic order in this regard. The same order is observed in protoplasm.

In this way it has been possible to explain without contradiction not only all those phenomena which are ordinarily said to prove the tenability of the laws of osmotic pressure for the processes of absorption and secretion, as observed in protoplasm under various pathological and physiological circumstances, but also the notable exceptions in behavior, which no one believes explainable on the osmotic basis.

In the study of fibrin and gelatine, it was found that various non-electrolytes, such as sugars and alcohols, are *relatively* ineffective in reducing their swelling in the presence of any acid. Adherents to the osmotic theory of water absorption have made this statement read, *entirely* ineffective; and, because certain non-electrolytes bring about shrinking effects in various cells and tissues, have seen in this a valid reason for rejecting the dominant importance of the colloids and their state in determining the amount of water held by protoplasm.

During the past year a systematic study of the effect of various non-electrolytes on the swelling of gelatine and fibrin has been undertaken. *The effect of non-electrolytes upon these is identical with their effect upon protoplasm.* The various organic compounds thus far studied (saccharose, dextrose, levulose glycerine, ethyl alcohol, methyl alcohol, propyl alcohol, propylene glycol, etc.) all decrease the swelling of gelatine or fibrin in either neutral or acid solution, and this the more the higher the concentration of the added compound. When equally concentrated (equimolecular) solutions are compared the sugars are found to be more effective than the alcohols in this regard. The same is true of protoplasm. The sugars among themselves are unequally effective in dehydrating protein colloids, and in a similar way are they unequally effective in dehydrating living tissues.