

THURSDAY, JULY 2, 1891.

## CRYSTALLOGRAPHY.

*Elements of Crystallography for Students of Chemistry, Physics, and Mineralogy.* By George Huntingdon Williams, Ph.D., Associate Professor in the Johns Hopkins University. Second Edition, Revised, pp. 246, with 383 Woodcuts and 2 Plates. (London: Macmillan and Co., 1890.)

THE position which crystallography ought to occupy in a scheme of scientific education is far from being generally recognized. Every day the importance of this branch of science, not only to the mineralogist and geologist, but also to the physicist and chemist, is becoming more deeply felt; and yet, as a general rule, the systematic study of crystallography is left quite unprovided for in our schools and Universities.

If we take any standard treatise on physics, we shall find that the subject of the measurement and calculation of crystal forms is almost, if not entirely ignored; and though it is, of course, absolutely impossible to discuss optical and other physical phenomena without reference to the wonderfully suggestive relations which exist between the properties resulting from internal molecular structures, and the crystalline forms which are the "outward and visible sign" of such molecular structure, yet the references are usually vague and, not unfrequently, misleading. In confirmation of this statement, it may be mentioned that in a very widely-used treatise on physics—one that has passed through many editions in this and other countries—there is a hopeless confusion between the terms "hemihedrism" and "hemimorphism" in the account which is given of the remarkable phenomena of pyro-electricity.

Nor, as a rule, have chemists dealt more adequately with the subject of crystallography than their brethren the physicists. In many chemical treatises we find such terms as pyramidal, prismatic, octahedral, rhomboidal, &c., employed so loosely as not to give the student the faintest idea of the real symmetry of the forms which are referred to. This neglect of crystallography by chemists is seen to be the more serious when we remember two important circumstances—first, that crystallization is often the only means which chemists possess of isolating and readily distinguishing many bodies; and secondly, that new substances are being continually formed by the chemist, the study of some of which may throw new and important light upon crystallographic principles.

Mr. Fletcher, in a very suggestive address to the Mineralogical Society, has justly remarked:—

"Hitherto, at least, the chemists of this country have been too content, either to leave the crystalline forms of their artificial products undetermined, or to impose the task of their determination on the already sufficiently occupied mineralogist. It seems obvious that in a satisfactory system of education every chemist should be taught how to measure and describe the crystalline characters of the products which it is his fate to call into existence. . . . A knowledge of the elements of crystallography, including the mechanics of crystal-measurement, ought to be made a *sine quâ non* for a degree in chemistry at every University."

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The consequence of this neglect of crystallography by physicists and chemists has been that the teaching of crystallography has fallen almost entirely into the hands of mineralogists and geologists. But there is no more reason why every book on mineralogy should commence with a crystallographic treatise, than that it should include dissertations on refraction or articles on chemical analysis. "Crystallography should be taught as a special subject," and the student who, after his training in physics and chemistry, takes up the subject of mineralogy, ought to know at least as much of the measurement and symmetry of crystal forms, as he does of the effects of various media on different kinds of radiant energy, or the reactions of the several bases and acids.

It would be easy to show that, much as mineralogists have done for the study of crystallography, the latter science would have been developed more logically, and perhaps more rapidly, if the illustrations of the phenomena of crystallization had not been so exclusively sought among natural products. We find not a few examples in the terminology of the science of the effects of this one-sided growth of crystallography.

Crystallography is based upon purely mathematical considerations, and the study of the principles of crystal-measurement, the discussion of crystal-symmetry, and the calculation of fundamental forms, ought clearly to be one of the first branches of applied mathematics to be taken up by the student of physics; thus the study of crystallography should certainly precede that of physical optics. If this course were followed, the student of chemistry and mineralogy would come to the teachers of those sciences with such an amount of preliminary information as would enable him to profit by their instructions.

In the work now before us, Dr. Williams fully recognizes the importance of the principles for which we have been contending, and has endeavoured to supply English-speaking students with a short and clear treatise on the principles of crystallographic science. It is certainly remarkable that the countrymen of Wollaston, Whewell, and Miller should have had to wait so long for a work of this character; though every student of the subject must gratefully remember the aid afforded by the admirable little primer prepared some years ago by Mr. Gurney, and published by the Society for Promoting Christian Knowledge.

Of Dr. Williams's qualifications for undertaking a work of this kind it is unnecessary to speak. His numerous original researches afford abundant evidence of his devotion to crystallographic study, and in the preparation of the work he has had the advice and assistance of one of the first crystallographers of the United States, Prof. S. L. Penfield, of New Haven.

In order to keep the work within the smallest possible limits, it has been restricted to geometrical crystallography, but otherwise the work has been modelled upon the same lines as Groth's standard work, "*Physikalische Krystallographie*." The plates and very numerous woodcuts afford the greatest possible aid to the reader, and the typography leaves nothing to be desired. In looking through this revised edition, we are struck with the almost entire absence of those typographical errors that so easily creep into a work of this kind, and which,

though so obvious to an expert, often prove to be a source of infinite trouble to the beginner.

In dealing with the vexed question of crystallographic notation, we think Dr. Williams has exercised a very wise discretion. The simple and easily understood symbols of Naumann have been employed in the first instance, but in almost every case the corresponding symbol of Miller's system has been added in brackets. While all students of physics, chemistry, mineralogy, and geology ought to equip themselves with such an amount of crystallographic knowledge as may be derived from the study of this book, only a very small proportion of them are likely to be called upon to deal with the higher and more complicated problems of the science. The small minority of students who devote themselves to purely crystallographic researches may be fairly recommended to employ from the first the beautiful method of notation devised by Whewell and perfected by Miller; but it is more than doubtful if the student with a smaller amount of mathematical training would gain any real benefit from such a course. In an appendix, "on zones, projection, and the construction of crystal figures," the author of this work has indicated to such a beginner the nature of some of the methods of investigation which are pursued by more advanced students.

In any future edition of the work—and such, we feel sure, will certainly be called for—we think that the author would do wisely to add a table showing the symbols of the chief forms according to all the different systems of notation commonly employed. The student who turns to the classical memoirs of Des Cloizeaux, Mallard, Bertrand, and others of the French school of crystallography, would thus be enabled to avail himself of much valuable literature, which, owing to the employment of an unfamiliar notation, must otherwise remain a sealed book to him.

We have spoken regretfully at the outset of this notice of the general neglect of crystallographical studies; but we are compelled to admit that, for this neglect, crystallographers themselves are largely to blame. The confusion produced by numerous rival systems of notation is answerable for much of that feeling of despair among those who attempt to make themselves acquainted with the subject. If the time has not yet arrived when a uniform crystallographic language can be agreed upon, much might be accomplished if the plan adopted by the author of this work of giving in every case the symbols according to *two* systems were followed. This is already done in the *Zeitschrift für Krystallographie*, the *Neues Jahrbuch für Mineralogie*, &c., the Journals of the English and French Mineralogical Societies, and several other well-known periodicals. If a conference of the leading crystallographers of Germany, France, and England could be held to decide upon the order in which the axes should be taken in writing symbols and other similar arrangements which are purely conventional and arbitrary, we might hope to see much of the confusion removed that has so long been a bar to the progress of this most fascinating and important branch of science.

We feel assured that the simultaneous publication in this country and in America of so simple and at the same time so accurate a text-book of the subject as the work we are now considering will do much towards reviving

and diffusing a taste for the study of crystallography. The student who masters the contents of this little book will undoubtedly have much more to learn before he is competent to deal with all the higher problems of crystallographic science; but, however far his researches may be carried in the future—and this is, perhaps, the very highest praise we can give to the book—he will certainly have little, if anything, to *unlearn*.

JOHN W. JUDD.

#### PHOTOGRAPHY IN COLOURS.

*Photographie des Couleurs par la Méthode Interférentielle de M. Lippmann.* By Alphonse Berget. (Paris: Gauthier-Villars et Fils, 1891.)

THIS interesting little *brochure* contains an account of the recent achievements in colour photography which have been made so widely known to the English public through the daily papers. Coming from the pen of an "attaché au Laboratoire des Recherches (Physique) de la Sorbonne," we may take this contribution as an authorized exposition of M. Lippmann's work, and as such it will be found useful by physicists, chemists, and photographers, as well as by the general reader who wishes to know the real state of the case concerning this important departure in photographic methods. In a short historical introduction the author calls attention to the previous photochromatic attempts by Seebeck in 1810, by Herschel in 1841, by Edmond Becquerel in 1848, by Niepce de St. Victor in 1851 to 1866, and by Poitevin in 1865. It is stated that these and all similar attempts were based upon purely chemical methods, the investigators seeking for some sensitive compound which would give chromatic impressions corresponding to the colours impinging on the film. M. Berget adds the important remark: "*a priori*, ce problème est irréalisable."

Chapters ii. to v. are devoted to elementary optical principles. Chapter ii. deals with vibratory movements and their propagation, wave-length and period, and sonorous waves. In the third chapter the phenomenon of interference is described and explained; in the fourth chapter we have sections on the luminiferous ether, the velocity of light, the decomposition of white light by a prism, and Fresnel's theory of the spectrum colours. The subject of complex colours, as distinguished from the pure colours of the spectrum, is also dealt with in this chapter, and is of special importance in connection with the colours of natural objects, to which the author devotes a short section. It is pointed out that the principle of superposition of vibrations holds good in optics as in acoustics, and that just in the same way that the diaphragm of a phonograph can take up and faithfully transmit the extremely complex system of superimposed aerial vibrations produced by the human voice, so the ether transmits the complex superimposed vibrations emanating from coloured objects. In connection with the history of the undulatory theory, the whole credit is given to Fresnel: "L'honneur de donner la première théorie rationnelle de la lumière, en la considérant comme résultat d'un mouvement ondulatoire, était réservé à un savant français: Fresnel." We should like to have seen Thomas Young receive at least an honourable mention.