cation that came to light our authors had some difficulty in placing, finding it hard to decide whether it belonged to the dicotyledons or monocotyledons, but as a final conclusion they say: "On the whole, judging from its detailed structure and general appearance, we incline to place the flower in the Liliaceæ." Is it to be presumed that such adumbrations as the above add much to the evolutionary history of the Liliaceæ, or of the monocotyledons in general?

It is not necessary to further mention the technical portion of the paper, and it only remains to call attention to some of the nomenclatorial anomalies. All the genera and species published as new to science in the present paper were printed a year earlier in the *Geological Magazine*, London, N. S., Vol. 6, 1909, pp. 557–559, but without characterization. They are all again listed on page 1 of the paper under review, some of them incidentally mentioned at various places in the introduction, each again appearing at the head of the section of the text in which it is described, while at the end of the description there is a formal generic and specific characterization where each is called "gen. nov.," or "sp. nov." The question arises as to how these shall be cited. To give *Cryptomeriopsis* as a concrete example: Shall we quote page 1 of this paper, where it is first printed; page 3, where it is mentioned and partially described; page 52, where it stands at the head of the description; or page 57, where the genus and species are formally dedicated?

The reviewer does not wish to be understood as in any way underestimating the value of histology in establishing a firm basis on which to work out the developmental history of plants, but if the study of the internal structure of fossil plants, as contrasted with the study of plant impressions, is to be given proper weight it must be subject to the same scrutiny. If the study of the intimate anatomy of fossil plants leads only to indefiniteness and inconclusion, it is not entitled to greater weight than attaches to the study of the impressions of plants.

F. H. Knowlton

SOME RECENT ADVANCES IN FLUORESCENCE AND PHOSPHORESCENCE [1]

After an opening period of great activity, which began with Becquerel, Herschel and Stokes and included the important work of Lommel, Wiedemann and Schmidt and of numerous other physicists, there was a long time of comparative quiescence during which *luminescence,* to use the word proposed by E. Wiedemann, was a neglected branch of optics. Quite recently there has been renewed activity in this field and it is of some aspects of this newer work that I shall try to give a brief account. No approach to a complete summary can be made in a single paper and I shall deal chiefly with certain investigations which are particularly suggestive of the beginnings of correlation in this involved and obscure portion of the science of radiation.

The Relations of Phosphorescence to Fluorescence.—The common view that phosphorescence is simply what remains of fluorescence after the cessation of excitation would seem to need essential modification according to the latest paper of Lenard,[2] who, after extending his observations to some fifty phosphorescent compounds, made by the addition of a trace of some metallic salt to a sulphide of strontium, barium or calcium and certain heat treatment with a flux, considers that it is necessary to distinguish two phenomena, the one temporary, which ceases almost instantly after the end of excitation (*Momentan-process*), and the phenomenon of long-time phosphorescence (*Dauer-process*). The distinction is three fold: The momentary process may be produced independently of the other (1) by very brief excitation; (2) it may be excited by the use of portions of the ultra-violet spectrum which are incapable of producing long time phosphorescence or (3) at temperatures above or below the range within which long-time phospho-

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[1] Abstract of a paper presented before Section B at the Minneapolis meeting of the American Association for the Advancement of Science.

[2] Lenard, *Annalen der Physik* (4), Vol. XXXI., p. 641, 1910.

rescence can be excited. Lenard regards the phosphorescence spectrum as consisting of one or more well-separated, broad and continuous bands usually lying within the visible spectrum. Detailed study of these bands with the spectrophotometer,[3] however, shows that they are really of a very complex structure and consist of overlapping components which can not be separated altogether for any given temperature or mode of excitation, but which are so differently affected when the wave-length of the exciting light is varied or when excitation occurs at different temperatures, as to indicate that they are not due to the luminescence of one and the same molecule or aggregate. It is probably on account of this complexity of the phenomena that Lenard has reached his view of the case. Certainly the evidence of recent work by Pierce,[4] Waggoner[5] and Zeller[6] goes to show that whatever may be true of phosphorescent sulphides prepared by the method of Lenard and Klatt, the relation between phosphorescence and fluorescence is in many other instances the intimate one that has usually been assumed to exist.

Fluorescence in the Ultra-Violet and the Infra-Red.—Stark and Meyer[7] have in a recent paper shown the existence of numerous fluorescence bands lying in the ultra-violet spectrum. In the case of the benzol derivatives with which their measurements have to do fluorescence depends for its position upon the complexity of the molecule and it is found that, as a rule, the heavier aggregations have bands in the longer wave-lengths.

Steubing[8] finds spectrum lying at still shorter wave-lengths (.1884μ) which he ascribes to the fluorescence of oxygen. This spectrum, like the corresponding spectra for vapors of gases having fluorescence in the visible spectrum, as described by Wood,[9] consists of a group of bands regularly but not uniformly spaced. As may be seen in Fig. 1 the distance between the bands increases gradually with increasing wave-length. Beginning at that end of the group which lies furthest in the ultra-violet, the intensity of the individual bands rises very rapidly to a well-marked maximum and falls off more slowly as the wave-length increases. An inspection of the remarkable photographs made by Wood of the fluorescence of sodium and other vapors leads one to believe that were measurements made of those spectra a similar distribution of intensities would be found to exist.

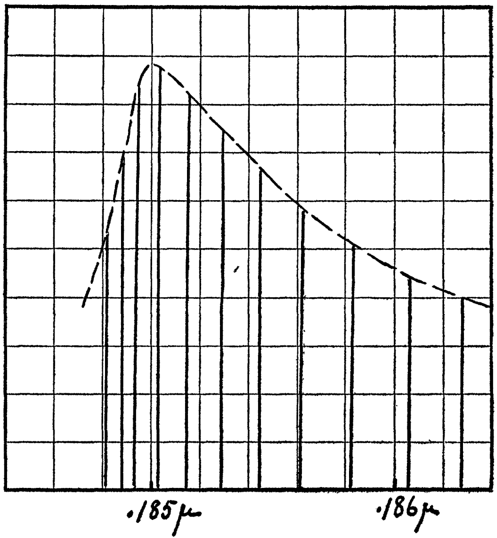

FIG. 1. Diagram showing the distribution and relative intensity of bands in the fluorescence spectrum of oxygen (Steubing).

Pauli[10] has recently subjected the preparations of Lenard and Klatt to systematic study, particularly with the view of corroborating Lenard's hypothesis that the active metallic atom embedded in the sulphide is to be re-

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[3] Nichols and Merritt, *Physical Review*, Vol. XXXII., p. 38.

[4] Pierce, C. A., *Physical Review*, Vol. XXVI., pp. 312 and 454; XXX., p. 663.

[5] Waggoner, C. W., *Physical Review*, Vol. XXX., p. 663.

[6] Zeller, C. A., *Physical Review*, Vol. XXXI., p. 367.

[7] Stark and Meyer, *Physikalische Zeitschrift*, Vol. 8, p. 250.

[8] Steubing, *Annalen der Physik* (4), Vol. XXXIII., p. 553, 1910.

[9] Wood, *Philosophical Magazine* (6), Vol. X., p. 513; Vol. XV., p. 581; Vol. XVI., p. 184.

[10] Pauli, *Physikalische Zeitschrift*, Vol. XI., p. 991.

garded as an electric oscillator, the period of vibration of which depends upon inductance and capacity. By modifying the dielectric constant of the solvent it was found that the position of the fluorescence band could be altered at will and Pauli succeeded in producing preparations having bands in the ultra-violet only and in other cases only in the infra-red.

The Complexity of the Fluorescence Spectra of Solids.—The complexity of fluorescence spectra which was first so strikingly exhibited in Wood's studies of sodium vapor is by no means confined to gases. Not only do we have solids whose spectra are made up of overlapping bands due to the presence of several fluorescing constituents, as in the case of the sulphides of Lenard and Klatt, but there are also substances of definite chemical composition, notably the uranyl salts, the fluorescence spectra of which consist of a group of several bands arranged in a manner which suggests the banded spectra of gases. E. Becquerel[11] in 1872 studied these fluorescence bands and discussed their relations to the corresponding absorption spectra. The subject has since received the attention of numerous investigators; the most recent contribution being that of Jones and Strong.[12] Henri and Jean Becquerel,[13] working at Leiden with Kamerlingh Onnes, have studied the fluorescence spectra of uranyl salts; photographing the same at 288° of the absolute scale, 80° (liquid air), 20° (liquid hydrogen) and 14° (solid hydrogen). Under these conditions the already unusually narrow bands are reduced to mere lines in the spectrum and each band is found to consist of a group of such lines.

The relation of the narrow fluorescence bands of the uranyl salts to the broad bands in the fluorescence spectra of other solids and liquids is not at first sight obvious. They appear to be intermediate between the broad bands usual to solids, of which sometimes only one exists, and the complicated groups of lines observed in the case of vapors. Some recent studies of the uranyl bands appear, however, to throw some light on this relationship.[14] Hitherto attention has chiefly been directed to the location of the bands in the spectrum. When, however, we measure the relative intensities of such a group of bands we find them to be related in a very interesting manner. The curve showing the relation between wave-length and intensity of the seven strongest bands in the fluorescence spectrum of such a salt has a form which is essentially identical with that of the typical curve for the distribution of energy in the broad single bands of ordinary fluorescence spectra. The shape is the same for the various uranyl salts; being shifted slightly in wave-length with the chemical composition or with the presence or absence of water of crystallization.

Fig. 2 will serve to indicate the characteristic form of these curves and the shift

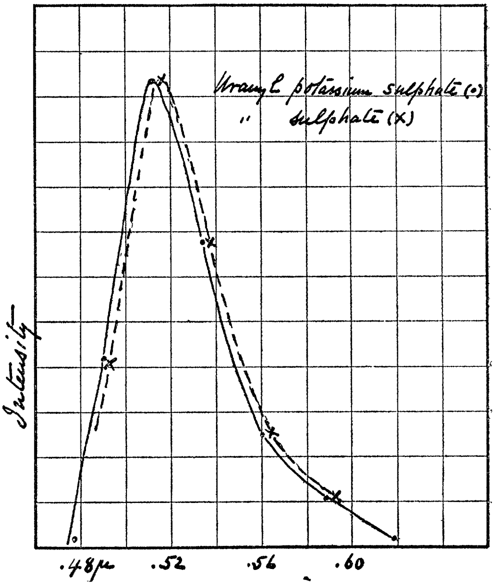

Fig. 2. Relative intensities of the seven principal bands in the spectra of two uranyl salts.

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[11] E. Becquerel, *Mémoires de l'Académie des Sciences*, XL., 1872.

[12] Jones and Strong, *American Chemical Journal*, XLIII., p. 37.

[13] H. and J. Becquerel and Onnes, "Leiden Communications," No. 110.

[14] Nichols and Merritt, "On the Fluorescence Spectra of the Uranyl Salts and on the Structure of Fluorescence Bands in General." A paper presented at the Minneapolis meeting of the American Physical Society, December 28, 1910.

due to change in chemical composition. The examples selected are uranyl sulphate ($UO_2SO_4 \cdot 3H_2O$) and uranyl potassium sulphate ($UO_2SO_4 \cdot K_2SO_4 \cdot 2H_2O$).

That this relation is not an accidental one, but that these various bands are probably due to the oscillations of one and the same complex mechanism may be almost conclusively established by observing the spectrum under various conditions of excitation and of temperature. When we subject accidental combinations due to different substances in a fluorescing mixture to such changes the independence of the various components is readily shown, but in the case of the uranyl bands when excited by the monochromatic light of various lines of the mercury arc from .4538μ to .2536μ it is found that the relation between the intensities of individual bands remains very nearly the same. When the substance is gradually cooled to the temperature of liquid air and observations are made at intermediate temperatures, it is found that all of the bands shift towards the violet and that their gradual movement as the temperature changes is of the same character for all. The relation of intensities in this case does not remain the same, but it is significant that the changes are such as to produce a modification in the curve of relative intensities precisely similar to that which is known to occur in the case of the ordinary broad continuous fluorescence bands when the excited substance is cooled. It would therefore appear that we have in the case of the fluorescence of the uranyl compounds a single fluorescence band of the usual type but broken up into several easily separable components. It is easy to imagine that a continuance of the change which occurs in the fluorescence of these substances as the temperature rises from that of liquid air to + 20° C. would result in the merging of these components into a continuous band in which they could no longer be distinguished from one another.

In the case of some of the uranyl salts, indeed, the overlapping of the bands is considerable under ordinary conditions, as may be seen in Fig. 3, which is from measurements of the three strongest bands of uranyl nitrate at 20° C.

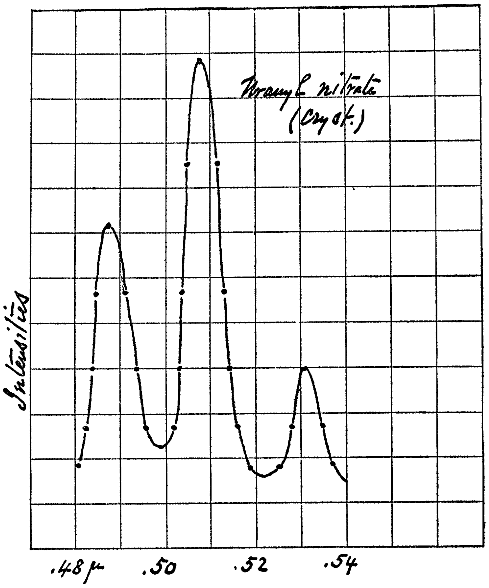

FIG. 3. Diagram showing the overlapping of the three principal bands in the fluorescence spectrum of uranyl sulphate.

The relation may be carried still further when we consider that the broad continuous bands of fluorescent substances are always associated with a broad absorption band usually overlapping the fluorescence band on the side toward the violet and that the absorption spectrum of the uranyl salts consists of a series of bands precisely similar as regards their arrangement and number to the bands of the fluorescence spectrum. This group of bands according to E. Becquerel is to be regarded as a continuation of the series of fluorescence bands. It has been shown by H. and J. Becquerel and Onnes[15] to overlap the group of fluorescence bands. According to their photographs the bands nearest the red in the absorption group when observed at the temperature of liquid air are nearly if not quite coincident with the last ones of the fluorescence group towards the violet.

As in the case of the fluorescence bands of the uranyl salts, the absorption bands increase

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[15] Becquerel and Onnes, *l. c.*

in intensity as we pass from either end towards the middle of the group, and we may depict the relation of the two groups by drawing the enveloping curve for the region of absorption and for that of fluorescence and showing the extent to which they overlap, as in Fig. 4. While detailed quantitative studies of the absorption bands have not yet been made, the preliminary observations indicate that the enveloping curve is an "image" of that of the group of fluorescence bands, just as the broad absorption band of resorufin and other fluorescent substances has already been shown[16] to be the overlapping image of the corresponding fluorescence band.

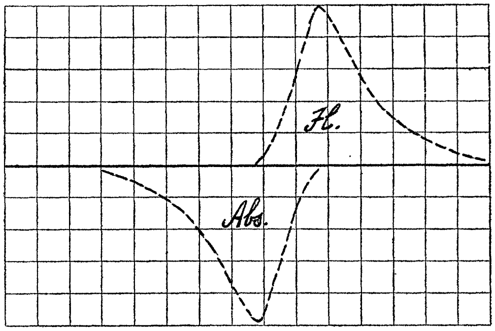

Fig. 4. Diagram showing the overlapping of fluorescence and absorption in the case of a uranyl salt.

Not only is the envelope of the fluorescence group of the same type as the curve of distribution of energy in ordinary fluorescence bands, but each component, as has been shown by spectrophotometric measurements, has a similar distribution of energy. Moreover, both curves have the same characteristics, although with very different scales of wave-length, as the energy curve of the temperature radiation of a black body. That the relation between the luminescence of solids and liquids and that of vapors is an intimate one is strongly suggested by the comparison of the diagram from Steubing's measurements of the fluorescence of oxygen (Fig. 1) with the curves for the uranyl salts just described, and this suggestion is strengthened by the inspection of Wood's curves for the fluorescence of sodium vapor. Moreover, the family resemblance of all these related cases of banded fluorescence spectra to the banded spectra of gases as we find them described in the papers of Deslandres and of Kayser and Runge is unmistakable. In view of these numerous indications of a common property may we not anticipate the attainment of some broader generalization concerning the various types of radiation than has hitherto been made?

E. L. Nichols

NOTES ON THE PRELIMINARY REPORT OF THE COMMITTEE ON THE TEACHING OF MATHEMATICS TO STUDENTS OF ENGINEERING

At the meeting of the Society for the Promotion of Engineering Education held at Madison, Wis., in June, 1910, the members present were handed sets of galley proofs of the Preliminary Report of the Committee on the Teaching of Mathematics to Students of Engineering, which committee was appointed at a joint meeting of the American Mathematical Society and Sections A and D of the American Association for the Advancement of Science in December, 1907. The committee consists of twenty members, ten of them being professors of mathematics, three presidents of technical institutions and seven professors of engineering and consulting engineers.

The report being only a preliminary one, it is subject to amendment before being presented as a final report, and no doubt the members of the committee will be glad to receive any suggestions which will tend to make the report more useful and more acceptable to engineering teachers. The writer acknowledges the great value of the report as a whole, but he has some criticisms to offer on one portion of it, viz., elementary dynamics, which he hopes will be carefully considered by the members of the committee and by others interested, who may be led by it to offer the committee additional suggestions.

In the preface to the report it is said:

> The defects in the mathematical training of the student of engineering appear to be largely in knowledge and grasp of fundamental principles,

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[16] Nichols and Merritt, *Physical Review*, Vol. XXXI., p. 376.