

subsidence, e.g. coral reefs and islands, are parts of the earth's surface which have lately increased rapidly in weight; and it may be worthy of consideration whether coral and volcanic islands have contributed to deepen the bed of the ocean.

J. F. ANDERSON

Cauterets, Hautes Pyrenees, July 12

Curious Rainbow

AN unusual atmospheric effect was witnessed here to-day, which I had a good opportunity of observing. The sun was about 8° from the horizon, shining brightly upon a heavy shower which had a background of dark clouds. The result was, of course, a double rainbow of remarkable brilliancy. In addition, however, to the ordinary circular and concentric bows, there was a third of an elliptical form, the two ends of which respectively sprang from the two ends of the inner arc, while the elliptical curve cut the outer arc at each extremity of a chord, which was parallel to, and which intersected the normal radius at a point about two-thirds of its length above, the diameter that formed the common base. The top of the elliptical bow was thus the outermost of the three, but the space between its inner margin and the outer margin of the second bow, although quite distinct, was not large.

The appearance of the third bow was due to light reflected from the sea. The sun being low, the resulting line of reflection was long, and it was the linear character of the source of light which gave the elliptical form to the bow it occasioned.

Dunskaith, Ross-shire, July 10

GERGE J. ROMANES

CHLOROPHYLL COLOURING-MATTERS *

II.

I THINK there can be no doubt that the spectra of the various yellow substances given in Pl. II., Figs. 3, 4, and 6 of Dr. Kraus's work, are due to a variable mixture of xanthophyll, yellow xanthophyll, and lichnoxanthine. These can be separated, and do occur in different kinds of plants, either alone or mixed in such variable proportions that the spectra of the solutions show the absorption-bands, not only in variable positions, but also much less distinctly in some cases than in others. This difference is ascribed by the author, not to a variation in the relative proportion of two or more substances, each having definite and unvarying characters, but to the modification of one single substance, due to some unknown cause, assigning as a reason for this supposition that the chemical reactions are the same, and that the positions of the absorption-bands vary so gradually from one extreme to the other that no distinct demarcation can be detected. Now this is so very fundamental a question in such studies, and, according as it is decided, would modify the conclusions so much, that it is requisite to discuss it somewhat fully. No doubt the position of the absorption-bands seen in the spectra of solutions in different liquids does differ very considerably, but I feel persuaded that the spectrum of the same chemical compound, dissolved in the same liquid, is the same in all cases; and that, if there is any difference between the spectra of two similar solutions, it is due to a difference in the substances themselves. I would restrict the term *modification* to those changes sometimes produced by the action of weak alkalis or acids, or by deoxidizing reagents, which are only of a temporary nature, so that when the solution is restored to its original state, the spectrum is seen to be just as at first. We really do require such a term, and I have myself constantly used it in this sense. There is, however, no such relation between the different colouring-matters belonging to what I have called the xanthophyll group; and, though the presence or absence of oily substances may, and sometimes does, materially influence the position of the absorption-bands seen in the spectra of plants themselves, yet, when dissolved in a relatively large quantity of a solvent, this effect is altogether overcome. As I have shown in my late paper the position of the

* Continued from p. 204.

absorption-bands in the different members of the xanthophyll group is very different, and yet it would be easy so to mix them as to have a perfect series of connecting links, and in my opinion the variations from what appear to be independent compounds may be explained in an extremely simple and satisfactory manner, without supposing that the optical characters are subject to any such variations as are ascribed to them by the author. Whenever I have met with these variations I have looked upon them as presumptive evidence of there being a mixture, and have always been able to prove the truth of this principle by subsequent conclusive experiments. The following example will serve very well to explain my views. Many yellow flowers are coloured by a variable mixture of what I have called xanthophyll, yellow xanthophyll, and lichnoxanthine. The former occurs separately in the Alga, *Porphyra vulgaris*, the second in such pale yellow flowers as the yellow *Chrysanthemum*, and the last in the yellow fungus, *Clavaria fusiformis*. The absorption-bands of these two kinds of xanthophyll are in a very different position, and the lichnoxanthine gives no bands, only an uniform absorption, extending over about one half of the spectrum from the blue end. The chemical reactions are also equally distinct. On dissolving each in absolute alcohol, and adding a little hydrochloric acid, the first fades slowly, without being first changed into another yellow substance, and without turning blue or green; the second is first altered into another yellow substance, giving a spectrum with two absorption-bands in a different position, and then turns to a deep blue, whilst the last remains unchanged for a much longer time, and fades very slowly. Now, of course, if all these were mixed together in variable quantities, we should get results varying according to the relative amount of each. The absorption-bands due to the two kinds of xanthophyll would lie in an intermediate position, according to the relative amount of each constituent, and would be more or less indistinct, according as there was more or less of the lichnoxanthine; and on adding a little hydrochloric acid to the solution in alcohol the colour would turn to a more or less blue green, and subsequently fade to a pale or deeper yellow, according to the relative quantity of each constituent.

In order to make my meaning more clear, let us suppose that we were to take a mixture of equal quantities of xanthophyll and yellow xanthophyll. Using the notation I have so often explained in former papers, the centres of the absorption-bands of the spectra of a solution in bisulphide of carbon would then be—

Xanthophyll	6½	8
The above mixture	6¾	8½
Yellow xanthophyll	7	8¼

Now on exposing solutions of xanthophyll or yellow xanthophyll to the sun both fade, and if examined when very little colour was left undecomposed, the bands would be seen to be in the same position as at first, the solution being in fact just as if a large part of the colour had been removed, or as if it had been much diluted. In the case of the mixture this would not be the case. Xanthophyll is more rapidly decomposed than yellow xanthophyll, so that when very little colour was left the bands would be no longer in the original position, but in the same place as those of yellow xanthophyll, showing that a small quantity of this is left, when all the other has been destroyed. If some lichnoxanthine had been mixed with the solution, after longer exposure to the sun no absorption-bands would be seen, only the general absorption due to that substance. Moreover if we took equally deep coloured solutions in absolute alcohol of the same three different specimens, and added a little hydrochloric acid to each, the xanthophyll would fade till it was colourless, the yellow xanthophyll would turn to a fine blue,