

matter genealogically, it is quite possible that by the obliteration of the lumen of gastro-vascular outgrowths of the primitive alimentary canal a large bulk of cellular elements should be furnished to the so-called "mesoblast" from the hypoblast, and that subsequently this solid mass of cellular elements should by splitting develop a cœlom. In this way it is conceivable that the schizocœlous condition might develop from the entero-cœlous and gradually lose all trace of its ancestral origin further than is afforded by the derivation of some mesoblastic cells from hypoblast. At the same time there is much to be said in favour of the schizocœlous condition being an aboriginal one, since we see that it really can make its appearance (in a rudimentary way) among Cœlenterata. The grouping of animals by Professor Huxley (*loc. cit.*) according to the actual mode of formation, and supposed corresponding ancestral distinction, of the body-cavity, which term has, according to his view of the matter, been applied to three very distinct kinds of cavities, cannot but draw increased attention to the actual and possible relationships of the spaces which develop between endoderm and ectoderm. Until there are facts to hand to show that it is *more* probable that the varieties of body-cavity in such groups as Mollusca, Vertebrata, and Chætogonatha, are of distinct origin in each case than that they are due to modification of one ancestral cavity, one is disposed to adopt the hypothesis of *uniformity* as the simplest and the least likely to lead into difficulties.

On the COLOURING MATTER of Bonellia viridis. By H. C. SORBY,
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SOME months ago my attention was called by Mr. E. Ray Lankester to a green colouring matter which he had obtained when at Naples from the above-named annelid. I immediately saw that it was a substance of great interest, and in order that I might be able to study it carefully Mr. Lankester kindly gave to me a large portion of the material he had collected. He has since furnished me with the notes and drawings which he made at the time, and with the following description of the animal, which it would be well to give before entering into the consideration of the optical characters of the pigment itself.

Bonellia is a worm which lives in holes in calcareous rocks.

Its body is globular and lies in a large cavity in the rock, whilst a long fan-like proboscis is exerted from a fissure connected with the cavity. Consequently *Bonellia* is not exposed to sunlight. The green colouring-matter occurs in clusters of fine granules dispersed in the tegumentary tissues, and is apparently deposited in the protoplasm of the epidermic cells. The green colour is of so deep a tint that the animal appears to be nearly black. The drawing of the spectrum of this substance when in the living animal, made by Mr. Lankester, agrees so closely with what can be seen in the alcoholic solution, which I have studied, as to show that no decided change has taken place, although it has been kept exposed to the air for more than five months, and thus it appears to be a compound of very considerable permanence. The position and relative intensity of the bands shown in the drawing also differ no more than was probably due to the colouring matter being associated with some oil, and not dissolved in the solvents used in my experiments.

In all my previous publications I have expressed the position of the absorption-bands seen in the spectra of coloured substances by referring them to a scale furnished by the black interference bands seen in the spectrum of the light passing through a plate of quartz between two Nicol's prisms, the thickness of the plate being such that the Fraunhofer line D is $3\frac{1}{2}$, and the line F $7\frac{1}{2}$, or thereabouts. I still use this scale for actual observation, but it appears to me that for the future it would be far better if all writers on such subjects would express the position of the absorption by giving the length of the waves of light at that particular part of the spectrum in millionths of a millimetre. In order to be able to do this I have constructed a table of the wave-lengths of every part of my quartz scale, so that, after having measured the position of any absorption-bands, I can immediately express it by numbers representing millionths of millimètres of wave-length. The advantages of this system are that, not only is it a scale that all may adopt for general comparison, but, as I shall be able to show in some subsequent paper, most important relations can be shown to exist between the wave-lengths of different bands, which relations cannot be recognised if any other scale be adopted. I propose, therefore, in future to express the position and character of bands by millionths of millimètres of wave, and by printing under the numbers symbols to indicate the relative intensity of absorption, thus :

Very faint absorption	.	.	.	.	.
Quite decided	„	.	.	.	..
Dark and strong	„	.	.	.	---
Black and very strong absorption	.	.	.	.	---

Now, by carefully discussing the wave-lengths of the centres of the absorption-bands in the spectra of substances which have a number of well-defined character, I find that they appear to be related to one another in the following manner. If the wave-lengths of a series of such bands, passing from the red end to the blue, be $a, b, c, d, \&c.$, the ratio between any consecutive pair is very closely, if not absolutely, the same; that is to say, $\frac{a}{b} = \frac{b}{c} = \frac{c}{d}$ &c. If,

however, the complete spectrum be a, b, c, d , it does not by any means follow that all the bands are always present. In the case of some substances the spectra of the acid and alkaline solutions are related thus:

Alkaline solution	.	.	.	.	a	b	c
Acid solution	.	.	.	.		b	c

It also frequently happens that under certain conditions some of the bands, which in accordance with this law ought to be present, are absent, so that the spectrum may be, for example, a, c, d , and in other conditions of the substance (for instance, dissolved in some other solvent) the missing band may make its appearance at the true interval. It must also be borne in mind that without any considerable change in the general character of the spectrum the wave-lengths of the bands may vary very considerably, according to the nature of the liquid in which the substance is dissolved, or according as it is in a free state or in solution; so that we have to consider both the alterations in the position of any particular band, as well as the development of new bands. Very much remains to be learned in connection with this subject, and I do not yet feel quite certain that the above-described relations are the true law, or only a better approximation than any hitherto made.

Having now given such a short account of my general conclusions as seemed necessary for the subject before us, I proceed to describe the spectra of the colouring matter of *Bonellia*, which for convenience may be named *Bonelleime*.

Being green and fluorescent, and the spectrum showing a very well-marked absorption-band in the red—being, moreover, insoluble in water, but soluble in alcohol and in carbon bisulphide—it might at first be mistaken for chlorophyll, or

might at all events be looked upon as a chlorophyll substance; but when more carefully examined it is soon found to differ completely from either blue or yellow chlorophyll or chlorofucine, which, according to my views, are the only genuine species of the genus chlorophyll hitherto described.¹ All of these are changed by strong acids into new substances, so that when the solution is subsequently neutralized the spectra are found to be totally unlike those of the original substances. On the contrary, on adding an acid to the green alcoholic solution of bonelleine the colour becomes purple, there is a great change in the spectrum, due to the removal of some bands and the greater development of others, but no other alteration, even after many days, and on neutralizing the acid the original spectrum is again seen just as at first, thus proving that no such decomposition takes place as in the case of chlorophyll. In this respect it resembles the well-known product of the action of acids on blue chlorophyll, but this latter differs from bonelleine in giving the same spectrum when the solution is acid as when it is neutral or alkaline.

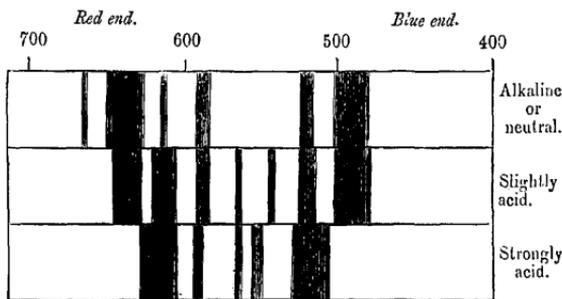
Bonelleine also differs from the three different species of the chlorophyll group in the character of its fluorescence. The neutral alcoholic solution gives *two* bright bands, whose centres are at wave-lengths 643 and 588, whereas the chlorophylls give only one. The spectrum of the fluorescence of the acid solution of bonelleine gives a single bright band at wave-length 619, whereas that of the product of the decomposition of blue chlorophyll by acids gives *two*. These are such important differences that it seems desirable to look upon them as of generic value, though, at the same time, in the present state of our knowledge it would, perhaps, be premature to decide what characters should be considered sufficient to constitute a natural group, or, so to say, genus, of colouring matters.

Before describing the various spectra in the manner already explained, it would be well to give the wave-lengths of some of the principal Fraunhofer lines, so that the position of the absorption-bands may be better understood by those who have been in the habit of referring their observations to those lines:

A	760	B	686	C	656	D	589
E	527	b	517	F	486	G	430

The greatest number of bands that I have seen in any

¹ 'Proceedings of the Royal Society,' vol. xxi, p. 452.



Spectra of Bonelleine in Alcohol.

The numbers given on the upper side represent the wavelengths of those parts of the spectrum in millionths of millimetres, and the scale on which it is drawn is 1 inch to 100 millionths, which appears to me to be a very convenient and suitable size.

A glance at the figure will at once show how some of the bands are common to both the alkaline or neutral and the slightly acid solution, whilst some are diminished in intensity or disappear, and others are made much more intense or are only developed when the solution is slightly acid. It will also be seen that the addition of more acid still further modifies the spectrum in a similar manner, and that the two principal bands represent two which are comparatively very feeble in the neutral solution, whilst the two principal bands in this latter have entirely disappeared. It will also be noticed that the addition of a strong acid lowers the bands at the red end somewhat towards the red and raises that at the blue end towards the blue, whilst the central band remains in the same position as when the solution is neutral.

It will thus be seen that, though the spectra of bonelleine are of an unusually complex character, they agree in a remarkable manner with the general principles which I have briefly explained, and furnish us with an admirable illustration of the peculiar laws connecting together the wavelengths of the bands, and of the influence of solvents and of such foreign substances as weak or stronger acids. I cannot but think that the further application of this method of

study to other substances will lead to a great increase of our knowledge of the relation between optical and chemical properties, and throw much light on many interesting questions connected with molecular physics and other branches of science; and it is this conviction which has made me anxious to give a complete description of the spectra of a substance which exhibits them to very great advantage.