served. Thus the notochord of Vertebrates, perhaps originally hypoblastic, has become mesoblastic, as have also Wolffian and Mullerian ducts. The former phenomenon, the atrophy of the cephalic nerve-ganglia, is in accordance with a principle which appears to have a wide application in embryology, namely, the transference or attraction of nutrition.

On the Chromatological Relations *of* Spongilla fluviatilis. By H. C. Sorby, F.R.S., &c.

I had long been anxious to examine fresh specimens of *Spongilla*, since the old and dry specimens which I had studied clearly showed that the colouring matters had been greatly altered. At length, through the kindness of Mr. E. Ray Lankester, I was able to investigate the subject in a perfectly satisfactory manner. I had previously examined some of the marine sponges growing on the coast of Devonshire, which are often of a fine orange colour, but sometimes have a well-marked green tint. In the natural state these did not show the band in the red characteristic of chlorophyll; and, though when dried and digested in carbon bisulphide the solution contained a small quantity of chlorophyll, yet I could not be certain that it had not been derived from a small portion of some alga accidentally enclosed in the sponge. The exact nature of the green substance is therefore still open to some slight doubt. The chief coloured constituent was an orange substance soluble in carbon bisulphide, which, when so dissolved, had a pink tint in dilute solution. The spectrum had no detached narrow absorption-bands, but cut off the whole of the green and blue, and when diluted allowed the blue to pass rather more readily than the green. I was not able to distinguish any difference between it and an orange-coloured substance found in the eggs of the crab, but it would be premature to say that the two are identical. There is also an orange colouring matter found in the soft parts of some species of *Cardium*, closely allied, though not identical, with these, and on the whole it seems pretty clear that the coloured compounds found in some marine sponges are either identical with or closely related to those met with in animals, and unlike those occurring in the higher classes of plants. Fungi do, indeed, sometimes contain very closely allied substances, but I do not yet know any certainly identical. At all events, when looked upon from a chromatological point of view, such sponges are closely related to animals, or to those plants which, like them, are nourished by complex chemical compounds, and cannot be supported by merely mineral substances, like the more perfect plants.

In my paper on comparative vegetable chromatology[1] I have shown that the highest classes of plants contain the following essential constituents, soluble in carbon bisulphide:

Blue chlorophyll.
Yellow chlorophyll.
Orange xanthophyll.
Xanthophyll.
Yellow xanthophyll.
Lichnoxanthine.

The constituents soluble in water are—

Various kinds of *chrysophyll.*

Various kinds of *erythrophyll,* which are often absent, and are not essential.

Now, when I came to examine the fresh specimens of *Spongilla fluviatilis* I soon found that it contained all the above-named substances soluble in carbon bisulphide, and a small quantity of a yellow substance soluble in water, very similar to, if not identical with, one met with in many fungi, differing from the chrysophyll of the higher plants in not being made deeper coloured by alkalies or paler by acids. The other constituents appear to be absolutely identical with those in plants, and I cannot agree with Mr. Ray Lankester in looking upon the chlorophyll as a distinct substance.[2]

There being thus very little *qualitative* difference between the *Spongilla* and the highest classes of plants, it became necessary to ascertain whether there was any well-marked *quantitative* difference, which would point to a closer relation to one class than to another. The plan of analysis adopted was to separate the various coloured constituents, wherever possible, and to determine their relative amounts by measuring in long test tubes of equal diameter the lengths of the columns of liquid giving the same intensity of absorption with equal illumination, and, when the constituents could not be separated, to compare the respective absorption-bands in the same manner. I may here say that, unlike what

[1] 'Proceed. Roy. Soc.,' 1873, vol. xxi, p. 442.

[2] See his paper in the 'Journal of Anatomy and Physiology,' vol. iv, p. 119.

occurs in the case of many plants, the yellow chorophyll cannot be partially separated from the blue chlorophyll, both in the case of *Spongilla* and of many lichens. The relative quantity of the xanthophyll and yellow xanthophyll was determined by the difference in the position of the absorption-bands, and also by the greater or less amount of the blue product of the oxidization of yellow xanthophyll, formed when the solution was treated with a little hydrochloric acid and nitrite of potash. The lichnoxanthine was estimated from the final residue after the xanthrophylls had been destroyed and rendered colourless by the slow action of citric acid and nitrite of potash. By such means and others described in my paper on comparative vegetal chromatology I have been able to draw up a table, giving, with approximate accuracy, the relative amounts of the different coloured constituents; but on the present occasion it seems to me better not to give the percentages, and to express the general results by means of the following symbols:—

A relatively large quantity	✱
A relatively moderate quantity	+
A relatively small quantity	•
A relatively mere trace	·

Table of the relative amounts of the various coloured constituents insoluble in water, that of the xanthophyll being taken as nearly constant.

	Blue chlorophyll.	Yellow chlorophyll.	Orange xanthophyll.	Xanthophyll.	Yellow xanthophyll.	Lichnothanthine sol. in CS_2.	Lichnothanthine insol. in CS_2.
Highest classes of plants—							
Development perfect	✱	+	✱	+	✱	·	
Development incomplete	+	·	✱	✱	+	•	
Development still more incomplete .	·		•	✱	+	•	
Spongilla—							
The external deep green part . .	✱	•	•	✱	+	•	
The internal yellowest part . .	+	•	·	✱	+	+	
Lichens—							
Very green species	✱	•	•	✱	+	+	+
Less green species	+	·	·	✱	+	✱	✱
Algæ—							
The green group	✱	✱	+	✱	+	·	
The red group	+		·	✱		•	

Now, although this table must be looked upon as merely a first attempt, yet the results appear to be sufficiently definite to warrant some provisional general conclusions.

The *Spongilla* is distinguished from the red group of algæ, not only by the absence of the characteristic red and purple substances soluble in water, but by the presence in the *Spongilla* of yellow chlorophyll and yellow xanthophyll, which are absent in the case of red algæ. There is a closer relation between *Spongilla* and the green algæ, but they contain a relatively far larger quantity of yellow chlorophyll. The lichens differ from the sponge, not only in containing a relatively larger amount of the lichnoxanthine soluble in carbon bisulphide, but are still more distinguished by containing much of the modification insoluble in that reagent, which is absent in the case of the sponge. In other respects there is a very strong analogy, since the relative amounts of blue and yellow chlorophyll and of the three different kinds of xanthophyll are almost identical. Comparing the most perfectly developed specimens of the *Spongilla* and of the highest classes of plants, it is distinguished by containing relatively less yellow chlorophyll, less yellow xanthophyll, and very much less orange xanthophyll, and by the presence of an entirely different yellow substance soluble in water, perhaps identical with one found in many fungi. The *Spongilla* is, however, completely distinguished from fungi by the chlorophyll and xanthophyll, which are quite absent from them. Though there is thus no *qualitative* difference between the colouring matters found in *Spongilla* and in plants, yet in none of the above-named classes do they agree in their exact *quantitative* relations. Some light is, however, thrown on the subject by examining the change in their relative proportions in variously developed individual leaves or portions of the *Spongilla*. By comparing together the more or less completely developed leaves in large buds, I find that in their earliest stage of growth, before being exposed to anything more than the weak light which penetrates through the exterior leaves, the amount of blue chlorophyll is very small, and that of the yellow chlorophyll relatively smaller than normal. In comparison with the amount of xanthophyll, there is an abnormally small quantity of orange xanthophyll and yellow xanthophyll, but greater of lichnoxanthine. As development proceeds the orange xanthophyll soon attains its normal proportion, whilst the other yellow constituents have undergone very little relative change and the amount of chlorophyll is but slightly increased, that of the yellow chlorophyll being still abnormally less in relation to that of the blue chlorophyll. The result of these changes is that at one particular state of partial development the ratio between the blue and yellow chlorophyll and that between all the different yellow constituents are the same in the leaves of the highest plants as in the well-developed *Spongilla*, but even then there is not perfect agreement, since it contains a far greater amount of the chlorophyll in relation to the other constituents. Comparing together different portions of the *Spongilla* in the same manner, we arrive at similar results. The lower portions, where exposed to feeble light, are far yellower than the exterior, and contain relatively much less chlorophyll, and the proportion between the yellow and blue chlorophyll is even less than normal. There is also a relatively less amount of orange xanthophyll, but an increased quantity of lichnoxanthine and of the yellow substance soluble in water which resembles that met with in fungi. It will thus be seen that the lower and less perfectly developed portions of the *Spongilla* approximate in these chromatological characters to the lowest type of normal lichens, and present us with a lower type of colouring than any that I have yet been able to find in the most rudimentary leaves of the higher classes of plants.

Taking, then, all the above facts into consideration, it will be seen that the colouring of *Spongilla* is not exactly the same as that of any particular class of plants, but represents more or less closely a special low type, in which development has proceeded according to a somewhat different law up to a point reached at an early period of their growth by the leaves of the highest classes of plants. The analogy between these facts and those met with in structural embryology will not fail to strike every one, and I cannot but think that the further study of such questions will throw much light on many interesting problems.

Seeing also that the less developed portions of *Spongilla* lose more and more of the characters of the higher plants and approximate more to the type of fungi, one need not be so much surprised that in some species of sponge the plant-character is altogether lost, and that the type of colouring closely approximates to that of fungi and of the lower animals. It would, I think, be therefore well worthy of study to ascertain whether low animal forms which, like *Spongilla*, contain chlorophyll, have when exposed to light the power of decomposing carbonic acid and supporting themselves to some extent as plants, and at the same time have the power of supporting themselves by means of organic particles conveyed into their interior by the water circulating about or through them. If so, they would be animals to some extent capable of plant-like growth, and would thus be the reverse of those plants which have lately attracted so much attention on account of their being able to partially support themselves by means of complex animal food, which they can digest and absorb like the most perfect classes of animals.

On the CLASSIFICATION *of the* ANIMAL KINGDOM.[1] By Professor HUXLEY, Sec. R.S.

LINNÆUS defines the object of classification as follows:—"Methodus, anima scientiæ, indigitat, primo intuitu, quodcunque corpus naturale, ut hoc corpus dicat pro-prium suum nomen, et hoc nomen quæcumque de nominato corpore beneficio seculi innotuere, ut sic in summa confusione rerum apparenti, summus conspiciatur Naturæ ordo." (*Systema Naturæ*, ed. 12, p. 13.)

With the same general conception of classificatory method as Linnæus, Cuvier saw the importance of an exhaustive analysis of the adult structure of animals, and his classification is an attempt to enunciate the facts of structure thus determined, in a series of propositions, of which the most general constitute the definitions of the largest, and the most special, the definitions of the smallest, groups.

Von Baer showed that our knowledge of animal structure is imperfect unless we know the developmental stages through which that structure has passed; and since the publication of his 'Entwickelungs-Geschichte der Thiere,' no philosophical naturalist has neglected embryological facts in forming a classification.

Darwin, by laying a novel and solid foundation for the theory of Evolution, introduced a new element into Taxonomy. If a species, like an individual, is the product of a process of development, its mode of evolution must be taken into account in determining its likeness or unlikeness to other species; and thus "phylogeny" becomes not less important than embryogeny to the taxonomist. But while the logical value of phylogeny must be fully admitted, it is to be recollected that, in the present state of science,

[1] Read at the Linnean Society, Dec. 4, 1874. Reprinted from 'Nature' with the permission of the author.