$$\Pi' = \int_0^{\frac{\pi}{2}} \frac{d\theta}{(1+n'\sin^2\theta)\sqrt{1-k'^2\sin^2\theta}}, \quad n'(1+n) = -k'^2.$$

This is not exactly the form considered by Jacobi, but if we write $\frac{\Pi}{K} - 1 = \frac{\mathrm{tn}u_0}{\mathrm{dn}u_0} Z(u_0)$ and $n = -k^2 sn^2 u_0$ his result is equivalent to

$$\zeta(u) = \frac{1}{2u_0} \log \frac{\Theta(u+u_0)}{\Theta(u-u_0)}$$

Connected with $\zeta(u)$ is a *second* function of the form

$$\zeta_1(u) = \frac{\pi}{2(1-\mu)\Pi K'}\left(p - \frac{P'}{K'}u\right).$$

This satisfies the relations

$$\left.\begin{aligned} \zeta_1(u+2iK') &= \zeta_1(u) \\ \zeta_1(u+2K) - \zeta_1(u) &= \frac{\pi}{K'} \end{aligned}\right\},$$

and I find that it can be expressed in terms of $\Phi(u)$ by means of the equation $\zeta_1(u) = \frac{1}{2u_0} \log \frac{\Phi(u+u_0)}{\Phi(u-u_0)}$, where u_0 is the same constant as above.

It thus appears that $\Theta(u)$ and $\Phi(u)$ are connected with and supplement each other in a very remarkable manner.

For example, if we write $\zeta(u)$ and $\zeta_1(u)$ in the more convenient forms $\zeta(u, u_0)$, $\zeta_1(u, u_0)$, it follows that besides Jacobi's result, $u_0\zeta(u, u_0) = u\zeta(u_0, u)$, we have likewise the equivalent form $u_0\zeta_1(u, u_0) = u\zeta_1(u_0, u)$.

II. "Further Observations on Enterochlorophyll and Allied Pigments." By C. A. MacMunn, M.A., M.D. Communicated by Professor M. Foster, Sec. R.S. Received April 21, 1885.

(Abstract.)

In a paper read before the Royal Society in 1883, I described the results of an examination of the so-called "bile" of invertebrates, and showed that the alcohol extracts of their liver or other appendage of the intestine answering to that organ, showed a spectrum so like that of vegetable chlorophyll, as to have led me to assume that no essential difference exists between the spectrum of enterochlorophyll and plant chlorophyll.

At that time I could not decide the points which are now considered: (1) Is enterochlorophyll due to the presence of symbiotic algæ? (2) If not, is it an *immediate* food product, and merely an instance of the intra-cellular digestion of food chlorophyll? (3) If it is not due to either of these sources, can it be proved that it is built up by the animal containing it? (4) In what points does it differ from plant chlorophyll and that of *Spongilla?*

I believe I can prove that the first two questions can be answered in the negative, and that it is an animal product, and does differ to a slight extent from vegetable chlorophyll, and also from that of Spongilla.

This evidence is based on the result of spectroscopic examination, especially of the bands in the blue half of the spectrum, on the results obtained by saponifying the colouring matters, and on the morphological characters of the enterochlorophyll in the organs containing it.

With regard to chlorophyll itself, I mean the mixture of colouring matters obtainable on extracting green leaves of land plants with alcohol, or with alcohol and ether, I believe that of the six bands of such a solution, five correspond to those seen in a living leaf, and that Kraus is correct in saying that such bands can be seen in a leaf.

The first four bands appear to belong to the green constituent of the chlorophyll, the other two to the yellow. On comparing solutions of enterochlorophyll with those of plant chlorophyll, it is seen that the bands corresponding to V and VI* of the latter are replaced by one, or by two, occupying a somewhat different position. The enterochlorophyll of the following species is described: *Paludina vivipara*, *Limnæus stagnalis*, *Trochus ziziphinus*, *Trochus cinerarius*, *Littorina littorea*, *Patella vulgata*, *Helix pomatia*, *Solaster papposa*, and several specimens of *Uraster rubens*, &c. In all these, enterochlorophyll is present, and presents very uniform spectroscopic characters, and the same as those described in the case of the Molluscs, Echinoderms, and Arthropods referred to in my former paper. The bands of the spectra of their solutions have been measured in wave-lengths, and show a remarkable agreement. In some cases two bands placed closely together in red replace the single dominant band of chlorophyll, and in every instance the solutions possess a red fluorescence.

In consequence of Hansen having published the result of saponifying vegetable chlorophyll, and of his having succeeded in obtaining certain crystals, which he maintains are those of isolated "chlorophyll green" and "chlorophyll yellow," I was anxious to try the effect of saponifying enterochlorophyll. It was necessary, however, to repeat his experiments on plant chlorophyll before saponifying entero-

* Adopting Kraus's numbers.

chlorophyll. On doing this, I found that his statement to the effect that chlorophyll is not decomposed by such treatment, is not supported by the results obtained. The bands of solutions after saponifying occur in an entirely different position from those of bands of similar solutions before saponifying, but I found the method useful in enabling me to compare the results when enterochlorophyll and Spongilla chlorophyll are saponified with those obtained in the case of plant chlorophyll.

I could separate, in the case of plant chlorophyll, the constituents called by Hansen "chlorophyll green" and "chlorophyll yellow," by adopting his methods, and found that the soap on repeated extraction with petroleum ether, lost all the yellow colouring matter, and that the latter could be obtained in some cases in yellow needles,* the residue giving the colour reactions of Schwalbe and Capranica. The alcohol and ether extracts on the other hand contained Hansen's "chlorophyll green," and none of the yellow constituent, and answered, except for the position of its bands, to Hansen's description.

On applying the same method to the chlorophyll of *Spongilla*, a complete separation of the constituents could not be brought about, as it was only partial, and an examination of the solutions showed a total alteration of spectra.

In the case of enterochlorophyll, saponification also alters the pigment. In some cases I succeeded in separating the yellow from the green constituent; and from the enterochlorophyll of *Uraster rubens*, I obtained *crystals* of "chlorophyll green" and "chlorophyll yellow," the former crystallising in sphere crystals, showing a black cross with polarised light, the latter in yellow radiating needles. But in almost every case it was found impossible to separate the constituents, as the petroleum ether showed a band in red, and the alcohol and ether bands in the blue end of the spectrum.

The solid chlorophyll yellow, while agreeing with that of plants in its behaviour towards nitric and sulphuric acids, did not, however, show the same blue-green colour with iodine in iodide of potassium, as it generally became reddish or remained unchanged.

I agree with Hansen that the chlorophyll yellow of plants is a "lipochrome," and also that of enterochlorophyll; the lipochromes being a class of colouring matters—so-called by Krukenberg—which were formerly known by the name of "luteins." Under this name are also included allied pigments, such as carotin, zoonerythrin, Kühne's chromophans—obtained by him from the retina, egg-lutein, and other pigments, which all possess bands in the blue and violet, and are soluble in such solvents as alcohol, ether, chloroform, bisulphide of carbon, benzol, petroleum ether, &c. They all are coloured

* It is not yet clearly proved whether these yellow needles may not belong to a fatty acid whose crystals are stained by the yellow colouring matter.

blue-green to blue by nitric and sulphuric acids, and generally blue-green with iodine in iodide of potassium (in the solid state).

On isolation of the yellow constituent of enterochlorophyll by saponification and extraction with petroleum ether, I found that it generally showed only one band, or sometimes two, but these bands generally gave different measurements from those of plant chlorophyll.

To see whether symbiotic algæ were present in the organs yielding enterochlorophyll, I examined fresh frozen sections, or portions of the organ teased out in salt solution, but the results were negative. On steeping such preparations, first in alcohol, then in weak solution of caustic soda, and neutralising with acetic acid, and afterwards testing with a solution of iodine in iodide of potassium and with Schultze's fluid, I never obtained evidence of the presence of starch or cellulose. Hence, apart from the absence of symbiotic algæ under the microscope, this result negatives their presence and also that of food chlorophyll. The morphology of enterochlorophyll was studied in similar preparations, and on the whole it appears to be present dissolved in oil globules and in granules, both of them enclosed in the epithelium lining the liver tubes. It also occurs dissolved in the protoplasm of the liver cells, and these appearances vary slightly in different cases.

It would therefore appear that enterochlorophyll is built up in the organ containing it; that it is a chlorophyll, of which there are several in animals, and that it is composed of two constituents, of which one resembles closely the corresponding constituent of plant chlorophyll, while the other is generally slightly different, but that no *essential* difference exists between the respective pigments is proved by the fact that the constituents of both may be obtained crystallised in the same form.

In enterochlorophyll there is probably a more intimate union between the constituents than in plant chlorophyll.

All readings are reduced to wave-lengths, and the most important spectra mapped in the accompanying charts. The appearance of enterochlorophyll under the microscope in different cases is also shown in the accompanying drawing, as well as the crystals referred to above.

III. "Note on a Previous Paper." By G. H. Darwin, F.R.S., Fellow of Trinity College and Plumian Professor in the University of Cambridge. Received March 19, 1885.

The paper entitled "On the Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains" ("Phil. Trans.,"