(2) That by the use of appropriate means these intracellular bodies can be isolated and cultivated outside the body.

(3) That these cultures, when introduced into certain animals, can cause death, with the production of tumours, so far of endothelial origin; and that pure cultures can be made from these growths which, when inoculated into suitable animals, will produce similar tumours.

"On the Gastric Gland of Mollusca and Decapod Crustacea: its Structure and Functions." By C. A. MacMunn, M.A., M.D. Communicated by Dr. M. Foster, Sec. R.S. Received February 23,—Read March 9, 1899.

(Abstract.)

In 1883 I communicated a paper* to the Royal Society, in which I described the occurrence of a pigment closely resembling vegetable chlorophyll in the so-called liver of Invertebrates, and in 1885 a further contribution in continuation of the same subject, which was published in the 'Philosophical Transactions' (Part I, 1886).

I named this colouring matter "enterochlorophyll," because after comparing it with all the animal pigments and plant pigments known to me, it seemed to resemble, both in its chemical and spectroscopic characters, the chlorophyll of plants.

In the latter paper, I endeavoured to describe the microscopic characters of this pigment, as it was found in the digestive gland, and I applied all the tests then considered to be distinctive of chlorophyll to the solutions of the pigment. I found that whereas enterochlorophyll appeared to be a chlorophyll, or a modified chlorophyll, it yet differed in some respects from chlorophyll, as it is obtained *directly* from fresh green leaves. Some recent writers have called in question the right to call this pigment by the above name, so I have reinvestigated the whole subject.

It was, however, necessary first of all to study the histology of the digestive gland, or gastric gland, as it is now named, and the microscopic characters of the pigment found in it. This has been done by Max Weber and Frenzel for the gland of crustacea, and by Barfurth and by Frenzel for the gland of mollusca.†

As can be gleaned from these observers, great difficulties attend the preparation of this gland for microscopic observation. I found after numerous failures that formol is the best fixative, used in stronger solution than it usually is employed in vertebrate histology. Thus it is necessary to employ solutions containing from 20 to 30 per cent. of

* 'Roy. Soc. Proc.,' vol. 35 (1883), p. 370.

† References are given in the complete paper.

formol. After from 12 to 24 hours the preparation is transferred to alcohol of 95 per cent., and, when hard enough, to a mixture of alcohol and ether, and finally into a solution of celloidin. When this is set, the preparation is cut either in the ordinary way, or by the freezing microtome. Clearing is done by means of oil of sandalwood, or oil of origanum. The sections were stained in various ways, but the best results are obtained with hæmalum, followed by eosin as a plasma stain. I also used mucicarmine, thionin, "Soudan III," and other stains for special purposes. In this way very satisfactory preparations can be obtained, and the celloidin keeps all the gland constituents *in situ*.

The glandular epithelium in the crustacea contains, according to Max Weber, two kinds of cells, hepatic cells and ferment cells. Frenzel subsequently called them fat-cells, or fat-holding cells, and ferment-cells. That of mollusca contains, according to Barfurth, hepatic cells, and ferment cells also, which Frenzel again re-named granular cells and club-cells. Now the sharp distinction drawn between these kinds of cells by these observers is found not really to exist, and we meet with transition-forms between them. The coloured contents of these cells, in the case of either ferment-cells or granular-cells, or fat-cells, are coloured by either enterochlorophyll or by a lipochrome, or by both.

It was, however, mainly my object, after having studied the histology of the gastric gland, to find out if I was really justified in calling this colouring matter enterochlorophyll, and if it has properties which class it among the chlorophylls, to find out how it gets into the gland, and so on.

It is impossible here to refer more fully to the histology of the gland, so that I shall merely give an account of the observations on the pigments found in it.

The only way in which any pigment giving a banded absorption-spectrum can be readily identified is, of course, by means of the spectroscope, but since spectrum analysis alone is attended by certain fallacies, one has to fall back on spectrophotometry. This being a quantitative method gives the most accurate results of all. Of course elementary analysis, if applicable, enables one at once to decide the identity or non-identity of pigments, but unfortunately the pigments with which we are now dealing cannot be prepared in a pure, or even in an approximately pure, condition for this purpose with our present knowledge, owing to their being mixed with fatty matters and other impurities.

The spectrophotometer which I have used is a modified form of that which Vierordt introduced. Some of the modifications were, I believe, introduced by the brothers Krüss;* others were suggested by me to Mr. Hilger, who constructed the apparatus.

* G. and H. Krüss, 'Kolorimetrie und Quantitative Spektralanalyse,' 1891.

When a solution of plant-chlorophyll in alcohol solution is compared with a similar solution of enterochlorophyll by means of curves obtained with the spectrophotometer, these curves do not correspond; but when we convert the plant-chlorophyll into the "modified" form, or, what is the same thing, the slightly acid form, by means of acetic acid, and allowing the solution to stand for a few hours, and then compare the respective solutions, we find the maxima and minima of the curves follow each other so closely as to lead one to conclude that the pigments are closely related to each other.

Again, if hydrochloric acid is added to a solution of plant chlorophyll in alcohol, and to a solution of enterochlorophyll in alcohol, and these two solutions are examined by means of the spectrophotometer, a remarkable agreement is noticed.

The numbers taken for these measurements are the percentages of the unabsorbed light, as the latter enable curves to be more easily constructed than by taking the co-efficients of extinction.

I have also examined Lankester's "chætopterin,"* and I find the curve obtained by the spectrophotometer follows closely that of enterochlorophyll and that of modified chlorophyll. But chætopterin is soluble in glycerin, while enterochlorophyll is not.

While examining *Chætopterus* at the Plymouth Laboratory, I found that an alcohol solution of the contents of the intestine, in the neighbourhood of that part of the gut coloured by chætopterin, gave exactly the same spectrum as a similar solution of chætopterin itself. The discussion of the inferences to be drawn from this observation may, however, be left for the present.

I have seen enterochlorophyll present in a finely granular form in the intestinal epithelium of *Patella*, and in the pseudo-villi of the glandular stomach of the same mollusc one can see crowds of leucocytes, some of which are insinuating themselves between the columnar epithelial cells. The inference, of course, is that the leucocytes carry away those substances which have been taken up by the epithelial cells in a more or less digested condition. Some have supposed that these granules are being *excreted* into the lumen of the gut, but in my opinion, based upon a study of numerous sections of invertebrate gastric glands, the excretion of enterochlorophyll by means of the gland cells—belonging to the various kinds mentioned—*takes place into the lumen of the alveoli, acini, or tubes of the gastric gland, and from these we can trace the excreted gland-cells into the intestine.*

From all these and other observations I have been forced, I must confess against my inclination, to believe that enterochlorophyll is a pigment which primarily has been taken up from the intestine *dissolved in a fatty medium*, and is carried either by leucocytes, or in some other way to be deposited with this fat, and perhaps other reserve

* 'Quart. Journ. Micros. Sci.,' vol. 40, p. 447, &c.

products, in the gastric gland. Whether it is utilised for the production of other pigments or not is a question for future investigation. That it is a chlorophyll derivative I now believe to be proved. Its stability, as compared with plant chlorophyll, is due to the fact that it has been altered by the action of the digestive juices. Such derivatives of complex mother-substances are, as is well known, much more stable, and less prone to change than the parent pigments.

"On the Structure and Affinities of *Matonia pectinata*, R. Br., with an Account of the Geological History of the Matonineæ."

By A. C. SEWARD, F.R.S., University Lecturer in Botany, Cambridge. Received February 28,—Read March 9, 1899.

(Abstract.)

The genus *Matonia* has long been known as an isolated type among existing ferns. It is represented by two species, *M. pectinata* R. Brown and *M. sarmentosa* Baker, both confined to the Malayan region. Matonia has not hitherto been examined anatomically, and its reference by several writers to an intermediate position between the Cyatheaceæ and Gleicheniaceæ, is based on the structure of the sorus, which, in the small numbers of sporangia and in its circular form, resembles the latter family, while the presence of an indusium and the position of the annulus afford connecting links with Cyatheaceous ferns.

In *Matonia pectinata* the frond has a characteristic pedate habit, with numerous long pinnæ having slightly falcate linear segments, practically all of which appear to be fertile. The sori are circular in form and indusiate, consisting of about eight large sporangia with an oblique incomplete annulus, containing sixty-four tetrahedral spores. The dichotomously branched rhizome, which grows on the surface of the ground, is thickly covered with a felt of multicellular hairs, and gives rise to long-stalked fronds from its upper face, and a few wiry roots, which may arise from any part of the surface of the stem.

The full paper deals more especially with the anatomical structure of *Matonia pectinata*. The material which rendered the investigation possible was generously supplied by Mr. Shelford, of the Sarawak Museum, Borneo, to whom the author wishes to express his hearty thanks.

The stem is polystelic, and of the gamostelic type; there may be two annular steles, with the centre of the stem occupied by ground-tissue, or in shorter branches of the rhizome a third vascular strand may occupy the axial region. Each stele consists of xylem tracheids and associated parenchyma, surrounded by phloem composed of large sieve-tubes, with numerous sieve-plates on the lateral walls, and phloem