On a Species of *Chlamydomonas* (*C. sphagnicola*,
F. E. Fritsch and Takeda—*Isococcus sphagnicolus*,
F. E. Fritsch).

BY

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With fourteen Figures in the Text.

IN the first of the 'Notes on British Flagellates',¹ published by one of us, a new genus of green Flagellates was described under the name of *Isococcus*. A further examination of more abundant material, collected in May of last year and since kept in the laboratory, has shown that there were certain errors in the original description of this organism. Moreover, the facts that have come to light and are detailed below indicate that the organism in question does not constitute a distinct genus, but is a somewhat peculiar species of *Chlamydomonas*, which must pass under the name of *C. sphagnicola*. Whilst the material upon which the new observations were made was collected from the same marsh at Keston (Kent) from which the organism was first obtained, it may be mentioned that this species of *Chlamydomonas* has since been discovered also in one of the ponds in Richmond Park (Surrey).

The motile individual of *C. sphagnicola* is rather variable in shape. As a rule it is broadly ellipsoid (Figs. 1-3); not rarely, however, it is ellipsoid or oblong-ellipsoid, with more or less pointed or rounded poles (cf. Figs. 5, 8, 9, 10, 12), whilst in a few cases the individuals are subglobose or even globose (Fig. 6). When viewed from the anterior or posterior end the organism is circular (cf. Fritsch, loc. cit., Fig. 1, D and G), but if front and side views of the same individual are compared (Figs. 7-9, 13) they are seen to show slight differences in shape. The length (excluding the papillae) varies between 15μ and 27μ , the breadth between 9μ and 22μ (up to 25μ broad according to the old description, loc. cit., p. 341). The cell-wall is remarkably thick, and consists of an outer firmer portion and a usually well-developed inner gelatinous portion (sometimes as much as 4μ thick) which, in the previous description (loc. cit., p. 341), was regarded

¹ New Phytologist, vol. xiii, 1914, pp. 341-6.

as a space. The outer firmer part of the wall is very conspicuous, and reaches a thickness of about $1\ \mu$. By using suitable stains such as acid fuchsin, safranin, erythrosine, or aniline blue, the inner gelatinous part is readily brought to view. In some cases it is more strongly developed at the posterior end of the cell (Figs. 4, 5, 8–10), a state found also in other species of *Chlamydomonas* and *Carteria*. Specimens have also occasionally been found in which the gelatinous layer is thickest at the anterior end (Fig. 7). In some cases this gelatinous part of the wall contains granules of an unknown substance¹ (cf. Fritsch, loc. cit., p. 344, and Fig. 1, F).

The protoplast in living individuals is in direct contact with the inner gelatinous part of the cell-wall. In plasmolysed specimens a narrow clear zone is sometimes distinctly visible between the gelatinous layer and the protoplast.

At the anterior end of the cell there are ordinarily two papillae (Figs. 1–7) which were wrongly interpreted as ciliary apertures in the previous account (loc. cit., p. 341). These papillae are, however, *solid* projections of the membrane, and the flagella do not pass through them, but emerge from the base on the abaxial side of each (cf. Figs. 7, 8, 10, 12). Whilst a considerable percentage of individuals exhibit two perfectly distinct papillae, all stages have been found connecting such forms with individuals in which there is but a single papilla (Fig. 11); the individuals shown in Figs. 8, 9, 10, and 12 illustrate intermediate conditions in which there is a single, more or less two-lobed, papilla. In shape the papillae are generally conical, with a rounded-truncate apex, although in some cases the conical character is less pronounced than in others. The papillae reach a height of $1\text{--}1.5\ \mu$. As far as we are aware this is the only known species of *Chlamydomonas* in which the papilla exhibits this character. We have not observed any further instances of the projection of the papillae on the inner side of the membrane as recorded in the earlier account (p. 342).

The surface of the protoplast is always more or less irregular, appearing unevenly crenate in optical section (Figs. 1, 4, 5) and often showing short faint lines when viewed from the surface. These features lead to a false impression of striation of the protoplast, but the phenomenon is most probably due to granulation of the surface. Occasionally the lines show a certain regularity, analogous to that depicted in the figures in the previous account, but the individuals examined by us never exhibited true spiral striation, and it is likely that the earlier description was in error in this respect.

At the anterior end the protoplast shows a well-marked colourless beak (loc. cit., p. 341), to the apex of which the two flagella are attached

¹ A similar feature has been observed in *Carteria Fritschii*, Tak., in which the inner gelatinous part of the cell-wall is often very well developed. For a description of this species see p. 369.

(Figs. 5, 7, 8, 10, 12). Below this beak lies a V-shaped colourless area, indicating the apex of the colourless protoplasmic mass enclosed within the central hollow of the massive chloroplast. The flagella are relatively coarse, and readily seen both in the living organism and in individuals fixed in

Chlamydomonas sphagnicola. $\times 1,000$. Figs. 1-12. Vegetative cells (= zoogonidia). Fig. 13. Very early stage in the formation of daughter-cells. Fig. 14. Four mature daughter-cells within mother-cell-wall. In Figs. 7-9 and 13 both front and side views are shown. Also in Fig. 14 two of the daughter-cells are viewed from front, while the other two are seen from side. Figs. 1-11 and 13-14 were drawn from fresh material collected at Keston in May, 1915, while Fig. 12 represents one of the individuals in the original preparations of *Isococcus sphagnicolus* collected in the same locality in May, 1914.

osmic acid. They are always longer than the cell, and sometimes reach a length of about one and a quarter times that of the body.

Two contractile vacuoles, which pulsate alternately, have been observed at the anterior end of the cell, just below the protoplasmic beak. There is a conspicuous stigma, lenticular in shape and somewhat anterior in position

(Fig. 7; cf. also loc. cit., Fig. 1, C). The chloroplast is a massive structure of a dark green colour which, as already mentioned, occupies the greater part of the cell. Four or more pyrenoids, more or less globular in shape and quite irregularly arranged, lie in a parietal position. The pyrenocrystal and amylaceous envelope can easily be differentiated by means of the usual stains. The small nucleus is situated in the centre of the cell.

To the earlier description of the formation of daughter-cells (p. 344) we are able to add but little. Prior to division, the pyrenoids seem to increase in number (cf. Fig. 13). At the same time the gelatinous part of the cell-wall appears to acquire a very thin consistency. The first division is longitudinal, and takes place in a plane which is at right angles to that containing the two papillae, the constriction of the protoplast starting at the anterior end (Fig. 13). The second division, when it takes place, appears likewise to be longitudinal, but runs at right angles to the first division-plane. By the time that the daughter-cells have acquired their mature characteristics, their arrangement becomes irregular (Fig. 14), which appears to be due to active movements on the part of the new individuals (cf. also Fritsch, loc. cit., p. 344). We did not observe any further instance of division into eight (cf. Fritsch, loc. cit., p. 344). Prior to liberation of the new individuals the mother-cell-wall swells up very considerably and acquires a very thin consistency.

As regards the affinity of *C. sphagnicola*, it may be compared with *C. longistigma*, Dill, *C. gloeocystiformis*, Dill, *C. angulosa*, Dill, and *C. gigantea*, Dill.¹ The first of these species (Dill, loc. cit., pp. 328, 354, Tab. V, Figs. 1–8) has a broad and flat papilla, somewhat recalling that found in the specimens of *C. sphagnicola*, in which but a single papilla is present (cf. above). It differs from our species in having a thin membrane, without any gelatinous layer, a smooth surface to the protoplast, and a long rod-like stigma.

C. gloeocystiformis, Dill (loc. cit., pp. 340, 354, Tab. V, Figs. 37, 38), has a thick gelatinous membrane, in which an outer firmer portion and an inner gelatinous part could perhaps be distinguished, although Dill does not discriminate between the two, either in his description or in his figures. The species differs from *C. sphagnicola* in having but a single papilla and a solitary pyrenoid which is not parietal.

C. angulosa, Dill (loc. cit., pp. 337, 354, Tab. V, Figs. 21–25), has a distinct papilla which is broadly conical in shape. The cell-wall is usually thin, and the gelatinous layer is only seldom developed to a slight extent at the posterior end. Moreover, this species possesses one, or rarely two, pyrenoids, which are axial, and a smooth protoplast.

C. gigantea, Dill (loc. cit., pp. 338, 353, Tab. V, Figs. 25A–30), resembles *C. sphagnicola* in having a considerable number of pyrenoids, which here,

¹ Cf. Dill: Die Gatt. *Chlamydomonas*, &c. Pringsh. Jahrb., vol. xxviii, 1895.

however, are not parietal but lie near the inner face of the chloroplast. Moreover, this species has a very thin cell-wall, without any gelatinous layer, and a poorly developed papilla. The stigma is situated near the centre of the cell, and is often very long.

The most striking feature presented by *C. sphagnicola* is certainly the customary doubling of the papilla at the anterior end of the cell. A somewhat similar condition has been recorded and figured by Wollenweber¹ in the case of certain species of *Haematococcus* (= *Sphaerella*), in which the flagella occupy the same position with reference to the two papillae as in our species. It can hardly be doubted that the paired papillae are the result of fission of the single structure normally present in other species of *Chlamydomonas*, &c., and occasionally even developed as such in *C. sphagnicola*.

In conclusion, we append a Latin diagnosis:

Chlamydomonas sphagnicola (Fritsch), Fritsch and Takeda, comb. nov. (Figs. 1-14).

Syn.: *Isococcus sphagnicolus*, F. E. Fritsch, in New Phyt., xiii, 1914, p. 351, Fig. 1.

Cellulae vegetativae (= zoogonidia) pro genere magnae, late ellipsoideae, non raro ellipsoideae vel oblongo-ellipsoideae, polis aut rotundatis aut subacutis, interdum subglobosae vel globosae. Membrana cellularum crassissima, pars exterior firma ad $1\ \mu$ crassa, pars interior gelatinosa plerumque bene evoluta, ad $4\ \mu$ crassa, polo anteriore papillis duabus vel tantum papilla singula plus minus biloba vel rarissime integra praedita. Flagella ca. ad $1\frac{1}{4}$ plo longiora quam corpore cellulae, rostro protoplasmaticae affixa. Chromatophora singula, urceolata, viridis, densissima, granulata; pyrenoidibus parietalibus, 4 vel pluribus, plus minus globosis, conspicuis; stigmatibus conspicuis, lenticularibus, fere anterioribus; vacuolis contractilibus duabus; nucleo centrali. Propagatio subdivisione cellulae matricis longitudinaliter in 2, vel 4, rarissime 8 partes fit.

Hab.: In Sphagnis, Keston, Kent (F. E. Fritsch, May, 1914-May, 1915); in stagno, Richmond Park, Surrey (H. Takeda, December, 1915, January, 1916).

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¹ Ber. Deutsch. Bot. Ges., xxvi, 1908, p. 245, Fig. 3 a and b, Fig. 7, and Tab. XIII, Figs. 1, 5-8.

Fritsch, Felix Eugene and Takeda, H. 1916. "On a species of Chlamydomonas (C. sphagnicola, F. E. Fritsch and Takeda— Isococcus sphagnicolus, F. E. Fritsch)." *Annals of botany* 30, 373–377.

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