very much puzzled to explain the object of these cells. At first sight they would appear to be due to the attacks of some parasite (possibly *Chytridium*), but after a considerable amount of observation, I do not think this very probable. As far as I have been able to make out, they have also no connexion with any process of reproduction. In fact I might not have mentioned them at all here, if I had not come across exactly the same cells whilst examining some young plants of *Stigeoclonium* (Fig. 22, 3, R). They in every way resembled the cells I had found in the *Aphanochaete*, but were not present in such quantities. The fact that they occur in two different genera is interesting.

I have as yet been able to find little mention of them in the literature of the Chaetophoraceae. Somewhat similar cells have been observed in connexion with the liberation of zoospores in other genera of Chaetophoraceae. Thus, Wille[1] mentions that outside the mother-cell, from which the zoospores are derived in *Trentepohlia umbrina*, Born., a vesicle is to be found, which is considerably larger than the zoospores themselves. He goes on to say: 'Diese Blase enthielt beinahe stets einige runde Körner von der Beschaffenheit des Zellinhalts, welche Körner Molecularbewegung zeigten. . . . Nachdem sie eine Weile gelegen hatte, löste sie sich in dem umgebenden Wasser auf.' Hildebrandt[2] describes a similar structure in the case of the zoospores of a species of *Chroolepus*; here, however, a small mucilaginous sphere is emitted from the sporangium, and round this a number of red granules are aggregated. At present I can say no more on this subject, but hope to return to it at a future date.

II. THE GERMINATION OF THE ZOOSPORES IN OEDOGONIUM.—Several authors (Wille[3], Cleve[4], and Poulsen[5]) have already described the germination of the zoospores in *Oedogonium*. Unluckily in all these cases the species which was used was not

[1] Ueber die Schwärmzellen u. deren Copulation bei *Trentepohlia*, Mart., Pringsheim's Jahrb., vol. xviii, 1887, pp. 427, 428. Pl. XVI, Fig. 1, *v*.

[2] Ueber eine *Chroolepus* mit Zoosporenbildung. Botanische Zeitung, 1861, pp. 82, 83; Pl. III, Fig. 9.

[3] Algologische Mittheilungen.—V. Ueber das Keimen der Schwärmsporen bei *Oedogonium*. Pringsheim's Jahrb. f. wissenschaftl. Bot., vol. xviii, 1887, p. 454.

[4] Iakttagelser öfver den hvilande *Oedogonium*-sporens utveckling. Öfvers. af K. Vet.-Akad. Förh., 1863, p. 247.

[5] Om sværmsporens spiring hos en art af slægten *Oedogonium*. Botanisk Tidsskrift, 3rd ser., vol. ii, 1877–79, p. 1.

certainly determined. There seems reason to believe that various characters in *Oedogonium*, which have received different interpretations by different authors, are really distinct, according to the species examined. This certainly appears to be the case with regard to the first division of the young plant.

I have examined the germination of the zoospores in *Oed. capillare*, Kütz., a species in which the end cell of the filaments bears a distinct tip[1]. During its active movement the zoospore has a nearly spherical form, but on the cessation of activity it acquires an oblong elongated shape (Fig. 23, *a*). Immediately after coming to rest, a strip of thick, whitish membrane begins to make its appearance at the end opposite to that which bore the cilia. This becomes gradually more and more distinct, whilst at the same time a delicate membrane is formed round the rest of the zoospore (Fig. 23, *a*). Soon after the thick portion of the membrane (which marks the anterior end of the new individual), undergoes, as it appears, mucilaginous degeneration, for shortly a clear space containing mucilage is to be found at this point, bounded towards the exterior by the thin membrane, which surrounds the whole zoospore. Thereupon this colourless portion grows out to form a short *hollow* tip[2] (Fig. 23, *b*). When this has reached a slight development, we see a similar strip of thickened membrane formed at the opposite, posterior end of the embryo (Fig. 23, *b*). Just as at the anterior end this is disorganized, leaving a well-marked clear space behind (Fig. 23, *c*), which grows out to form the root of the new individual (Fig. 23, *d*). In the case described, the root after growing for some time divided at the apex into two rootlets, which continued to grow separately and apically. I was unable to figure the whole course of the development in a single individual, so that the stages in Fig. 23, *a–d*, are from different plants.

It is noteworthy that the tip practically always commences its development before the root. It is not uncommon to find a young plant with an almost fully-developed tip, whereas the root is scarcely developed. The time in which the tip develops seems to vary very much, from 2–24 hours; probably from 3–4 hours is the normal

[1] A number of species of *Oedogonium* are provided with a tip like that of *Oed. capillare*; thus Wolle (Freshwater Algae of the United States, 1887) figures the young plants of *Oed. autumnale* (Pl. 81, Figs. 4 and 5), which bear a very distinct tip: cf. also *Oed. crispum*, var. *rostellatum* (Pl. 74, Figs. 12 and 13).

[2] Later on this tip becomes solid (cf. Fig. 23, *f*.)

time. I occasionally observed zoospores which still exhibited a jerking movement, whose one end had already commenced to form the tip.

Cohn[1] gives figures of the development of a zoospore of *Oed. capillare*, but gives no description thereof. The figures are excellent, but do not illustrate the details of the development.

Developing zoospores of *Oed. capillare* are also figured by Kützing[2]. In Fig. 4 the germinating zoospore is shown, and this shows a well-developed root before the tip is scarcely developed. My observations in general do not agree with this, although occasionally the development of the tip commenced after that of the root. It is noteworthy that all the young plants figured by Kützing have long rhizoids, although some of them consist of as many as five cells. The fact that no disc is figured makes me rather doubtful whether he had the same species as I had[3].

Cleve[4] only observed the germination of the zoospores derived from the sexual generation. Although much smaller, their appearance is very much like that of the common zoospores. The young plants possess a tip, and figures illustrating its development to some extent are added, but no details are given in the text.

In my cultures the young plants rarely divided to form a several-celled filament, but after some two or three days again liberated their contents as a zoospore; the upper part of the cell-wall together with the tip being pushed on one side like a hinged lid (Fig. 23, *e*). This is differentiated in the same way as in the cells of the adult plant, the contents rounding themselves off at the corners, and a distinct colourless area being developed on one side. Indications of the formation of the lid are to be found some little time before the liberation of the zoospore. A little way below the tip the membrane shows a very slight thickening on its inner side, extending right round the circumference of the wall of the young plant, and appearing as a faint line in surface-view, and as two little knobs on the inside of the wall in optical section. This is the line along which the lid is split off.

[1] Untersuchungen über die Entwickelung der mikroskop. Algen u. Pilze. Leop.-Akad., 1854, vol. xxiv, pars I, p. 231.

[2] Phycologia generalis, 1843, p. 254, Tab. 12^{II}, Fig. 4–10.

[3] The young plants of *Oed. capillare* usually possess a well-marked basal disc; an elongated rhizoid is rare in this species.

[4] Öfvers. af K. Vet.-Akad. Förh., 1863, pp. 248, 249.

If the cultures containing such germinated zoospores were retained for some days, the successive generations of zoospores, derived from the first individual, showed a gradually decreasing scale of development. Thus the zoospores liberated from the fully-developed unicellular plants, described above, on coming to rest and germinating did not form nearly so long a root, nor was the tip fully developed before the contents of the young individual were again liberated as a zoospore. The plant, resulting on the latter's germination, was still less developed, until in the final stage the zoospore on coming to rest merely surrounded itself with a membrane, and after some hours, without further germination, the contents were again set free. Such are the last struggles for the maintenance of the species against the accumulating masses of bacteria!

Under normal conditions the zoospores of *Oed. capillare* on coming to rest formed a well-developed basal disc, and after a short time proceeded to divide and form a two-celled plant (Fig. 23, *f*). Poulsen[1] has carefully described this first division in the case of an (unluckily) unknown species. He found that this first division took place in a manner rather different from that found in the adult plant. He says (loc. cit., p. 5): 'When the club-shaped cell prepares to divide, the first preparation for the stretching (of the cell) is made by part of the cell-membrane's inner layer, which lies in the uppermost arched part (and thus has the form of a spherical cap), thickening itself, so that this layer, consisting of pure cellulose, is at least double as thick as usual at the point mentioned. However, it is thickened far more strongly at its lower end than higher up in the arch.' In the fully developed condition this is not unlike the normal cellulose-ring in appearance, 'but there is the difference, that whilst the ring's[2] . . . outline . . . makes acute angles with the cell-membrane's inner limit, there is only one of these angles present here, . . . namely, the lower one; above the ring goes slowly over into the upper, less thickened part of the cellulose layer (cf. Figs. 7, 8, 13, 12).' In the next stage of development a hemispherical slit appears in this thickened portion of the wall, and stretches down into its swollen lower margin, dividing this part of the membrane into two (secondary) layers. 'When the thickened part of the cellulose-layer has reached its ultimate development, the upper end of the wall of the cell is burst off as a little

[1] Botanisk Tidsskrift, 3rd ser., vol. ii, 1877–79, p. 1, &c.

[2] The ring in the cell of the adult plant is meant here.

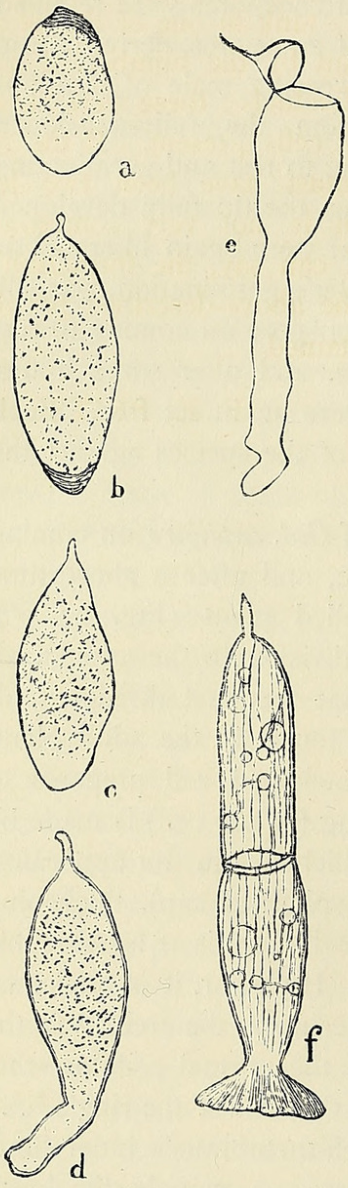

FIG. 23. *Oedogonium capillare*, Kütz. *a*, *b*, *c*, *d*. Stages in the development of the zoospores : *e*. The young, unicellular plant has liberated its contents, the upper part of the cell-wall forming a kind of lid. *f*. A young, two-celled plant with a well-developed basal disc. (All Figs. × 375.)

watch-glass-shaped cap (Figs. 9, 10, 11, 13, 4), which consists of cuticula and the outermost of the above-mentioned secondary layers' (p. 6). Through the aperture thus formed, the contents protrude, bounded apically by the inner (elastic) secondary membrane mentioned above. After this new membrane has been considerably stretched by the growing out of the contents, the first transverse-wall appears. The further divisions generally took place normally, but in some few cases this phenomenon appeared in a later stage, when the plant already consisted of 6–8 cells (p. 7).

Hirn[1] rather passes over this point, merely mentioning that the form of the first ring is slightly different from that of the succeeding, and that owing to its peculiar shape the cap is not infrequently cast off.

I have omitted to follow out the first division of the germinating zoospores in detail, but I have seen nothing like what Poulsen describes and figures. Certainly the first cap is not thrown off in *Oed. capillare*, or we should not find the tip present on the many-celled young plants. All species of *Oedogonium*, that in the older state bear a tip or hair apically, probably behave in the same manner. But even in other species the casting-off of the cap appears by no means to be the rule; in a small (undetermined) species from the River Severn this is not the case, nor in

[1] Monographie und Iconographie der Oedogoniaceen. Act. Soc. Scient. Fenn., tom. XXVII, 1900, p. 15. Wille (loc. cit., pp. 455–6) agrees with Poulsen's description in all essential points.

another (also undetermined) species from a tank in one of the pits at Kew. I was able to determine this point by the number of caps found on the apical cell of few-celled individuals; these were always found to be one less than the number of cells present. If the first cap had been cast off, their number must have been two less. Probably the case observed by Poulsen is not very common in *Oedogonium*, or rather, although for all I can say, the formation of the first ring may always take place in the above-described peculiar manner, the cap is certainly very often retained.

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