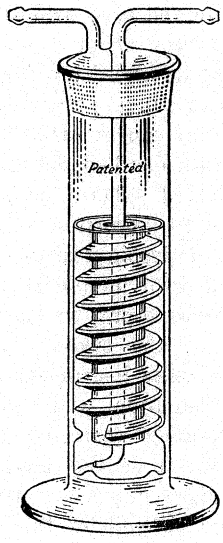
cylinder (1), a cylindrical shield (2) fitting loosely into the outer cylinder and serving to support and fit closely to a heavy inner cylinder (3) the walls of which are pressed in the form of a spiral, and a gas inlet tube (4) integral with a ground-glass stopper and outlet tube. The bottle is filled with liquid up to just above the top of the spiral. The inlet tube serves to introduce the gas at the base of the spiral, and the gas bubbles travel slowly upward circling around the spiral in contact with the liquid until



they escape at the surface. The liquid circulates upward with the bubbles and then downward both through the center of the spiral and around the outside of the shield.

The important features of this bottle have been patented, and it is now available, of American manufacture, fitted with either a ground-glass stopper or a rubber stopper, under the name "Milligan gas-washing bottle."

LOWELL H. MILLIGAN

SPECIAL ARTICLES

SOME FEATURES OF STRUCTURE AND BEHAVIOR IN VAMPYRELLA LATERITIA[1]

DURING the past fall colonies of *Spirogyra Weberi* harboring numerous individuals of *Vampyrella lateritia* were obtained. The manner of feeding of this animalcule is such as to produce repeatedly and in almost precisely the same manner a surgical operation on individual cells of *Spirogyra*—upon which it feeds exclusively, as has long been known—of utmost nicety. Inasmuch as the behavior of the protoplast of the plant had a distinct bearing on certain other behaviors during its conjugation (Lloyd, 1924, 1926), I paid a good deal of attention to the matter and incidentally learned several things about the animal which, officially, I had no right to learn.

Vampyrella has been regarded as homaxial (Hoogenraad).[2] When viewed from above the animal is spherical during free movement, but some facts indicate that it has anterior-posterior polarity. If a central vacuole is present, this is not symmetrically situated. During movement forward the center of the vacuole is behind the topographical center of the animal, and kept thus, albeit the antero-posterior axis suffers oscillations. This movement is produced by long slender pseudopodia, the longest of which project much further than thought by Hoogenraad (1907), namely, about three diameters, and the laterally projecting ones always display characteristic curvatures, there being in each a delicate knee-like bend evidently produced by the strains attending ambulation. Aside from pseudopodia used in walking, long ones extend out in all directions while doing so.

On attacking a *Spirogyra* cell the apposing surface of the animal flattens, long pseudopodia are extended along the algal filament, and, becoming quite amoeboid, he spreads partly around the doomed cell. The long pseudopodia generally disappear (Hoogenraad), only short ones, often pin-headed, clothing the free surface. Within a minute or so the transverse walls of the attacked cell begin to bend gradually inward. By the time the limit of this buckling is reached, the animal suddenly swells. This results from the injection of algal cell contents into the animal through an oval opening effected by digestion of the cellulose (Cienkowski[3]). The stretching of the attacked area of the wall during the earlier period of hydrolysis relieves the turgor pressure—hence the bending inwards of the cell wall—due to the now superior pressure of the neighboring cells. The final bursting outwards of the hydrolyzed piece of wall permits the sudden blowing up of the animal and at the same time the punctured cell is disarticulated. As soon as the turgor pressure is relieved, the animal begins to actively suck out the protoplast. Adhesion of the algal cytoplasm to the wall prevents its ready displacement, but the chloroplast is much more rapidly drawn out. Within one and a half minutes after the hole has been made, the whole chloroplast swells and becomes

[1] Identification based on Leidy's description. "Fresh water Rhizopods of North America," Rep. U. S. Geol. Surv. of the Territory," *12*: (253–256) 1879.

[2] Hoogenraad, H. R., "Einige Beobachtungen an Vampyrella lateritia Leidy," *Arch. f. Protistenkunde, 8*: 216–224, 1907.

[3] Cienkowski, L., "Beitrage zur Kenntniss der Monaden," Archiv. f. mik. Anat. *1*: 203 (218–221, pl. 12–14) 1865.

tubular. During conjugation there is exerted tension on the male chloroplast, but since this does not cause swelling it may be inferred that the response to the animal follows contact with some substance or substances derived either from the animal itself or from the surrounding medium. Similar swelling, for example, results from the ingress of salts or from undue pressures. After the chloroplast has been partially withdrawn, the "primordial utricle" follows, but rather reluctantly, and the animal has evidently considerable to do to get it all out. Sometimes he takes up a new stance, extending pseudopodia in new directions for anchorage and thus readdressing himself to the task. These in part may be under pull; others seem to push, but I think act merely as guys. The whole of the ingested material is received into a central, correspondingly enlarging vacuole, and at the close of a course, the animal is considerably swollen. But being a voracious beast, a single course does not satisfy him; he now moves off to another cell and repeats the operation, which occupies about twenty minutes or less, as Hoogenraad also noted. I have watched an animal devour four *Spirogyra* cells one after the other. The volume of a single cell being about ten times the original volume of the animal, one sees that he ingests about forty times his volume, most of which is water. But he does not get forty times as big. In fact he can be observed during a few minutes to decrease materially in volume, and, when five minutes after the end of the last courses, he finds himself plethoric and disposed to rest, perchance to sleep and dream, and settles down to encystment, his volume is little greater than it was at first. Inasmuch as *Vampyrella* has been supposed not to have contractile vacuoles, I wondered by what mechanism the water was got rid of. It could hardly be assumed that the animal has no semipermeability. On watching closely an individual just after he had come to rest for encystment, I found, contrary to the previously held view, (Hertwig and Lesser,[4] Hoogenraad) that he has not one, but many quite, but not uniformly small contractile vacuoles. I watched a large number of these form *within the hyaline margin, and burst.* Hertwig and Lesser saw them, but state that they are non-contractile. Having once seen them I found them without difficulty in the motile condition of the animal. They are so numerous and small that they readily escape notice, but it seems certain that their combined action is rapid and efficient enough to rid the animal of unneeded water at a high rate. The whole procedure is extraordinarily like that in the gametes of some species of *Spirogyra* during conjugation, *e.g., S. maxima,* especially when the process is somewhat slow. During feeding, especially if the animal is plethoric, there usually occur vigorous spasmodic contractions accompanied by the ejaculation of excreta (presumably). This arises as a dense cloud of granules floating for a short space above the surface of the animal. The setting free of granules of this sort in fewer numbers takes place more or less constantly and irregularly. One pictures what happens correctly if he sees many vacuoles contracting and expelling their contents at once—possibly a special kind of minute vacuole containing excreta.

After the contents of the *Spirogyra* cell attacked have passed into the receptive vacuole, the chloroplast rapidly shrinks into denser rounded masses and these are now taken into food vacuoles by moving toward the periphery of the animal into his cytoplasm. The central vacuole meanwhile disappears. A fully fed animal is crowded with masses of the green chromatophores and the less visible protoplasm of the alga. The former retain their color for a long time (Hoogenraad states the contrary) their digestion occupying several days. While the masses of food are reduced in size, the containing vacuoles remain of their original dimensions, becoming spherical only, evidently containing sap of some concentration.

The oval resting animal—in the sense of Hertwig and Lesser—is covered by two membranes (Cienkowski) one immediately investing him, of some thickness and rigidity, the other (velum) hanging loosely like a veil and serving to fasten the whole to an algal filament. Both of these membranes afford the cellulose reaction, not the inner merely, as stated by Cienkowski.

In the resting condition the deep orange granules appear to increase in numbers; at all events the color of the animal becomes much deeper and richer. The pigment would seem to be carotin—Cienkowski and West[5] thought it due to the nature of its food—and to be in solution in an oil in minute vacuoles. It is not soluble in water, but it is in alcohol. It is not in crystalline condition. I attempted to get the spectrum, but failed, the amount of pigment in a single animal being too small to avail.

I can confirm Cienkowski's statement that this *Vampyrella* is very knowing in regard to the quality of the contents of the *Spirogyra* cell. He may settle down for a moment on an empty cell, but he soon rejects it. He sucks cells, but he prefers them fresh.

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[4] Hertwig, R., and Lesser, E., "Uber Rhizopoden U. S. W.," Archiv. f. mik. Anat. *10*: sup. 35 (61–65) 1874.

[5] West, G. S., "On Some British Freshwater Rhizopods and Heliozoa," *Journ. Linn. Soc. Zool., 28*: 308–342 (333) pl. 28–30, 1900–1903.