man bloß Vermutungen aufstellen, das scheint aber sicher zu sein, dass die Leukocyten sich hier in großem Maße beteiligen. Ihre auffallende, oben besprochene Lage in verschiedenen Nymphenstadien liefert dafür gute Beweise. Der Umstand ist besonders auffallend, dass die Sekretion mit dem Erscheinen der ersten Oocyten zusammenfällt; wahrscheinlich ist die Sekretion von diesem Momente ausgelöst worden. Für dieses Stadium, welches jedenfalls für die Entwickelung von Wichtigkeit ist, schlage ich den Namen Oophanstadium vor[1]). [77]

The Movements and Reactions of Amoeba.

H. S. Jennings.

The writer has recently published elsewhere[2]) an extensive study of the movements of Amoeba and its behavior under the action of stimuli. The results of this study are on certain points of such importance as to warrant a brief summary in the present journal. The movements of Amoeba were demonstrated to be of a character differing fundamentally from the accounts usually given. It was found possible to determine the exact movements of the outer layer of the body by causing foreign particles to adhere to it. The movements of these particles showed that the motion of Amoeba is of a rolling character. In an advancing Amoeba a particle which becomes attached at the posterior end moves upward to the upper surface, then forward to the anterior edge. Here it goes over the edge, coming in contact with the substratum, and remains at rest until the body of the animal has passed over it. At the posterior end it passes upward and then forward again; in some cases a single particle was seen to complete the circuit of the body many times (Fig. 1). These observations are made with the greatest ease on Amoeba verrucosa. Particles of finely ground soot mingled with the water containing these animals cling to the surface in numbers, and their movements are conspicuous. Similar observations were made by the writer on other Amoebae, of the proteus type, though here the particles do not cling so easily, so that the observations require more patience. The results showed that it is not merely a thin outer layer that moves forward; on the contrary, the whole substance of the Amoeba, save that part which is in contact with the substratum, flows forward in a single stream. This was shown by the behavior of particles that were at first attached to the upper surface, then slowly sank through the ectosarc into the endosarc. From beginning to end of this process such particles move uniformly forward. There is, then,

1) Das Material zu dieser Mitteilung stammt aus dem Unter-Pročernitzer-Teiche in Böhmen und wurde auf der ehemaligen biologischen Station, bevor diese kassiert wurde, gesammelt.

2) The Movements and Reactions of Amoeba. Contributions to the Study of the Behavior of the Lower Organisms, sixth paper, pp. 129—234. Publikation Nr. 16, Carnegie Institution of Washington. 1904.

typically no backward current in a progressing Amoeba, though the appearance of one is produced by the contrast between the rapidly moving internal fluid and the lateral margins, in contact with the substratum, which are at rest. A diagram of the movements of Amoeba is shown in Fig. 2.

The same method of study shows that in the pseudopodia the movement of material is uniformly outward, both on the surface and within. In a pseudopodium in contact with the substratum the attached surface is at rest, while the remainder moves outward.

Fig. 1.

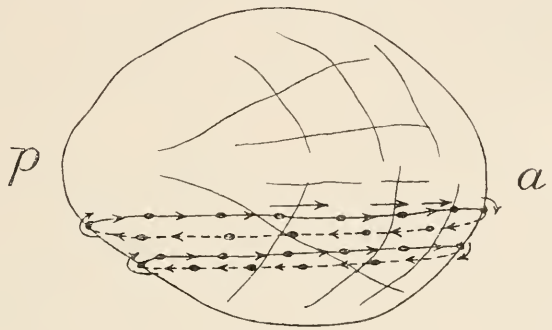
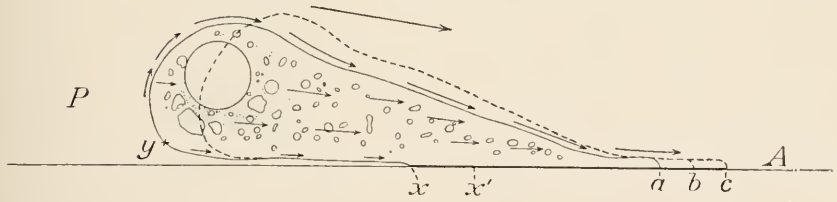


Fig. 2.



In a free pseudopodium all parts move outward, new portions of the surface of the body continually passing to the surface of the pseudopodium.

That the movements of Amoeba are of a rolling character was held by Lachmann in 1858, while Wallich in 1863 set forth briefly but clearly and correctly the real nature of the movements. Wallich's correct statement has been neglected in recent years. Bütschli observed in 1892 that the currents of water about Pelomyxa are forward, not backward, as would be expected if the surface moves forward, while Blochmann in 1894 observed distinctly that the surface moves forward in Pelomyxa. Both these authors held however that this forward movement was confined to a thin surface film; experimental study shows that this is not the case in Amoeba.

In accordance with the foregoing account, the movements of Amoeba lose their supposed resemblance to those of a fluid mass moving as a result of a local change in surface tension. In

movements due to this cause there is a surface current away from the region of lower tension, with a central current toward this region, while in Amoeba surface and central currents are congruent; they are indeed one and the same. Such movements as are shown by Amoeba cannot be produced through local changes in the surface tension of a drop of fluid. The commonly accepted explanation of the movements of Amoeba, to the effect that they are due to a decrease in surface tension at the anterior end, must then be given up. Such a local decrease of surface tension would produce movements of a character totally different from those which actually occur[1]). The actual movements of Amoeba resemble even in details the movements of a drop of fluid which adheres on only one side to the substratum. But all the movements concerned in the locomotion of Amoeba can take place without such adherence, so that this does not furnish an explanation for the movements of the animal.

All the movements, and the reactions to stimuli, were studied carefully and are described in the original paper in much detail. Special attention was paid to the various physical explanations that have been proposed for the reactions, and it was found that most of these will not stand the test of a comparison with what actually occurs in the organism. Under some conditions the behavior was found to be very complex; this was notably true of the process of food taking. Illustrated descriptions are given of Amoebae following a spherical cyst of Euglena, which is pushed forward by the efforts of the animal to ingest it; in some cases a single Amoeba follows the same rolling cyst for fifteen minutes over an irregular path. The pursuit of one Amoeba by another is described in a number of cases. A twenty minute drama is illustrated in detail, with sketches made while it was in progress. One Amoeba pursued another for a long time, finally capturing and ingesting it. After carrying it away for a short distance, the prey partly escaped, and was recaptured. It again escaped completely, but was pursued, overtaken, recaptured, and again carried away. After five minutes it escaped again, and this time completely, so that the hunter Amoeba went on its way without its meal.

University of Pennsylvania, Philadelphia, Penn., U. S. A.,
Nov. 7, 1904. [80]

Explanation of Figures.

Fig. 1. Paths of two particles attached to the outer surface of Amoeba sphaeronucleolus. The animal is moving toward the end marked *a*; no attempt is made to represent this movement in the figure. That portion of the paths that is on the lower surface is represented by broken lines. These two particles were seen to make five complete revolutions about the animal, in the paths shown.

Fig. 2. Diagram of the locomotion of Amoeba, in side view. A, anterior end; P, posterior end. The arrows show the direction of the currents of proto-

1) There remains of course the same possibility as for ciliary and muscular movement, — that the phenomena result in some way from changes in the surface tension of the ultimate protoplasmic elements. This hypothesis is not open to experimental test.

plasm. The lower surface from *a* to *x* is attached to the substratum, and is at rest. In the forward movement the thin anterior edge rolls forward, occupying successively the positions *a*, *b*, *c*, while the body is pulled forward till it occupies the position shown by the broken outline.

Über eine Wasserblüte von Volvox minor und Volvox globator.

Von **Dr. Otto Zacharias** (Plön).

Es kommt gelegentlich vor, dass gewisse Volvocineen sich in so hohem Grade innerhalb eines Gewässers vermehren, dass dasselbe durchweg eine deutlich grüne Färbung annimmt und ganz durchsetzt mit den kugelförmigen Kolonien dieser Phytoflagellaten ist. Ich habe diese Erscheinung vor einigen Jahren an den Promenadenteichen der Stadt Hamburg beobachtet, wo eine solche Ergrünung infolge einer enormen Wucherung von *Eudorina elegans* auftrat. Neuerdings (zu Beginn des Augustmonats d. Js.) habe ich ein sogen. „Blühen" des Wassers auch im Pfaffenteiche zu Schwerin bemerkt und die Gelegenheit dazu benutzt, es etwas näher zu untersuchen. Der genannte Teich ist ein oblonges Becken von 750 m Länge und 200 m Breite; er besitzt dabei eine Tiefe von 4,5 m. Die mikroskopische Untersuchung des mit einem Gazenetze aufgefischten Planktons ergab, dass dasselbe zum bei weitem größten Teile aus den Kolonien der bekannten beiden *Volvox*-Arten bestand und nur wenige kleine Krustazeen außerdem aufwies. Nachdem ich mit Hilfe eines geaichten Maßes 25 l Wasser von der Oberfläche des Teiches abgeschöpft und durch einen Gazefilter geseiht hatte, beschloss ich, durch Zählung festzustellen, wie viel *Volvox*-Kugeln wohl in dieser Flüssigkeitsmenge vorhanden seien. Es ergaben sich auf diesem Wege 17000 Kolonien; somit 680 für das Liter.

Das war mittags zwischen 12 und 1 Uhr. Am Abend desselben Tages um 9 Uhr wiederholte ich dieses Wasserschöpfen und seihte abermals 25 l durch. Auch deren Gehalt an *Volvox* wurde der Zählung unterworfen und es ließ sich konstatieren, dass nur 7000 Kolonien darin vorhanden waren, d. h. also nur 240 Kolonien pro Liter.

Nun wiederholte ich dieselbe Prozedur am folgenden Tage morgens um 9 Uhr und erzielte bei dem gleichen Ermittelungsverfahren 13000 Stück Kolonien, also eine Ziffer, welche derjenigen, die sich tags zuvor mittags ergeben hatte, ziemlich nahe steht, wogegen das abendliche Ergebnis aber erheblich von den beiden Tagesresultaten abweicht.

Hieraus ergibt sich die Tatsache, dass die reichliche Hälfte der *Volvox*-Kolonien, welche am Tage direkt an der Oberfläche zu flottieren und zu assimilieren pflegen, bei Einbruch der Nacht spontan tiefer hinabsinken und von dort bei Wiederkehr des Tageslichtes alsbald emporsteigen, d. h. sie sind positiv heliotropisch, wie auch längst durch direkte Experimente im Laboratorium festgestellt worden ist. Interessant ist es aber immerhin zu wissen, in welchem Maßstabe diese Flagellatenkolonien auf die Einwirkung