Like hæmoglobin and hæmatin, urobilin appears to be a very unstable body, which easily splits up on treatment with reagents into decomposition products, each giving a peculiar spectrum.

III. "On the Coalescence of Amœboid Cells into Plasmodia, and on the so-called Coagulation of Invertebrate Fluids." By P. GEDDES. Communicated by Professor BURDON SANDERSON, F.R.S. Received March 13, 1880.

[PLATE 5.]

Whether one collects the perivisceral fluid of a sea-urchin or of a worm, or the blood of a crustacean or a mollusc, the same phenomenon is always more or less distinctly to be observed. A kind of coagulation takes place, the fluid separating sooner or later into two portions, which have considerable superficial resemblance to the clot and serum of vertebrate blood.

It is easy to watch the formation of the clot by placing a drop of fresh-drawn fluid upon a cover-glass and inverting this above a glass cell, of which the edge is oiled to prevent evaporation. The drop thus hangs freely and the coagulation can go on without interference.

The phenomena observed in various invertebrates are best understood by reference to the plate. Fig. 1 represents some of the groups into which the amœboid corpuscles of the perivisceral fluid of the earthworm run immediately after drawing. In fig. 2 we have a few adjacent corpuscles from the gill of *Pholas*; in fig. 3 they are commencing to adhere; in 4 and 5 their adhesion is complete; in fig. 6 they have all but completely merged into one mass, which is about to absorb a new-comer; in figs. 8 and 9 the mass is now completely homogeneous, is altering its form and throwing out pseudopodia in all directions. Figs. 10—12 represent the similar union of corpuscles of *Patella*, and figs. 13, 14 those of *Buccinum*.

In *Pagurus* the corpuscles are of two very markedly different kinds, the coarsely and the finely granular. The former are much elongated when freshly drawn, but rapidly become oat- or egg-shaped, and then throw out blunt pseudopodia from any part of their surface. These stages are represented in fig. 15. The finely granular corpuscles, drawn separately at fig. 16, send out filamentous pseudopodia, and alone possess the power of union. Fig. 17 represents a small clot, formed by the union of the finely granular corpuscles, and containing a number of coarsely granular corpuscles, which do not merge into the surrounding mass. The large pseudopodial process of hyaline ectoplasm on the left of the figure is worthy of notice.

Figs. 18—23 show the union of five of the finely granular corpuscles

of the common shore-crab (*Carcinus mœnas*). Fig. 24 represents a few of both kinds of corpuscles of *Cancer Pagurus*, and fig. 25 a small clot formed by the union of the finely granular corpuscles. In fig. 26 are represented some of the corpuscles of the common starfish (*Asteracanthion vulgare*), showing the curious looped pseudopodia usual among the Echinoderms. Figs. 27 and 28 are successive drawings of a group of uniting corpuscles from the same preparation. As in fig. 17, the development of large pseudopodia from the completely fused mass is evident.

But it is among the Echinoidea* that the phenomena of corpuscular fusion occur on the most extraordinary scale. A good specimen of *Echinus sphæra* furnishes perivisceral fluid enough to fill an ordinary tumbler. The fluid is at first homogeneous and of a uniform pinkish grey tint, but rapidly becomes cloudy. The cloud contracts constantly, and so becomes gradually darker and of more defined form, and in the course of a few hours shrinks into a small brown pellet. When a drop of this fresh fluid is examined in the moist chamber, it is seen to contain, in addition to its coloured amœboid corpuscles, the same two types of colourless corpuscles, the coarsely and the finely granular, as have just been described in *Pagurus* (figs. 15 and 16). Here too the clot is entirely due to the union of the finely granular corpuscles, which almost instantly run into small heaps, these into larger, and larger ones, and so on until we have a vast amœboid mass, which rapidly differentiates into endoplasm and ectoplasm, the former containing the nuclei and granules of the constituent corpuscles, and the latter, produced by the union of their hyaline ectoplasm, forming a broad clear margin, and sending out pseudopodia, sometimes blunt, but usually filamentous. These pseudopodia frequently run out over such distances that an adequate idea of their extraordinary size could scarcely be given within the limits of the entire plate.

The resemblance of all these cases of the fusion of amœboid cells taken from so many types of Invertebrata is too close to be accidental. All the evidence points to the conclusion that the clot which appears in any invertebrate corpusculate fluid is formed, always partly, and sometimes wholly, by the *fusion* of the finely granular amœboid corpuscles therein suspended.† Thus, while the blood of a lobster is still capable of clotting after removal of the corpuscles by filtration (Frédéricq), the perivisceral fluid of a sea-urchin is not.

* A detailed account of the corpuscles of *Echinus*, &c., will shortly appear in the "Archives de Zoologie Expérimentale."

† With regard to the amœboid corpuscles of vertebrates, I have not yet been able to make any satisfactory observations. Ziegler has concluded from his researches on the formation of giant cells in exudation liquids (Exp. Untersuch. ueber d. Herkunft d. Tuberkeelmente, &c., Würzburg, 1875) that a coalescence of amœboid cells does actually sometimes take place.

It is impossible to avoid comparing the above-described unions of amœboid cells with those occurring in the ordinary life-history of the Myxomycetes,* and the resemblance is so complete that it seems not only convenient, but necessary to extend the term *plasmodium* to the former.

The formation of plasmodia was at first supposed to be peculiar to the Myxomycetes, but several Rhizopods (*Microgromia*, *Rhaphidiophrys*, *Phonergates*, &c.) have been described, in which a more or less complete cell-fusion has been observed, or perhaps, as I am disposed to think, cell-fusion has been more or less completely observed.

After comparing the descriptions and drawings of these forms† (see Buck's figures of *Phonergates*, copied in the Plate, figs. 30—33) with those of uniting corpuscles already given, the identity of the process of coalescence in the two cases with each other, and with that of a Myxomycete, will be sufficiently obvious.

Finally, although much further observation is desirable, alike upon the undifferentiated cells of Vertebrates and Invertebrates, and upon the lowest plants and animals, it may be safely asserted that all the evidence we possess points to the conclusion that the power of coalescing with its fellows, under favourable circumstances, to form a plasmodium, is at any rate a very widely-spread, if not a general property of the amœboid cell.

The observations were chiefly made last summer at the Scottish Zoological Station at Stonehaven.

EXPLANATION OF THE PLATE.

Fig. 1. Corpuscles of perivisceral fluid of *Lumbricus terrestris* commencing to unite.

Figs. 2—9. Eight successive drawings of the same group of corpuscles (*Pholas*).

Figs. 10—12. Union of group of corpuscles (*Patella vulgata*).

Figs. 13—14. Union of group of corpuscles (*Buccinum undatum*).

Fig. 15. Coarsely granular corpuscles (*Pagurus Bernhardus*).

Fig. 16. Finely granular corpuscles of same animal.

Fig. 17. Small plasmodium (*Pagurus Bernhardus*) formed from finely granular corpuscles, and containing several coarsely granular corpuscles in its interior.

Figs. 18—23. Union of group of corpuscles (*Carcinus Mænas*).

Fig. 24. Group of coarsely and finely granular corpuscles of *Cancer Pagurus*.

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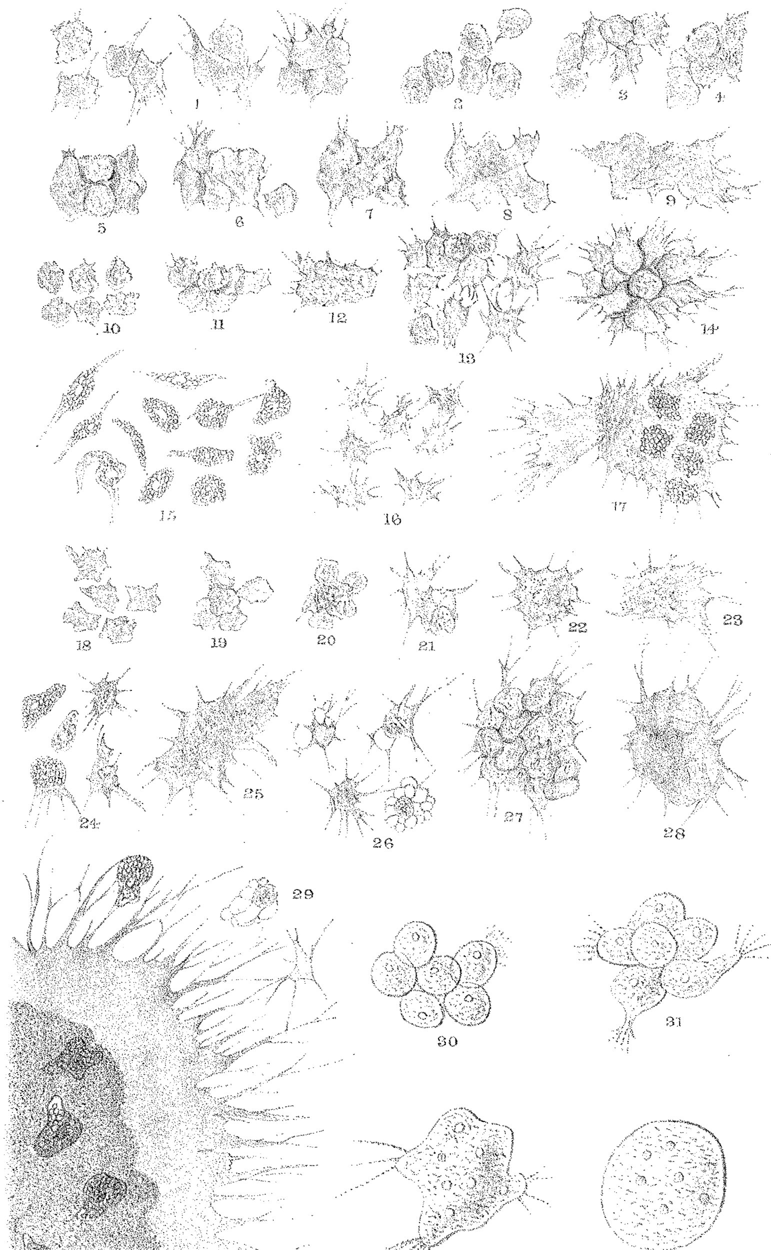
* Sachs. "A Textbook of Botany." De Bary. "Die Mycetozoons." "Zeitsch. f. Wiss. Zool." Bd. X. 1860.

† R. Hertwig. "Ueber *Microgromia socialis*, eine Colonie bildende Monathalamie des süssen Wassers." "Archiv. f. Mikros. Anat." Bd. X. Taf. 1. 1874.

L. Cienkowski. "Ueber einige Rhizopoden und verwandte Organismen." "Archiv. f. Mikros. Anat." Bd. XII. 1876.

E. Buck. "Einige Rhizopodenstudien." "Zeitsch. f. Wiss. Zool." Bd. XXX. 1878. Taf. 2.



P. Geddes del. West, Newman & Co. lith.

Fig. 25. Plasmodium (*Cancer Pagurus*).

Fig. 26. Corpuscles of *Asteracanthion vulgare,* freshly drawn.

Figs. 27—28. Union of a group of corpuscles of *Asteracanthion vulgare.*

Fig. 29. Portion of a plasmodium produced by the union of the finely granular corpuscles of *Echinus sphæra,* showing distinct endoplasm containing the coarsely granular and the coloured corpuscles, and ectoplasm sending out filamentous pseudopodia, which unite with those of free corpuscles.

Figs. 30—33. *Phonergates vorax,* from " Zeitsch. f. Wiss. Zool." Bd. XXX. 1878. Taf. II, figs. 54—57.

All the figures drawn with Verick, Oc. 2, Obj. 7.

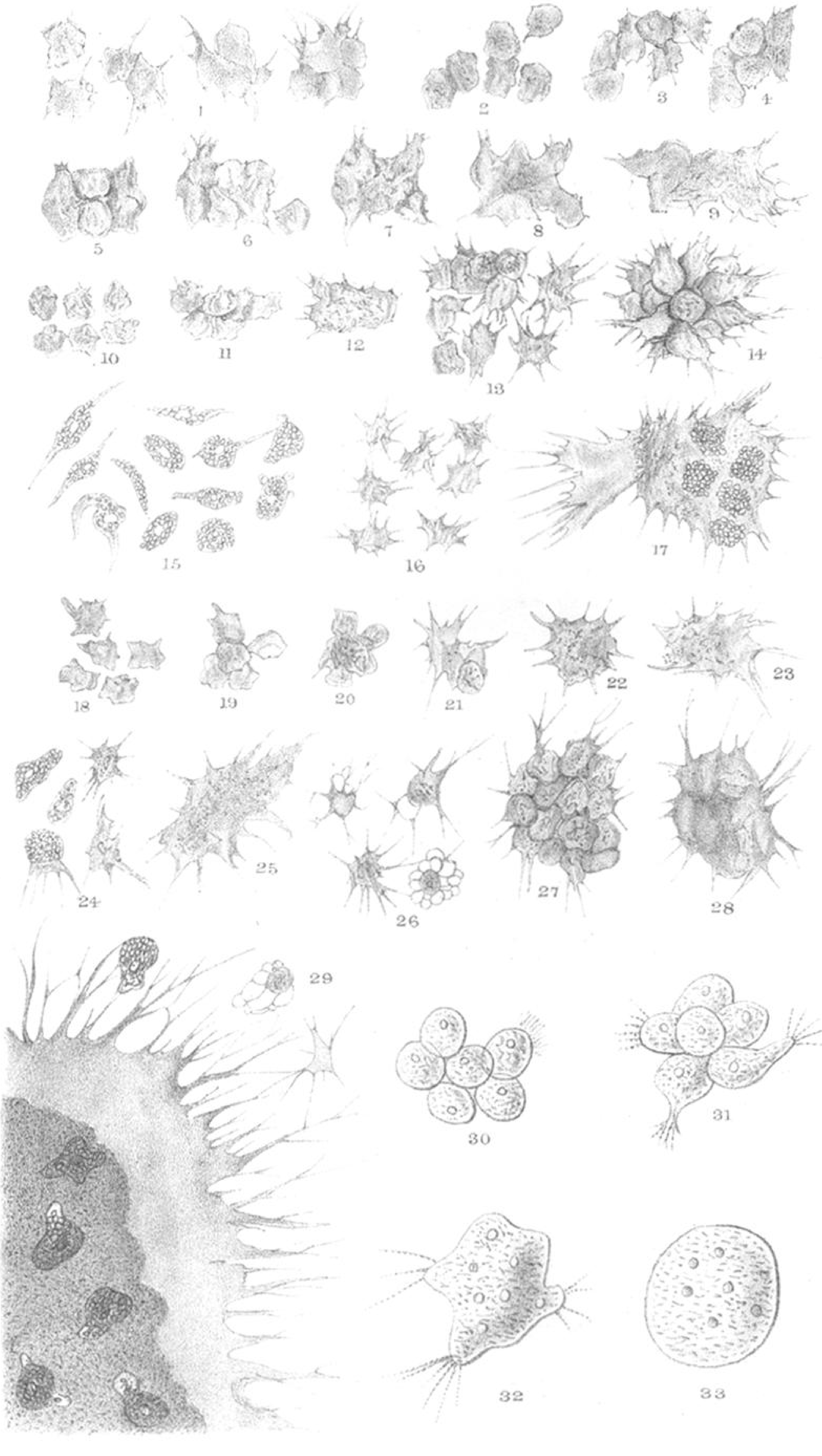
IV. "On the Analytical Expressions which give the History of a Fluid Planet of Small Viscosity, attended by a Single Satellite." By G. H. DARWIN, F.R.S. Received March 6, 1880.

In a series of papers read from time to time during the past two years before the Royal Society, I have investigated the theory of the tides raised in a rotating viscous spheroid, or planet, by an attendant satellite, and have also considered the secular changes in the rotation of the planet, and in the revolution of the satellite. Those investigations were intended to be especially applicable to the case of the earth and moon, but the friction of the solar tides was found to be a factor of importance, so that in a large part of those papers it became necessary to conceive the planet as attended by two satellites.

The differential equations which gave the secular changes in the system were rendered very complex by the introduction of solar disturbance, and I was unable to integrate them analytically; the equations were accordingly treated by a method of numerical quadratures, in which all the data were taken from the earth, moon, and sun. This numerical treatment did not permit an insight into all the various effects which might result from frictional tides, and an analytical solution, applicable to any planet and satellite, is desirable.

In the present paper such an analytical solution is found, and is interpreted graphically. But the problem is considered from a point of view which is at once more special and more general than that of the previous papers.

The point of view is more general in that the planet may here be conceived to have any density and mass whatever, and to be rotating with any angular velocity, provided that the ellipticity of figure is not large, and that the satellite may have any mass, and may be revolving about its planet, either consentaneously with or adversely to the planetary rotation. On the other hand, the problem here considered is more special in that the planet is supposed to be a spheroid of fluid of small viscosity; that the obliquity of the planet's equator, the inclina-



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All the figures drawn with Verick, Oc. 2, Obj. 7.