

- (4) Iodine solution. A small crystal of iodine in 30 cc to 100 cc of gasoline.

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SPECIAL ARTICLES

THE ROLE OF KINOPLASM IN THE GENESIS OF VACUOLES

THE genesis of vacuoles is a subject which is receiving much attention at the present time. Nasanov, Ludford, Uhlenhuth and Bowen, for example, have studied the development of secretory vacuoles in *Protozoa* and in gland cells of higher animals, and a host of workers, as exemplified by recent letters to *Nature*, are busy with the origin during oogenesis of various kinds of yolks—all of which, since they lie in pockets in the cytoplasm, are probably definable as vacuoles or more strictly the content of vacuoles—while Guillermond and his school and recently Bowen have investigated the inception of the “vacuome” in plant cells. It is argued by many, though Bowen disagrees, that the contractile vacuole of the *Protozoa*, and also the plant vacuole, are homologous with the Golgi apparatus of metazoan cells; that fatty yolk at least as well as certain secretory vacuoles are a product of the same structure; but that other kinds of yolk and of secretory vacuole may arise from mitochondria and from nuclear extrusions. Whatever rôle these various structures may play in secretion of the vacuolar contents, our own observations on living cells, chiefly of plants, lead us to the conclusion that the actual formation of the vacuoles is the function of a more active labile and fundamental element of the cytoplasm of which one rarely hears mention at the present time, *viz.*, Strasburger’s *kinoplasm* (active substance). Recent cytological research has concentrated on those bodies which give more or less characteristic staining reactions, but the above differentiation of the cytoplasm is also sufficiently characteristic in another way, *viz.*, in the behavior in life, to warrant, it would seem, the continued application of a distinctive title.

The kinoplasm is distinguished from the matrix by a slightly higher refractive index, by its origin and metamorphoses, and usually by its motility—characteristically, protoplasmic streaming and the translocation of other formed bodies in the cell is a function of the kinoplasm alone. The form most commonly assumed is filamentous, but Strasburger recognized the identity of the fibrillar with the film type of structure and his conception is supported by our own observations (1) of the origin of the fibrils from and (2) their retransformation into films or membranes. This relation, which bears on the subject of

our title, is illustrated in more ways than one. Thus the kinoplasmic processes which lie within the cytoplasm, *e. g.*, in cells of *Spirogyra*, may frequently be observed to stream out from the demonstrably differentiated film of clear cytoplasm which envelopes the chloroplasts, or they may become attached to such a surface at both ends flowing out from one and into the other. Similarly, they may arise from the boundary of the nucleus where also a differentiated film of cytoplasmic substance can be shown to exist. The probable origin of other intracytoplasmic processes from the external or the vacuolar membrane is only inferred from what follows.

Similar in behavior and origin to the above are the little known pseudopodium-like processes which commonly fringe the central sap cavity in plant cells. Here again by extending across the vacuole the filaments may flow both into and out of a differentiated film, the vacuolar membrane or tonoplast. While there is, no doubt, some difference in character between films and filaments which are in contact with the cell sap and those which are internal to the protoplasm, their similarity of behavior seems to allow of the extension of the generic term kinoplasm to cover both. (Of course the more massive strands which cross the vacuole may contain several streams of kinoplasm with matrix between.) We may, with Strasburger, include also cilia and fine pseudopodial extensions of the plasmatic membrane on the exterior of naked cells, but to extend the term as he did to nuclear elements (hypothetical at that) is to destroy its usefulness.

All this, however, is somewhat aside from our main point, which is that the typical kinoplasm within the cytoplasm becomes transformed on occasion into vacuoles or at least into the lining membranes of such. For example, during conjugation in *Spirogyra* the gametes get rid of water by means of “contractile” vacuoles.¹ These first become conspicuous as mucilaginous looking globules which in turn are formed by condensation of the kinoplasm. A similar formation of vacuoles—which also may be contractile, *i. e.*, may burst—frequently takes place under more pathological conditions, as for example, when cells are acted on by a strong plasmolysing agent which penetrates somewhat, or by a narcotic. In such cases the kinoplasm may give rise to vacuoles by other mechanisms than preliminary sphere formation. The erstwhile streaming processes may fuse into a honeycomb structure, or the various membranes, the vacuolar and chloroplastic envelopes particularly, may develop blisters in their substance.

In suggesting that these observations on the origin of vacuoles be taken into account in the study of yolk

¹ Lloyd, Trans. Roy. Can. Inst. 15 (2) 1926.

formation and glandular secretion, we are speaking with little direct knowledge but are influenced by several suggestive facts bearing on the relation of the kinoplasm to the other structures involved. As regards the Golgi bodies, the structure which reduces osmic acid is associated with a chromophobic substance, the "idiosome," which is usually recognized only in form of spheres, (also called archoplasmic, *i. e.*, kinoplasmic spheres) such as we have observed to swell into secretory vacuoles in *Spirogyra*. Gatenby's difficulty² in reconciling the sphere and vacuolar (Parat's theory) origin of fatty yolk seems to disappear in view of this observation. From certain drawings (*e. g.*, Bowen Q. J. M. S. 70, part 3) this chromophobic substance appears sometimes to be spread out over the Golgi apparatus. Similarly, the reducing substance in the tonoplast of plant cells is separable experimentally from the true membrane, which, like the kinoplasm generally, is at most only slightly osmophile. While the chromophilic Golgi substance may, as Bowen argues, synthesize and secrete certain vacuolar contents, we submit that the chromophobic substance which actually forms the vacuole is identical with the kinoplasm.

As regards the mitochondria, the kinoplasm is so intimately associated with this more conspicuous element that we wonder if operations have not been ascribed to the latter which really belong to the former in cells where the kinoplasm is less easy to observe than in plan cells. The relation between these two elements of the cell is shown in various ways. (1) The most abundant development of kinoplasmic processes is found in those cells and regions of a cell where mitochondria are densest. (2) The majority of the mitochondria are included in or attached to the kinoplasm. (3) A reciprocal relation is indicated by the observation that as the mitochondria are caused to increase by vital staining the active kinoplasm decreases in amount. (4) In its film form the kinoplasm occasionally stains lightly during the life by basic dyes. (5) The mitochondria are recognized as largely composed of lecithin and the behaviors of the kinoplasm are paralleled in many ways by those of lecithin and of lecithin-containing substances. Thus the kinoplasmic processes may be compared to the myelin growths of lecithin in water, while the vacuolization of kinoplasmic spheres in the cytoplasm—as also of lipoid containing droplets which may be caused to condense in the sap of many plants—is paralleled by the vacuolization and swelling of droplets of egg yolk (*e. g.*, of the cockroach) when squeezed out into water.

Our hypothesis, based on the above, as to the essential nature of the kinoplasm is that its differentiation

from the cytoplasmic matrix depends on its larger lipoid content, resulting in orientation of molecules or micellae, in film formation, etc.; while the mitochondria we are inclined to regard as a reserve of substance for kinoplasm formation rather than the active elements they are claimed to be.

To sum up, while our observations tell us nothing of the process by which water and other materials are secreted in vacuoles, they certainly point to the formation of the enveloping films as a metamorphosis of the neglected kinoplasm and indicate that water at least may accumulate without the visible interaction of any other structure.

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THE VIRGINIA ACADEMY OF SCIENCE

THE Virginia Academy of Science held its fourth annual meeting at the Virginia Polytechnic Institute at Blacksburg on May 6 and at the State Teachers College at East Radford on May 7.

The following officers were elected for the coming year:

Dr. Donald W. Davis, president.

Dr. L. G. Hoxton, member of the council.

Dr. Sidney S. Negus, publicity chairman.

Twenty-three papers were read before the section of astronomy, mathematics, and physics; twenty-nine before the section of biology; thirteen before the section of psychology and education; and twelve before the Virginia section of the American Chemical Society which functions as a section of the academy.

A prize of fifty dollars in gold offered by a friend of the Academy for a particularly meritorious paper read at the meeting was awarded to Dr. C. C. Speidel, of the University of Virginia, for a paper entitled "Regenerative Phenomena under Conditions of Hyperthyroidism." This prize was awarded by the permanent committee on the encouragement of research in Virginia which was established last year. President Horsley reported that he had succeeded in raising more than eight thousand dollars toward an endowment fund for the encouragement of research in Virginia, the income from which will be administered by this committee. A committee was also appointed to effect the incorporation of the academy.

After the meeting about eighty of the biologists made a field trip to Mountain Lake and about twenty of the chemists visited some of the industries at Pulaski.

E. C. L. MILLER,
Secretary-Treasurer

² *Nature*, Dec. 11, 1926.