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Electron Micrographs of the Nematocysts of Hydra¹

By MARIETTA ISSIDORIDES, H. W. BEAMS, A. W. SEDAR
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INTRODUCTION

Seventeen different kinds of nematocysts have been described and classified by Weill (1930) on the basis of the characteristics of the discharged tube. Only four of these are known to be present on hydras, namely, volvents (desmonemes), streptoline glutinants (holotrichous isorhizas), stereoline glutinants (atrichous isorhizes), and penetrants (stenoteles). The discharged penetrant (fig. 1) consists of the capsule *a*, butt, which is composed of the shaft *b*, stylet *c*, spinneret *d*, and tube *e*. In the glutinants the tube is attached directly to the tube, and is either spiny (streptoline glutinant) or smooth (stereoline glutinant). In the resting nematocyst all the component parts are inverted and contained within the capsule.

It has been generally accepted that the mechanism of discharge involves an eversion of the shaft, spinneret and tube to the outside of the capsule. Kepner, Reynolds, Goldstein and Taylor (1943) however, presented some evidence that the eversion is limited to the shaft and spinneret, and that the tube is formed by the extrusion of a magma. This magma would be a mixture of liquefied capsular colloid and liquefied internal tube. This theory was questioned by Jones (1947) who introduced additional evidence in favor of the "eversion of tube" idea. Recently, although Kepner, Reynolds, Goldstein, Britt, Atcheson, Zielinski and Brickert Rhodes (1951) amplified their previous work, at the present the mechanism of discharge seems still open to further study.

Our investigation was undertaken with the purpose to study the fine structure of discharged nematocysts in the hope of finding structural relationships that would support one or the other of the above theories.

MATERIALS AND METHOD

The hydras (*Pelmatohydra oligactis* ?) were obtained from Turtox General Biological Supply House, Chicago, Illinois. The small size of the animal made it possible to work directly on the specimen

¹Grants to the Radiation Research Laboratory from the Iowa Division of the American Cancer Society have made possible the purchase and maintenance of the electron microscope.

holder of the electron microscope. This specimen holder (grid) has a diameter of about 3 mm.; it is a wire mesh containing eight holes per mm. . Several grids are placed on a glass slide submerged in distilled water in a Petri dish. A drop of 2% collodion in amyl acetate placed on the surface of the water forms a thin membrane in a few seconds. The slide is carefully lifted out of the dish carrying with it the collodion membrane, which coats the grids and secures them in place. When the slide has completely dried the hydra is placed on the coated grid in a small drop of tap water or culture medium. The discharge of the nematocysts is affected by either a weak electric current or mechanical means by dropping a cover glass on the animal and applying pressure. The first method was found to cause the extrusion of a much larger amount of nematocysts and was therefore adopted more frequently. The electric shock was delivered by touching the drop with two microelectrodes connected to a 6 Volt D.C. battery. The preparations were first dried on a warm plate then washed with distilled water and finally dried thoroughly in a desiccator.

The electron microscope used was an R.C.A. model EMU-2B, equipped with an unbiased gun. Magnification of the electron micrographs is indicated by the $1\ \mu$ scale drawn on each figure.

RESULTS

Of the four kinds of nematocysts present in hydra, the volvents are extremely dense to the electron beam revealing no internal structure. This means that the impinging electrons are completely absorbed. The remaining three kinds seem to consist of material of lesser density since considerable detailed structure is evident at the same electron intensities that are absorbed by the volvents.

The capsule of the penetrant (figs. 1 and 2) is homogeneously opaque when compared to either shaft or tube and contains irregular cord-like masses of a denser substance. At first glance these dense masses were thought to be folds of the capsular wall resulting from the drying of the preparation. Closer inspection, however, ruled out this possibility. It is easy to show that the wall of an ovoid sac-like body, when flattened out, will fold on itself in areas of greater curvature, but each fold will taper to a point toward the periphery. Such a fold appears across the base of the capsule in figure 5, and is optically different from the cord-like mass in that same capsule.

There is a clear line of demarcation between capsule and shaft of the penetrant. The wall of the shaft is thin and seems to have collapsed during desiccation, however, it contains streaks of material having the same optical density as the contents of the capsule. The

shaft extends approximately $4.45\ \mu$ above the capsule and merges into the spinneret at the level of the stylets. The rows of spines which have been described as occurring above this level are not very evident in our micrographs (figs. 1 and 2).

The external filament is continuous with the tip of the spinneret. This external filament is definitely a tube and not a solid structure; ridges and folds and some granular material in its lumen are evident in figure 2. In some cases the tip of the external filament is differentiated into a spike-like structure (fig. 3) bearing some resemblance to the pointed tip of trichocysts (unpublished). If this spike is a variation of the generally accepted structural pattern of the penetrant, it has to form after discharge since it has never been observed on the internal filament of the resting nematocyst by other authors.

Figure 4 is a portion of the filament of a streptoline glutinant. It has all the optical properties of a solid structure. The spines are thorn-like, with their bases attached to a thicker rim on the surface of the filament (fig. 4*a* and *b*).

The capsule of the stereoline glutinant (fig. 5) differs from that of the penetrants (figs. 1 and 2) only in shape and size. The filament of the stereoline glutinant tapers to less than half its diameter at the point of attachment to the capsule. The filament (fig. 5) shows no indications of being a hollow structure; its boundaries are obscured by what seems to be an exudate of some kind.

DISCUSSION

Our results indicate that the filament of the penetrant is a hollow membranous tube; the filaments of the glutinants seem to be structurally solid. We also observed that the discharged capsules of both penetrants and glutinants contained some material that is not used up during discharge. It would have been very enlightening to determine the state of this material and its relationship to the internal filament of the resting nematocyst. Unfortunately, the undischarged nematocyst absorbs the electrons thus appearing completely black.

It is difficult to visualize the physical conditions that would mold the extruding magna into a hollow structure according to the theory of the Kepner group. A condensation of the magna, as it reaches the medium, would result at the most in a solid cylindrical structure. This is not true of the penetrant, but could conceivably be true of the glutinant which does appear solid. The formation of spines, however, would require the presence of an elaborate differentiating mechanism operating while the magna is being extruded and condensed; we have no evidence for or against this.



PLATE 1

Figure 1. Discharged penetrant of Hydra: a, capsule; b, shaft; c, stylet; d, spiniferet; e, tube.

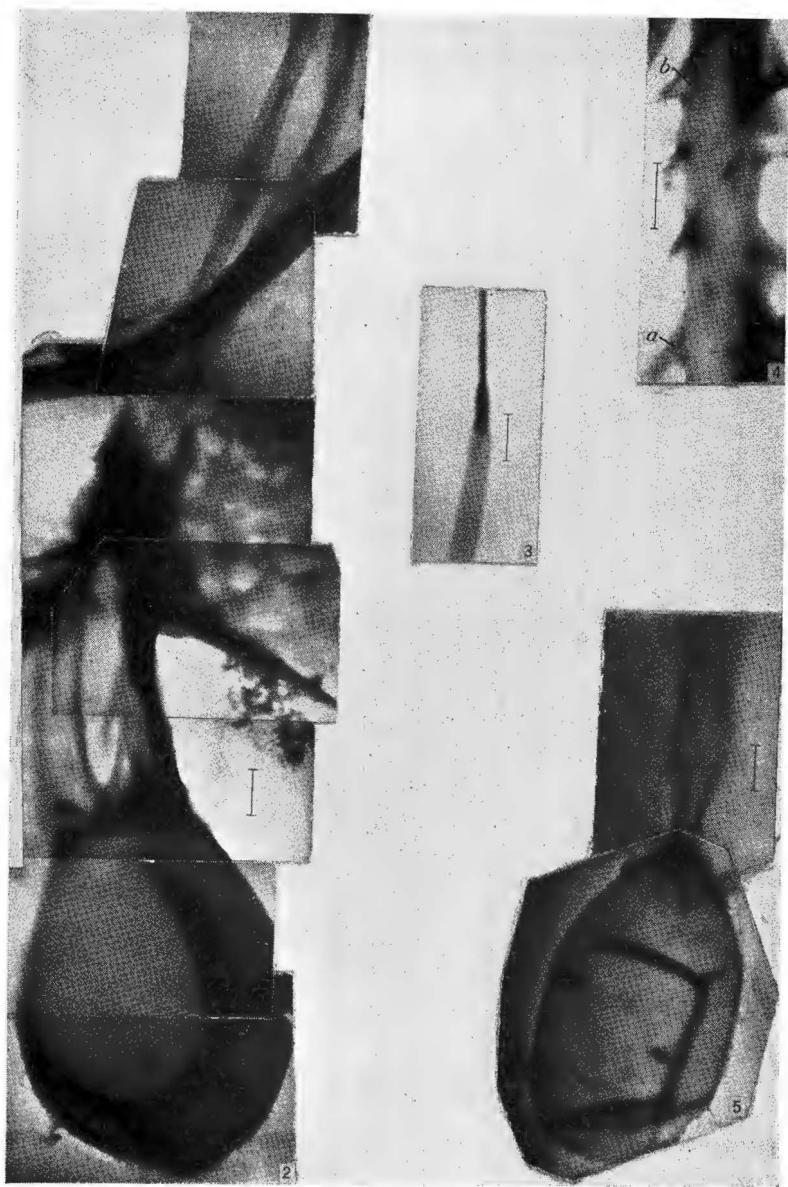


PLATE 2

Figure 2. Discharged penetrant of Hydra.

Figure 3. Spike-like structure at the tip of the tube of a penetrant.

Figure 4. Portion of spiny filament of a streptoline glutinant; *a* and *b* are spines the bases of which are attached to a thickened rim on the surface of the filament.

Figure 5. Discharged stereoline glutinant.

The presence of the spike at the tip of the penetrant's tube is an indication that not all component parts of the nematocyst are necessarily laid down before discharge.

SUMMARY

Discharged nematocysts of hydra (*Pelmatohydra oligactis?*) have been examined with the electron microscope in the unfixed, dried state. Structural components of the penetrant, streptoline glutinant and steroline glutinant are described and discussed.

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