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MASTER

THE ACCUMULATION AND TRANSPORT OF MINERALS BY MARINE PROTOZOA

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ABSTRACT

Tintinnida are abundant microzooplankton found in all of the world's oceans, and important components of the marine food web as predators, prey, and as regenerators of nutrients. The agglutinated forms take on added importance in coastal waters. Representatives of this group have the unique ability among ciliates to pick up particles from the environment and incorporate them into the lorica. The ecological significance of the phenomenon lies in: (1) it is a pathway whereby radionuclides, metals and other toxic substance can be biologically concentrated and transferred from sediments and the water column to the biota; (2) from the viewpoint of microzooplankton as indicators of environmental perturbations, pollution, or water mass movements, it is important to determine whether minerals accumulated on the lorica can serve as a guide to the site where the structure was built.

Studies are in progress on the types of mineral matter accumulated by tintinnids. The project consists of 2 parts: (1) observations on naturally occurring forms; (2) experimental uptake of particulate matter by laboratory-reared specimens.

Techniques were developed for removing adhering mineral matter from an agglutinated form for investigation of the underlying organic matrix. Naturally occurring detritus as well as particles of known composition are being used to investigate particle selectivity by the protozoa.

Introduction

The biological consequences of mineral accumulation by tintinnids depend upon the nature of the substances taken up by the protozoa and the predators consuming them. Innocuous materials would pass through the food web unnoticed; indeed, much of the biotic and abiotic particulate matter found on tintinnid loricae during the course of these investigations falls in this category. Silicon, it was determined in these studies, is the predominant mineral accumulated by agglutinated species in temperate waters of the northeast United States. However, toxic substances may also be incorporated along with the innocuous silt-sized particles or sorbed to them. One purpose of this project, therefore, is to determine whether or not this is a meaningful route for transfer of such materials through the food web.

The process of mineral accumulation by these protozoa is poorly understood. As an aid in determining the 'how' and 'why' of mineral accumulation, a technique was developed for removing adhering particles from a lorica. The procedure has resulted in the unexpected observation - having important taxonomic consequences - that a matrix may be absent in some agglutinated forms. This has important implications insofar as the ecologist is concerned. Identification of associations of planktonic species depends upon knowledge of the taxonomic position of the organisms under consideration. The data generated in this program provides specialists with an accurate new way to confirm species diagnoses for these microzooplankton.

1. Mineral Accumulation and Developmental Processes

1.1 Observations on loricae treated with HF are summarized in Section II, Reprint C, entitled The Role of Protozoa in Cycling Minerals in The Sea. Briefly stated, the adhering particles were dissolved away with acids on a variety of species loricae of the 2 genera Stenosemella and Tintinnopsis (Fig.1). All of the common neritic species had organic matrices with thickened regions that outlined the spaces where the particles had been embedded; the resultant organic structure had a coarse irregular mesh. A species collected in the Hudson River in the vicinity of Indian Point, N.Y., so treated - identified as Tintinnopsis wangi - left no organic remains. This suggests 3 possibilities: (1) that the particles were only lightly cemented together; (2) that a matrix was dissolved by the acid, or rather, as suspected; (3) that an organic lining was absent. Readers are referred to the abstract cited above for a more thorough discussion of this aspect of the work.

1.2 The experimental uptake of particles is proceeding along several lines: (a) detritus has been prepared from natural plankton samples, which includes biotic as well as abiotic particulate matter, and added to cultures;

(b) commercially available diatomaceous earth has been added to cultures of Tintinnopsis inasmuch as this type of material has repeatedly been found adhering to some species' loricae; (c) activated charcoal powder is being tested as a source of particulate matter so that mineral sorption tests will be facilitated; (d) carmine and $CaCO_2$ particles are being incorporated into the lorica. The dye contains aluminum and therefore may be useful in conjunction with X-ray mapping for studies on the rate of deposition of a lorica.

1.2 The development of the lorica differs in agglutinated and hyaline forms. Both processes have important implications insofar as ecologists interested in species associations are concerned. As an example, it has been shown by a French microscopist that polymorphism in a lorica is so great that 2 varieties produced by the same species were actually described as representatives of 2 different genera! This observation by Laval explains the occurrence of specimens identified as Coxliella in the plankton in association with Favella. The conditions under which one or the other type of lorica is produced remain to be determined. A distinct possibility, however, is that the Coxliella type of lorica is produced by the cell after it has discarded its Favella type of lorica. Fig. 2 is an example of the phenomenon taken from SEM micrographs of Favella cultured in this laboratory.

Observations have been made in this laboratory on modifications in loricae obtained on culturing specimens under defined conditions. It is expected that the artifacts produced in culture will give insight into lorica production methods and into the significance of polymorphism *in situ*. Fig. 3 is an example of *Helicostomella subulata* from nature, and also several days later in culture. The presence of the posterior horn and the anterior spiral region confirm the fact that Fig. 3 is a *Helicostomella subulata* lorica and an artifact of cultivation.

2. Morphological features

2.1 Tentaculoids are unusual organelles found only on certain tintinnids examined thus far. Their presence on relatively few specimens raises the question of their function, which at the time is believed to be tactile. A brief description of the structures and micrographs are presented here, inasmuch as these are the first SEM observations of tentaculoids to be reported. The structures were observed on specimens _in vitro_; never on specimens reared in the laboratory.

The structures are interspersed between the oral membranelles. There is a bulbous region at the end of a thin stalk (Fig.4); at higher magnifications, the bulbous portion appears to be porous.

Legends

Fig. 1. Examples of arenaceous loricae. Left, top to bottom: *Stenosemella ventricosa*, *S. oliva*, *Tintinnopsis rapa*. Right, loricae of the same species treated with HF to dissolve away the siliceous particles.

Fig. 2. Left: *Favella ehrenbergii* from nature showing diagnostic features characteristic of the species (Magnification 500X). Right: A specimen produced *in vitro* showing morphological features characteristic of the genus *Coxliella* (Magnification 750X).

Fig. 3. Left: *Helicostomella subulata* from nature showing diagnostic features characteristic of the species (Magnification 600X). Right: A specimen produced *in vitro* showing similarities to the above, i.e. spiral in the anterior region, modified posterior horn. Particles are absent (Magnification 1300X).

Fig. 4. Various magnifications (1,000X-18,000X) of tentaculoids on *Stenosemella oliva*.

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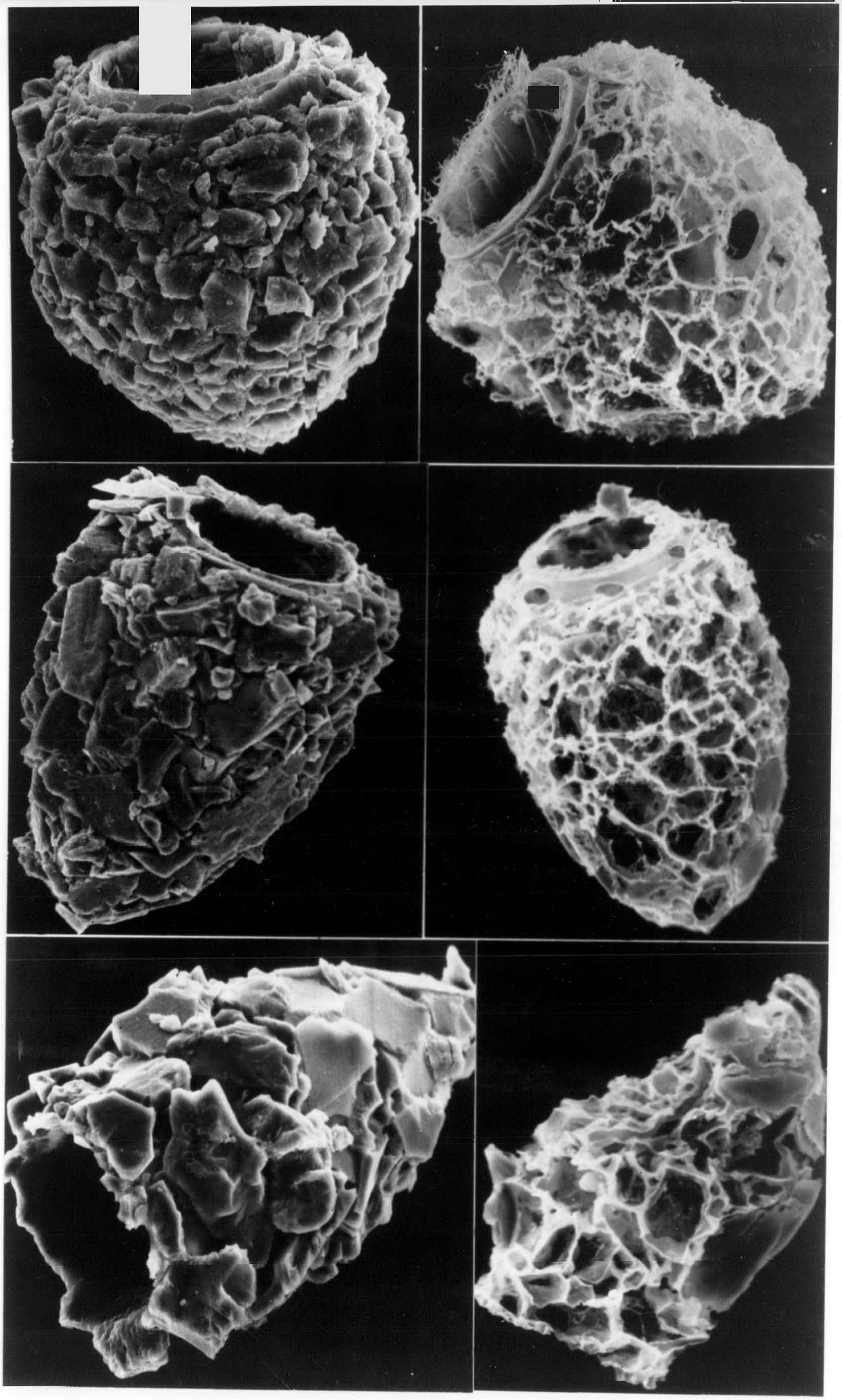

Fig. 1

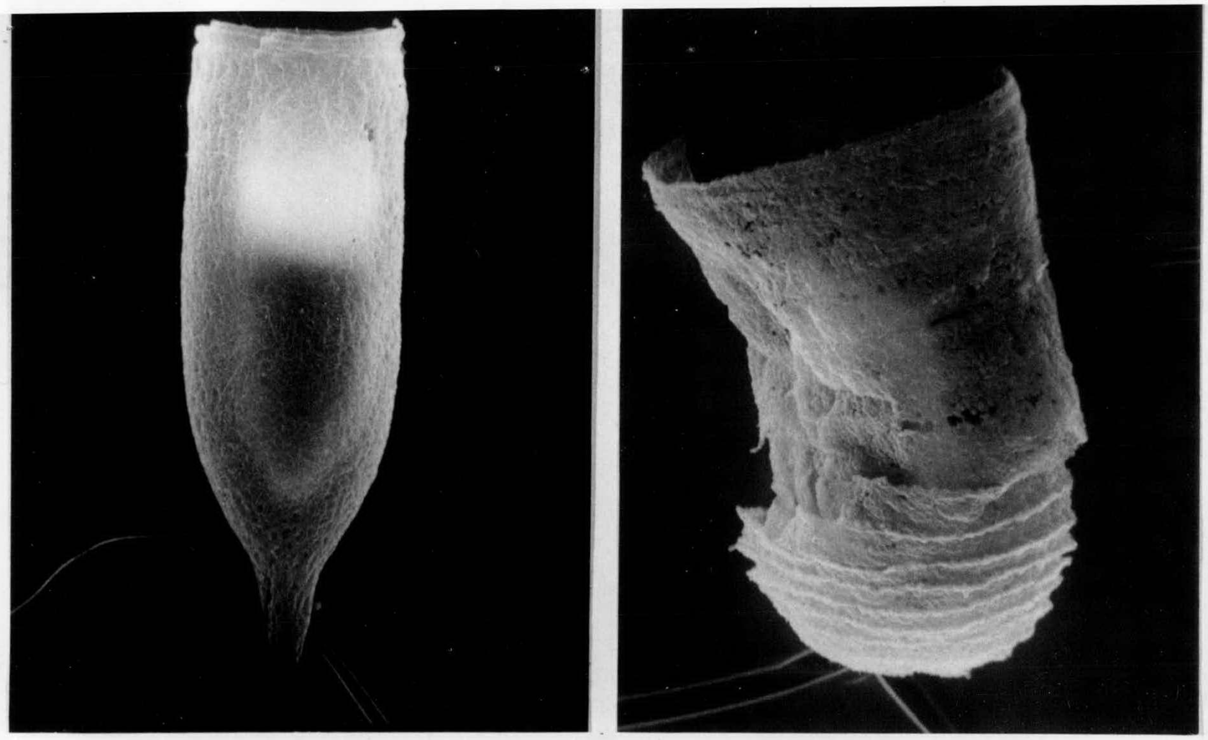

Fig. 2

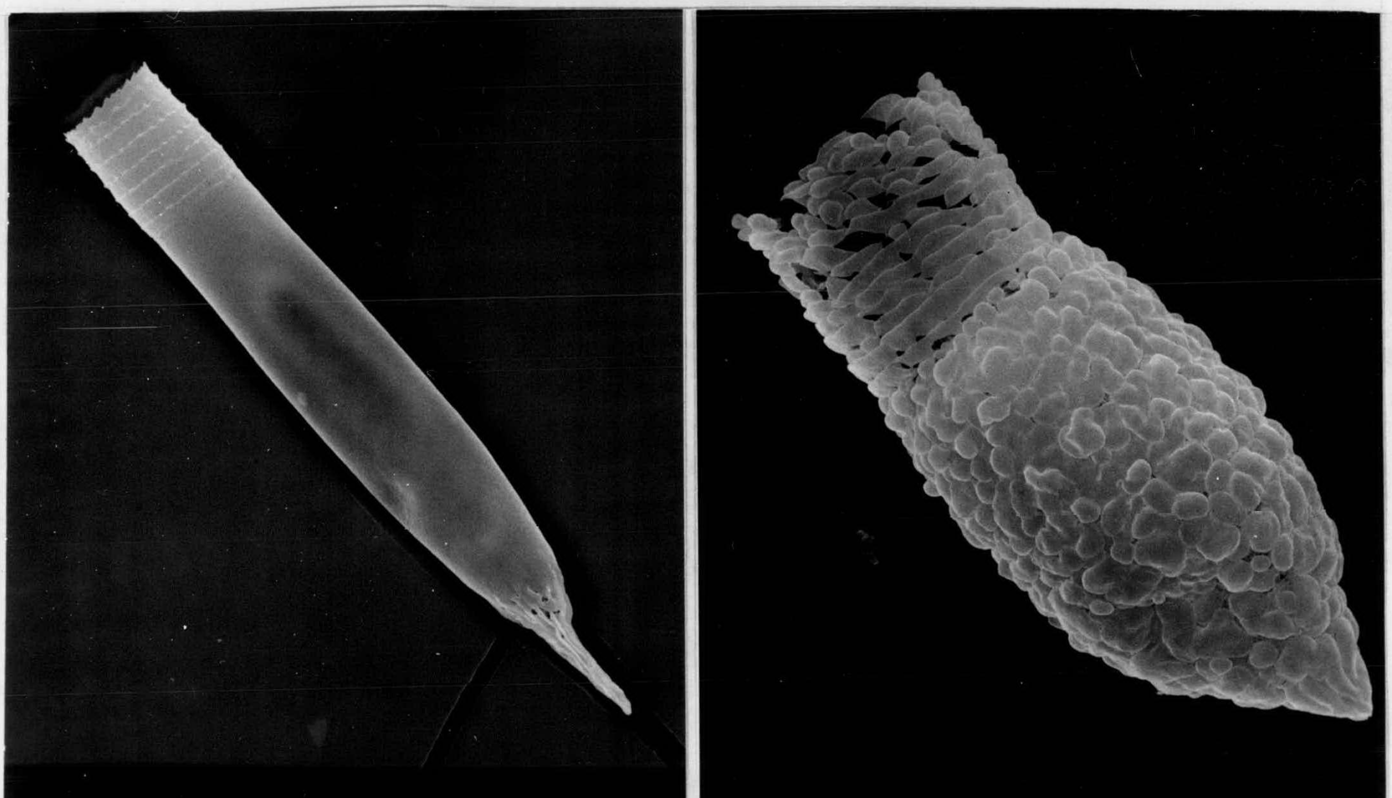

Fig. 3

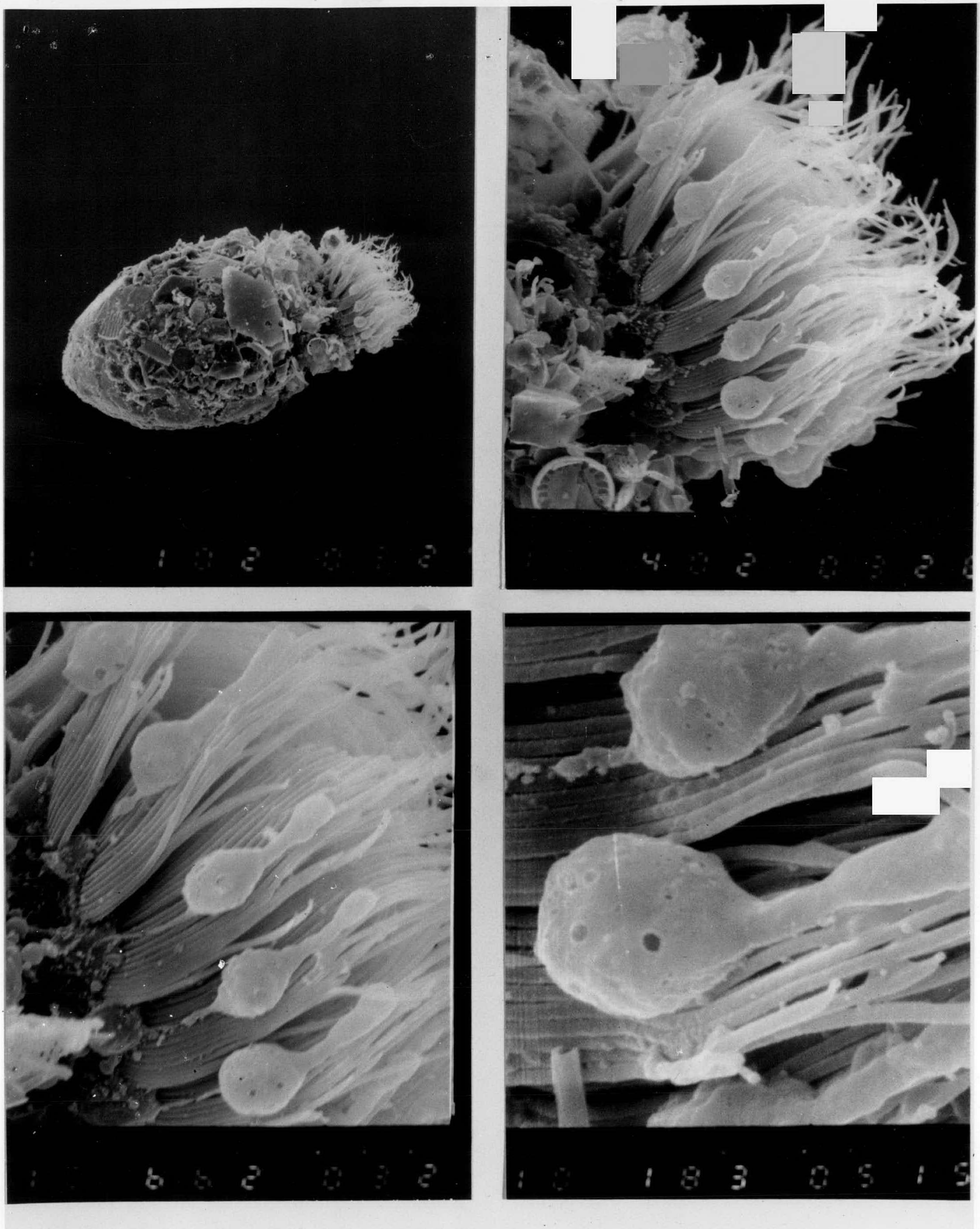

Fig. 4