Ultrastructure of the Plasmodial Slime Mold
Perichaena vermicularis

I. Plasmodium

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With 15 Figures

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Summary

Mature plasmodia of Perichaena vermicularis require a light period to induce sporulation. In this paper the ultrastructure and acid phosphatase localization of the mature plasmodium of Perichaena vermicularis are investigated. Acid phosphatase is localized in vacuoles containing remnants of bacteria and cell organelles. Morphological and histochemical evidence support the interpretation that these vacuoles constitute two types of lysosomes called respectively heterophagic and autophagic vacuoles. Coated vesicles which apparently originate from smooth endoplasmic reticulum are dispersed throughout the plasmodium and frequently associated with lysosomes. Several dumbbell-shaped mitochondria are observed in the plasmodium at the onset of fruiting but not during later stages of plasmodiocarp development. Cytoplasmic microtubules are identified in Perichaena vermicularis. Some of these are closely associated with microfilaments.

1. Introduction

Studies concerning the fine structure of the plasmodial stage in the myxomycetes are numerous. After Leewy (1952) extracted a contractile protein from Physarum polycephalum, investigators were interested in finding filaments which could serve as the motive force for protoplasmic streaming (Spoulsler and Bath 1953, 1954, Stewart and Stewart 1959, 1960, Téada 1962). However, no plasmodial filaments were observed until Wohlforth-Bottermann (1962) identified filaments with a diameter of 70 Å in Physarum

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2 This constitutes a portion of a thesis presented to the Regents of the University of California by the first author in partial fulfillment of the requirements for the Ph. D. degree.
polycephalum. The presence of these structures in other myxomycetes was soon verified by McMANUS (1965), and McMANUS and ROTH (1965). RHEA (1966) and DANIEL and JÄRLFORS (1972 a) have made extensive studies of the location and distribution of filaments in Physarum polycephalum. Recent investigations identify 70 Å microfilaments in situ as F-actin and this is additional evidence of the role of filaments in protoplasmic streaming (see ALLÉRA et al. 1971).

The ultrastructural components of myxomycete plasmodia have been examined by DUGAS and BATH (1962), TERADA (1962), and McMANUS (1965). Several investigators have described mitosis during the plasmodial stage (see RYSER 1970). KAZAMA and ALDRICH (1972) have examined the distribution of acid phosphatase in food vacuoles and other organelles of the myxamoebae of Physarum flavicumum. However, ultrastructural studies of sequential development in a myxomycete from a plasmodial stage through spore formation are rare.

Plasmodia of P. vermicularis require a small, as yet undetermined amount of light after the fifth day in culture in order to produce plasmodiocarps (Ross 1973). The mature plasmodium of P. vermicularis is colorless, with well developed fans and streaming channels (Ross 1967 a).

We have examined the development of P. vermicularis beginning with the plasmodium, which has received the required light period to induce sporulation, through the formation of the mature plasmodiocarp. This paper is one of a series about the ultrastructure and enzyme localization in P. vermicularis and is concerned with the mature plasmodium. We have examined and identified various kinds of vacuoles which contain acid phosphatase, and acid phosphatase localization in other membrane-bounded structures is discussed. Ultrastructural relationships which have not been described previously in plasmodia are reported, such as the association of microtubules with microfilaments.

Fig. 1 is a brief outline of the life cycle of P. vermicularis (Ross 1967 a und b). First the spore (A) germinates to form a myxamoeba (C) which may transform into a flagellated swarm cell (B) in a liquid environment. The myxamoebae fuse (D) and produce a zygote (E), and the zygotes develop into a multinucleate plasmodium (F) by nuclear divisions. The plasmodium, after a period of vegetative growth and photoinduction, differentiates into one

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Fig. 1. The life cycle of Perichaena vermicularis begins with the germination of the spore (A) and ends with completion of plasmodiocarp (G) maturation. See the text for details

Fig. 2. Perichaena vermicularis. Cross-section of the mature plasmodium showing the main components of this stage including the plasma membrane (PM), cortical layer (CL), large, conspicuous vacuoles (V), mitochondria (M), and lipid droplets (LD). Escherichia coli (EC) cells are embedded in the invisible slime layer which covers the plasma membrane and in vacuoles. ×7,890