

Preface

Endosymbiosis is a primary force in eukaryotic cell evolution. Recent studies of algal evolution have shown that this phenomenon has occurred several times and has yielded a wide diversity of eukaryotic cells. Despite the importance of this phenomenon, however, molecular mechanisms for induction of endosymbiosis between different microorganisms are not so well known. How can a symbiont invade the host cytoplasm? How can the symbiont avoid digestion by the host's lysosomal enzymes? How can the symbiont grow synchronously with the host cell? How are symbionts transferred to daughter cells when the host cell divides? Through endosymbiosis, what merit does the host cell obtain to adapt to new environments and to augment its survivable environments? To elucidate these questions, experiments for reestablishment of the endosymbiosis by symbionts isolated from the symbiont-bearing host cells and the symbiont-free host cells are indispensable. In many endosymbiotic communities, however, both the endosymbionts and the aposymbiotic host cells have already lost the ability to survive and grow independently.

Ciliated protista belonging to species of *Paramecium* are extremely valuable cells that allow experiments on the reestablishment of the endosymbiosis, and they frequently bear prokaryotic or eukaryotic or both endosymbionts in the cell. To date, about 60 bacteria (Görtz and Fokin and Fokin and Görtz, this volume), various *Chlorella* species (Hoshina and Imamura, Kodama and Fujishima, Kato and Imamura, Miwa, and Sommaruga and Sonntag, this volume), and yeasts are known as endosymbionts of *Paramecium* species. Probably, the prominent phagocytic activity of the *Paramecium* cell is a cause for acquisition of various endosymbiotic organisms. The importance of *Paramecium* species for studies of such symbioses is that these species retain the ability to grow without the endosymbionts. Although most endosymbiotic bacteria of *Paramecium* species cannot grow outside the host cell as a result of their reduced genome size, even when they are isolated from the host cells they can maintain their infectivity to new host cells for a limited time (Görtz and Fokin, Fokin and Görtz, Fujishima, and Schrällhammer and Schweikert, this volume). Consequently, reestablishment of endosymbiosis between the symbiotic bacteria-free host cells and the symbionts isolated from the host cells is easily done by mixing them. After endosymbiosis, the bacteria alter the host gene expression; the host thereby acquires resistance against various stresses, providing an excellent opportunity for us to elucidate not only the infection processes but also to assess the

associations leading to eukaryotic cell evolution (Fujishima, this volume). On the other hand, *P. bursaria* is the only species of *Paramecium* that forms symbiotic relationships with green algae belonging to the genus *Chlorella*. The algae-free host cells and the symbiotic algae retain the ability to grow without a partner. Their mutual endosymbiosis is readily reestablished by mixing them. The finding of four checkpoints for the reestablishment of the symbiosis with the algae reveals that *P. bursaria* is an excellent model for studying the infection process of the algae and the evolution of eukaryotic cells through secondary endosymbiosis between protozoa and algae (Kodama and Fujishima, this volume).

Following earlier published reviews (Fokin 2004; Görtz 1983, 1986, 1988; Preer 1948; Preer et al. 1974; Quackenbush 1988; Sold 1974), great progress has been made in the study of endosymbiosis in *Paramecium*. This book is the first monograph on the endosymbionts of the ciliates, and comprises nine chapters. We know of other topics, some of which were not included in this book, with rapidly developing investigations. We made efforts to cite papers from such research areas in related chapters. It is our hope that the omissions displease neither the researchers involved in those regrettably excluded topics nor readers who might be interested in them.

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