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## Introduction

*„Es ist schlimm genug,” rief Eduard,  
„dass man jetzt nicht mehr für sein ganzes Leben lernen kann.  
Unsere Vorfahren hielten sich an den Unterricht,  
den sie in ihrer Jugend empfangen;  
wir aber müssen jetzt alle fünf Jahre umlernen,  
wenn wir nicht ganz aus der Mode kommen wollen.”*

Johann Wolfgang Goethe, *Die Wahlverwandschaften*, 1807

*“It is bad enough,” said Eduard,  
“that our learning does not last for our whole life.  
Our ancestors could hold onto the learning that they acquired in their youth;  
we have to relearn everything every five years, just to remain fashionable.”*

(Author’s translation)

This volume summarizes our knowledge on a group of diverse and “unusual” cell organelles. It is published at a most appropriate time when it seems that a consensus is emerging about the nature of these entities. Evidence accumulating over the past few years has brought home the prodigal sons of the mitochondrial family. Hydrogenosomes and mitosomes are now within the fold of the well-known and respected organelle family that includes the “powerhouses” of the aerobic eukaryotic world. Chapters in this book describe in detail these organelles which exhibit a bewildering array of characteristics but according to an emerging consensus of most biologists all are mitochondria in different guises. They are assumed to represent a monophyletic group of biological entities that originated from an ancestral endosymbiotic event that gave rise to the protomitochondrion. Of course the emerging consensus does not mean that there are no dissenters in many quarters of the biology community. What convincing arguments today might not turn out to be red herrings tomorrow? The history of the past 30 or so years gives ample warning. Our views and theories related to this field have changed drastically so many

times during these years that we cannot be certain that future surprises are not lurking around the corner.

At any rate, this book takes stock of the status quo. It presents a cast consisting of double-membrane bounded organelles of eukaryotic protists and fungi, which live under anaerobic or hypoxic conditions, as well as certain intracellular parasites of aerobic cells. The common denominator of these organelles is that they lack the aerobic energy conservation system of typical mitochondria, i.e. the cytochrome-dependent electron transport chain and oxidative phosphorylation. Another common denominator is that—one curious exception disregarded—they are the site of a process, the synthesis of iron–sulfur clusters, which is regarded today as the only really indispensable function of eukaryotic mitochondria. These organelles exhibit, however, properties and characteristics in so many different combinations that all generalizations of the group (beyond the just-mentioned major negative and positive hallmarks) would be futile, i.e. any general definition would require more qualifications than unequivocal statements.

As evident from the individual chapters, the major members of this family are the mitosomes, small organelles without a known role in energy metabolism, and the hydrogenosomes, organelles of the approximate size of mitochondria, characterized by their ability to produce molecular hydrogen as a metabolic end product. Recent evidence, however, has revealed that the latter organelles can be quite different, anywhere from typical mitochondria to organelles that do not resemble mitochondria at all. The individual differences within these groups are so great, and the boundaries between them so undefined, that no generally acceptable nomenclature has yet emerged. Each investigator uses a different designation for his/her organelle.

I wish to emphasize the perhaps most significant aspect of the emerging consensus. The distribution of these organelles in the living world is broad. They are found in certain members of almost all of the currently recognized major evolutionary lineages of eukaryotes. Their presence seems to be primarily correlated with the ecology of the organisms, which live in an anoxic habitat or in a nutrient-rich intracellular niche that permits life without the efficient energy-generating system of typical mitochondria. This distribution argues strongly for the hypothesis that diverse mitosomes and hydrogenosomes arose independently, and repeatedly, during the diversification of the eukaryotes. Convergent evolution in action! It also argues strongly against the earlier assumption that the presence of these organelles could represent an ancestral, pre-mitochondrial state.

As mentioned above, the road leading up to the present state of affairs was convoluted, and often terminated in dead-end streets. We had to change our views and hypotheses repeatedly, had to relearn everything, just as Eduard was required to relearn everything two centuries ago. This foreword is not the place to recount the history of our views of these organelles. I gave an account of the events leading up to the first description of a hydrogenosome in another

place (Müller, 2007), and so I hope that someone will tell us the story as it has unfolded during the intervening years.

I wish to add some personal remarks here. I was very pleased when the editor of this volume, Honza Tachezy, asked me to write a brief foreword and I thank him very much. I am certain that this book will play a major role in the future development of this exciting area of comparative and evolutionary biology. Little did Don Lindmark and I think in 1973 that our description of an unusual cell organelle from a group of odd parasites would give the first push to the unfolding of what turned out to be a most exciting story in evolutionary cell biology (Lindmark and Müller, 1973). It is a great personal satisfaction to me, and I am sure, to all those who were with me at various times, to see where our endeavors have led. I look forward to seeing what the future holds.

Lastly, I wish to acknowledge the unfailing support and friendship of my mentor Christian de Duve. It was in his Department at Rockefeller University where Don and I performed the initial experiments, and where I have spent many productive years. I would like to thank all the past members of my group who were responsible for all their own work on these organelles. I also thank all those colleagues working in diverse parts of the world who believed in the promise this field held and carried the torch further. I received much moral support from them, however, they are too numerous to be named here. I also acknowledge the uninterrupted support of our original work at the Rockefeller University for almost 30 years by the same NIH grant (AI 11942) and also by several grants from NSF.

The Rockefeller University, New York  
and Collegium Budapest, Budapest, September 2007

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Hydrogenosomes and Mitosomes: Mitochondria of  
Anaerobic Eukaryotes

Tachezy, J. (Ed.)

2008, XII, 287 p., Hardcover

ISBN: 978-3-540-76732-9