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Preface

The evolutionary aspects of bioenergetic systems

The universality of the genetic code is traditionally brandished as the hallmark of the unity of all life on this planet. The fact that the code is universal represents the very foundation for molecular phylogeny, our most powerful tool to date to uncover the evolutionary history of life almost all the way back to its origins. It was indeed molecular phylogeny which came up with the concept of a Last Universal Common Ancestor of Bacteria, Archaea and Eukarya, the LUCA, the mother of all extant cellular life so far detected. Of course, the complexity of the LUCA, which has become apparent since its conceptual creation, implies that it must have corresponded to a community of cells indiscriminately exchanging genes rather than a single organism. Now, if LUCA was already sophisticated life, what then came before?

Biology's standard answer to this question presently appears to be: the RNA-world and its metabolism mediated by ribozymes instead of protein- and cofactor-based enzymes. So are RNA polymers the first unmistakable feature of life? Encouraged and backed by thermodynamics, I would argue without hesitation that another feature of cellular life must be even older than the putative ribozymes: energy conversion, *i.e.* bioenergetics! Exploring the evolutionary history and thereby ultimately the roots of bioenergetics may indeed take us even closer to life's origin than the proposed RNA world. Furthermore, whereas the RNA-world so far remains a hypothetical construct, basic thermodynamics assures us that a kind of primordial bioenergetics playing midwife in life's emergence MUST have existed.

Of course, one might argue that the energy converting mechanism allowing the extraordinary entropy-decreasing machine "life" to originate may have been very different from what we see today, almost 4 billion years later, in extant life. And doesn't the bewildering diversity of energy harvesting mechanisms in modern species indicate that, in striking contrast to the genetic code, energy conversion isn't universal? This latter argument may have appeared valid still 20 years ago. Certainly not so anymore today. X-ray structure resolution, genome sequencing, bioinformatic methods and, most importantly, in-depth biochemical and biophysical analyses of the various, seemingly dissimilar, bioenergetic systems have reversed the trend: What used to be an increasingly confusing multitude of energy metabolisms has turned into an, admittedly large, family of related systems. Although our understanding of the mutual family relationships is still in its infancy, the potential to eventually trace back the evolutionary history of The Bioenergetic System is undeniably unfolding in front of our eyes.

Evolutionary pathways of a given bioenergetic metabolism and its family ties to other energy converting systems are frequently addressed as side-aspects of articles, reviews and volumes dedicated to the specific metabolism. Serving as guest editor for this special issue of BBA Bioenergetics provided me with the opportunity to shift the focus and put "The Evolution of Bioenergetics" centre-stage. The contributors to this special issue have agreed to specifically treat evolutionary aspects of their favourite energy converting systems and to highlight relationships and similarities with other types of bioenergetic electron transfer chains. Inevitably, only a very small subset of the vast family of energy converting mechanisms could be dealt with in this collection of articles. However, even this small subset bears witness to the appeal and strength of the comparative approach to the evolution of bioenergetics. It also pinpoints several controversial and hotly debated issues, which is, I would argue, natural and fitting for a young and emergent research topic.

I would like to thank all participants in this special issue for their contributions as well as the numerous reviewers for their help. I am furthermore grateful to the BBA Editorial Staff and in particular I have to say thank you to Sandra Tokashiki for her help and superhuman patience with an often distracted guest editor.

I am fully aware that the colleagues having participated in this special issue represent only a small subset of the community sharing our vision outlined above and I apologise to all those who couldn't be contacted due to space and time schedule limitations.

Finally, I would like to take this opportunity to encourage our community to not be afraid of putting forward the evolutionary aspect of our research. Spending taxpayers' money for studying microbial bioenergetics is mainly, and rightfully so, justified by the struggle to avert our society's Damocles sword, *i.e.* shortage of energy supply. However, we should not be shy to say that research in bioenergetics also has a substantial word to say in our quest to reconstruct the origin and subsequent history of life on this planet. For this claim, we have the 2nd law of thermodynamics on our side.

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