

Preface

It took quite a long time to complete this book. More than 20 years had elapsed since I wrote my last volume as an author, not just as an editor. And I felt it important to find again the breadth of reasoning that a book allows, or rather demands, thus going beyond the length limitations of single scientific papers. I had been working for some years on protocell models, a definitely important and fascinating topic, so in 2012 I proposed to Aldo Rampioni to write a new book, and a contract with Springer was signed.

I had guessed that probably a year-and-a-half time would have been necessary, but in the end it took more than four years. And in the meantime, the flavour of the book changed; while this is of course not uncommon, I think it is interesting to explain why. My original idea was that of providing an overview of the most relevant models, but as time passed new things happened. My colleagues and I were able to develop a series of protocell models that are different from most of the existing ones, and that can take into account several aspects while still being manageable. Therefore, I decided to shift the balance of the book; while the most important models are mentioned, they are not discussed in such depth as our models are. This shift in attitude also motivated the idea to associate my friend and colleague Marco Villani, with whom a large share of the work had been done, to the actual writing of the book. While this is a joint book, Marco's contributions are mainly found in Chaps. 4 and 5: he wrote the first drafts that were later discussed together and modified. The same happened, inverting the roles, to the other chapters, where I wrote the first drafts.

This shift of the focus of the volume also explains some choices concerning the references. We do not try to provide a complete bibliography of protocell research, nor of protocell models. There are some important recent books and reviews that fill this need, quoted in Chap. 1, so we limit here to mention the papers that have been most important in shaping our understanding of the field, and in inspiring our modelling choices. However, we also think that the reference list provided in the volume suffices for the reader as a starting point to deepen her understanding of any aspect of protocell research that may be of interest.

The motivations of our studies are described in detail in the book, so I will not anticipate them: let it suffice here to say that they were largely due to the gap that exists between what one might expect on the basis of the results of various theoretical models, and the behaviours that are actually observed in the laboratory. Different models suggest that sets of molecules able to self-replicate should spontaneously appear, provided that, from the very beginning, there are many different molecular types, while experiments do not show this feature. In some cases, it has been possible to develop sets of collectively self-replicating molecules, but they are carefully designed by smart chemists. This difference between theory and experiment cannot be ignored, since it is not a matter of quantitative imprecision, but it implies qualitatively different outcomes. And since self-replication is one of the main features of life, it is of the utmost importance.

So our models aim at providing indications about the possible reasons of this gap. But this is not the whole story: we think that these models can be further improved, and that they, or their improved offspring, can be the basis for designing new experiments, and new processes that will be able to generate real protocell populations, able to grow and to evolve.

Indeed we hope that some smart experimentalists (there are many in this field) will be able to use these indications (and others! We are not alone in this business) to actually synthesize a sustainable protocell population, i.e. to achieve a scientific result of enormous importance, both for practical and for theoretical reasons. Among the former, let me mention the possibility of an entirely new “bio” technology, which might deliver very useful microscopic devices for various medical, environmental and industrial applications. On the other hand, its theoretical importance would not be limited to the field of soft matter physics and chemistry (albeit this is extremely important in its own) but would also affect our understanding of the possible origins of life, thereby also influencing our understanding of our place in the world.

I am indebted to several colleagues, and only some of them will be recalled here. David Lane, an extremely bright scientist and a deep thinker, proposed me to move from industry to academia, a shift that is entirely uncommon in Italy, and that has been extremely important in my life: thank you, David! Stuart Kauffman is an extraordinarily creative scientist who inspired my work and encouraged my group and me, appreciating our results, providing illuminating suggestions and inviting us to important meetings in Calgary and Geneva. Irene Poli, former head of the European Centre for Living Technology in Venice, supported us and gave us the opportunity to develop our research in a particularly stimulating scientific environment. I also thank the participants to the EU project PACE (Programmable Array of Cells, led by John McCaskill) for introducing me to the field of protocell research, and in particular Norman Packard, Steen Rasmussen and Ruedi Fuchslin. I also gratefully acknowledge the support of the Università di Modena e Reggio Emilia and of the European Centre for Living Technology, and the contribution of the European Union which financed the PACE project.

I also benefited from the collaboration of some very smart PhD students and post-docs, the most talented among them being Alessandro Filisetti, now at Explora in Venice, Chiara Damiani and Alex Graudenzi, now at the University of Milano-Bicocca. They decided to remain in Italy, and the bad conditions of scientific research in my country have not yet allowed them to get the permanent positions in universities that they deserve, so best wishes for your next years!

I wish also to thank Timoteo Carletti, now at the University of Namur, who played a major role in the development of our work on synchronization in protocells.

I am also deeply indebted to Marco Villani, with whom I shared almost all my best research in the last 20 years. Marco is bright and fast-thinking, and I am happy to collaborate with him. However, now Marco is a co-author, so I do not really need to thank him here.

I have been extremely lucky in meeting Aldo Rampioni from Springer and his assistant Kirsten Theunissen. Aldo and Kirsten have always shown interest in our project and patience for our delays; they supported us in many ways, and their contribution and advice have been fundamental for reaching completion of this work. Writing takes time and effort, and I had to pursue different duties at the same time: not only doing scientific research and teaching (both quite demanding activities!) but also keeping up with the increasing bureaucratic burden that Italian universities impose upon professors. So I sometimes felt inclined to leave the project, but the continuous interest and stimuli from Aldo and Kirsten have been fundamental in resisting this temptation.

In the end, let me thank my wife Elena for her patience when I spent hours writing and re-writing, and above all for her support in all the important choices of my life. When I moved from industry to academia, I gave up a well-paid job, as director of a research centre of a major industrial group, to enter an uncertain territory where I had no guarantees (research in Italy is always endangered, and in those years the government had issued a crazy prohibition for universities to hire new professors). I was lucky enough that the regulations changed, so I became full professor at the Università di Modena e Reggio Emilia in a few months, but Elena never complained, nor did she try to make me change my mind, on the grounds of the uncertainties. Moreover, she is very skilled in English language, and she helped us in revising the style of some chapters. So thank you Elena!

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Modelling Protocells

The Emergent Synchronization of Reproduction and
Molecular Replication

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