

Preface

Emerging Topics in Physical Virology is a state-of-the-art account of recent developments in the analysis and modelling of virus structure, function and dynamics. It pays tribute to the importance of interdisciplinary research by integrating an exposition of experimental techniques such as cryo-electron microscopy, atomic force microscopy and mass spectrometry with mathematical and biophysical modelling techniques. The number of chapters co-authored by experimentalists and theoreticians is testimony to the importance of interdisciplinarity in tackling some of the most challenging and exciting research problems in this area.

The aim of this book is to introduce the reader to recent developments in the field, and to provide a comprehensive review of the results that prompted them. It is therefore not only a primer for researchers working in the analysis and modelling of viruses, but also serves as an introduction for non-experts into this tantalising field of research. The book starts with a description of cryo-electron microscopy by Neil Ranson and Peter Stockley and demonstrates its power in determining the structure and dynamics of viruses. Structural insights gained from X-ray crystallography have revealed an intriguing phenomenon: there is a striking conservation in the topologies of the capsid proteins that form the containers encapsulating viral genomes. This has prompted Dennis Bamford, David Stuart and collaborators to classify viral families into lineages based on the concept of the viral 'self'. An important feature of this conservation of capsid protein folds is that it appears to be non-sequence-specific, i.e. the chemical structures of proteins with homologous folds can often be very different. This suggests that there must be a guiding principle for the formation of the capsid proteins that is independent of their sequences. Thomas Keef and Reidun Twarock suggest that the icosahedral symmetry of many viruses may provide such a guiding principle, and they introduce novel group theoretical techniques to model this effect. Their approach implies that a wide spectrum of viral features can be predicted based on symmetry, and that perhaps the limited number of structural folds is a

consequence of the fact that only a limited number of layouts are possible for viruses with such symmetry.

Atomic force microscopy provides important insights into the mechanical properties of viruses as detailed in the chapter by Wouter Roos and Gijs Wuite. The authors discuss capsid shell structure, presence of encapsidated material, capsid failure, maturation and capsid protein mutations in relation to viral material properties and highlight similarities and differences for different types of viruses. Another important experimental technique in the study of viruses is mass spectrometry. Eric Monroe and Peter Prevelige show how this technique can be used to gain invaluable information on viral proteins. Mass spectrometry can also play a crucial role in the study of virus assembly, i.e. the process of formation of viral particles from their protein building blocks and genomic material. An overview of capsid assembly kinetics is provided by one of the pioneers in this area, Adam Zlotnick, and his collaborator Zachary Porterfield. Their chapter covers both modelling and experimental techniques and provides a comprehensive overview of viral capsid kinetics. An important factor in virus assembly and disassembly is the mechanical stress on different components of the viral capsid. A beautiful account of how stress distributions impact on the assembly and disassembly of viral capsids formed from pentamers and hexamers is provided by Robijn Bruinsma and collaborators.

Viruses may package genomic material in the form of DNA or RNA. An important question concerning the formation of RNA viruses is 'what determines the size of an RNA virus?' It is addressed by Chuck Knobler and Bill Gelbart in their discussion of the correlation between capsid and genome sizes. The impact of genome length versus capsid size on the physics of viral infectivity is also discussed with respect to double-stranded DNA (dsDNA) phages by Alex Evilevitch and Martin Castelnovo. Another intriguing feature of packaged DNA genomic material is its topology. Together with their experimental collaborator Joaquim Roca, Jarvier Arsuaga and De Witt Sumners provide a comprehensive account of the mathematical and experimental analysis of the topology of viral DNA.

A volume on emerging topics in physical virology would not be complete without a discussion of the fascinating applications of viruses and virus-like particles in biomedical nanotechnology that are opened up by

these recent theoretical and experimental approaches. We therefore conclude with a chapter by Kristopher Koudelka and Marianne Manchester that discusses the state of the art in this area.

We would like to express our special thanks to the authors of these fascinating chapters for making this volume possible by sharing their exciting research with us.

Contributors

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Preface

Chapter 1:	Cryo-Electron Microscopy of Viruses	1
	<i>And A. Rangan and Peter G. Stockley</i>	
Chapter 2:	What Does It Take to Make a Virus?	35
	The Concept of the Viral 'Self'	
	<i>Isabel G. A. Alvarez, Jonathan H. Gammie,</i>	
	<i>Elizabeth E. Fry, Janne J. Rantala,</i>	
	<i>Leanne H. Randall and David L. Stuart</i>	
Chapter 3:	Beyond Quasi-Equivalence: New Insights	59
	Into Viral Architecture via Affine Extended	
	Symmetry Groups	
	<i>Tomasz Kogut and Reidun Twarock</i>	
Chapter 4:	Mechanical Properties of Viruses	85
	<i>Walter H. Reid and Gips J. L. White</i>	
Chapter 5:	Investigating Viral Structure, Function	103
	and Dynamics with Mass Spectrometry	
	<i>Eric B. Mowbray and Peter E. Prentiss</i>	
Chapter 6:	An Overview of Capsid Assembly Kinetics	131
	<i>J. Zachary Porterfield and Adam Zlotnick</i>	
Chapter 7:	Assembly and Disassembly of Dehydrothermal	139
	Viral Shells	
	<i>Alexander Tu, Marston, Joseph Paulovich,</i>	
	<i>Leijun F. Brannstrom and William S. Kluge</i>	
Chapter 8:	What Determines the Size of an RNA Virus?	185
	<i>Charles M. Kneller and William M. Gelbart</i>	