

*Ultrastructure of
Bacterial Viruses*

Ultrastructure of Bacterial Viruses

Anna S. Tikhonenko

*Institute of Molecular Biology
Academy of Sciences of the USSR
Moscow, USSR*

Translated from Russian by

Basil Haigh

Cambridge, England



PLENUM PRESS • NEW YORK-LONDON • 1970

Library of Congress Catalog Card Number 69-17902

ISBN-13: 978-1-4684-1781-4 e-ISBN-13: 978-1-4684-1779-1
DOI: 10.1007/978-1-4684-1779-1

The original Russian text, published for the Scientific Committee on Problems in Molecular Biology of the Academy of Sciences of the USSR by Nauka Press in Moscow in 1968, has been corrected by the author for this edition. The translation is published under an agreement with Mezhdunarodnaya Kniga, the Soviet book export agency.

Анна Сергеевна Тихоненко

УЛЬТРАСТРУКТУРА ВИРУСОВ БАКТЕРИЙ
UL'TRASTRUKTURA VIRUSOV BAKTERII
ULTRASTRUCTURE OF BACTERIAL VIRUSES

© 1970 Plenum Press

Softcover reprint of the hardcover 1st edition 1970
A Division of Plenum Publishing Corporation
227 West 17th Street, New York, N. Y. 10011

United Kingdom edition published by Plenum Press, London
A Division of Plenum Publishing Corporation, Ltd.
Donington House, 30 Norfolk Street, London W.C.2, England

All rights reserved

No part of this publication may be reproduced in any form
without written permission from the publisher

This book is
dedicated to my mother
Aleksandra Davydovna Sheinina

Introduction

After the discovery of the tobacco mosaic virus by D. I. Ivanovskii in 1892 [14], the new science of virology was born and began to develop rapidly.

The number of viruses now known is enormous and they can infect nearly all animal and plant organisms. Microorganisms themselves are no exception to this rule.

Despite intensive study of viruses, their origin and nature are still a subject for speculation and hypothesis.

The general concept of viruses embraces a wide group of biologically active structures occupying an intermediate position between living and nonliving matter. The dual character of viruses is determined by the fact that, while they do not possess an independent system of metabolism, which is a characteristic feature of every living being, they nevertheless carry within themselves all the necessary information for autoreproduction.

A striking feature of the virus is that it consists essentially of two components: a protein envelope and the nucleic acid contained within it.

In contrast to the elementary structural unit of the living organism, the cell, which contains two types of nucleic acid (DNA and RNA), the virus particle contains only one type of nucleic acid – either DNA or RNA. It is perhaps this which is responsible for the imperfection of the virus as a living organism.

Unlike living cells, viruses cannot reproduce by any way known for cellular organisms (by division or gemmation). For their reproduction they utilize the energy resources of another,

more highly organized, living system. After infecting the host cell, viruses lose their morphological individuality, and they do not persist as specific structures throughout their cycle of development. The formation of individual structural components of the virus takes place separately within the cell, and it is only at the final stage of intracellular development that they come together to form the mature virus particle.

An extremely characteristic feature of viruses is the strict consistency of their shape and size.

Early electron-microscopic investigations established that most viruses of animals and plants are either rod-shaped or spherical.

In 1941, Ruska [320] showed for the first time that the viruses of bacteria, or bacteriophages, as a rule, are particles of characteristic shape resembling spermatozoa.

The relatively simple organization of viruses, carrying their own genetic system providing for autoreproduction and variation, has attracted the attention of investigators seeking to solve fundamental biological problems.

Bacterial viruses, because of their comparative accessibility and the simplicity of working with them, have proved to be the most convenient viruses for analysis of major virological and general biological problems.

Bacteriophagy as a general biological problem has developed rapidly in the last 20-25 years and has attracted specialists in different fields of science. It should be pointed out that the progress made in many of the fundamental theoretical problems in modern biology is largely bound up with the study of phages. In recent years, phages have occupied the center of the stage as a model for the study of the basic problems in molecular biology. It was this model which was used for classical investigations to study the fine structure of the gene, to decipher the genetic code, to study the mechanism of transmission of information for protein synthesis and so on.

The study of the macromolecular structure of phages is accordingly of considerable interest. It forms the subject of this monograph, which is based largely on the results of investigations carried out by the author and her collaborators.

Contents

Chapter 1. Electron-Microscopic Methods of Investigation of Bacteriophages.	1
The Supporting Grids	1
Preparation of the Mounting Film	2
Methods of Preparing Suspensions of Bacteriophages	8
Methods of Obtaining Concentrated Suspensions of Phages	9
Purification of Biological Preparations	11
Contrasting of Objects	17
Methods of Fixation of Bacteria for Preparation of Ultrathin Sections	22
Terminology	24
Chapter 2. Classification of Phages Based on Morphological Characteristics	29
Chapter 3. Filamentous Phages and Phages with Tail Analogs	33
Filamentous Phages (Group I)	33
Phages with Tail Analogs (Group II)	36
Chapter 4. Short-Tailed Phages (Group III)	63
Subgroup I: Phages of Type T3 and T7	66
Subgroup II: Phages of Type P22, s_d	69
Chapter 5. Phages with a Noncontracting Tail (Group IV)	77
Structural Variation among Phages with a Noncontracting Tail	88

Chapter 6. Phages with a Tail Possessing a Contractile Sheath (Group V)	101
Phage T2	110
Phage No. 1 of <i>Bacillus mycoides</i>	121
Phage N19 of <i>Bacillus mycoides</i>	131
Phages of <i>Bacillus subtilis</i>	135
Staphylococcal and Streptococcal Phages	143
Chapter 7. Defective Phages and Bacteriocins	147
Chapter 8. Action of Chemical and Physical Agents on Various Phages	161
Action of pH	166
Urea and Other Agents Breaking Hydrogen Bonds	181
Detergents	187
Freezing and Thawing	192
The Effect of Temperature	196
Action of Adenosinetriphosphatase on Phages	209
Chapter 9. The Aggregative Properties of Phage Proteins	217
Polysheaths	219
Polyrods	227
Polyheads	230
Chapter 10. Phosphatase Activity of Phages and Some Properties of the Contractile Phage Protein	237
Localization of Phosphatase Activity in Structural Elements of Phage T2	242
Physicochemical Properties of the Contractile Protein of Phage T2	245
Chapter 11. Organization of Phage DNA During Its Replication in the Bacterial Cell	255
Conclusion	267
Literature Cited	271
Index	291