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Bacteriophage Genetics

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I. INTRODUCTION

Bacteriophages, or bacterial viruses, have been major research tools for molecular biology, and the history of research with them is virtually a history of molecular biology itself

(see Cairns et al., 1966). In this chapter we focus primarily on the large, virulent T-even

coliphages (viruses of *Escherichia coli*) because of the central role they have played in the development of our understanding of many fundamental processes and control mechanisms. For example, they were first used to demonstrate that viruses can direct the synthesis of enzymes that the host was not previously capable of making, and thus they carry their own genetic information. Other important advances included demonstrations of DNA as the genetic material; the colinearity of gene and protein; the nonoverlapping triplet nature of the genetic code, with specific triplets used to signal the end of the protein; the existence and properties of messenger RNA; the processes leading to the assembly of complex functional structures; the mechanism of DNA replication; and the occurrence of DNA restriction and modification. Karam et al. (1994) give a thorough review of the work with these phages up to that date. We will therefore focus particularly on work since then, as well as on some of the most classical experiments. We will also look briefly at some *Bacillus subtilis* phages as parallel examples in gram-positive bacteria. In addition, temperate phages are considered by Hendrix (this volume) and small single-stranded phages by LeClerc (this volume).

II. THE CONCEPT OF A VIRUS

Viruses are too often discussed as if they are merely small, simple organisms. They are not. The distinction between the concepts of "organism" and "virus" was drawn clearly, and with great good humor, by Lwoff (1953) and Lwoff and Tournier (1966). Only confusion results from any attempt to meld them into a single category.

1. An organism is always a cell or collection of cells (or, sometimes, a multinucleated cytoplasm that is simply not divided by cell membranes). No virus has such a structure. A virus is a particle, called a *virion*, which consists of a nucleic acid genome enclosed in a protein covering, or *capsid*, of distinctive geometry (Fig. 1). The nucleic acid and

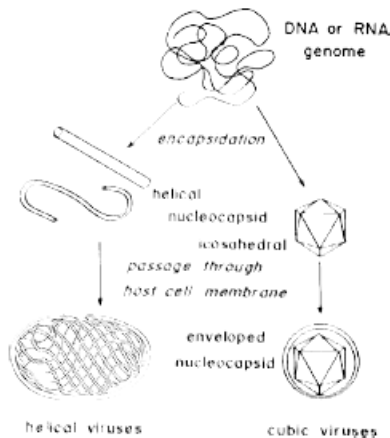


Fig. 1. A virion consists of a genome (either DNA or RNA) enclosed in a protein capsid, which has either a helical or icosahedral form. Some viruses mature by passage through a host-cell membrane, thus acquiring an outer envelope that encloses the nucleocapsid.

capsid together are known as the *nucleocapsid*. The nucleocapsid of some viruses is surrounded by an enclosing membrane, derived from the membranes of the host cell in which it was formed, but this in no way gives such a virion the properties of a cell.

- a. The virion contains only one kind of nucleic acid—either DNA or RNA—whereas every cell needs both kinds to function. Viruses reproduce solely using the information from this one nucleic acid (using additional machinery from the host), whereas organisms, including infectious organisms, reproduce by means of an integrated action of their nucleic acid constituents.
- b. Cells grow by enlargement and binary fission. No virus grows in this way. The virion is merely a vehicle for transporting the nucleic acid genome to another host cell. The genome enters the host cell and begins an infection, which results in production of a large number of new virions; the capsid is not reused.