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ORGANIC AND BIOMATERIALS CHEMISTRY

# LABORATORY EXPERIMENT 4<sup>\*</sup>

## Viruses as Materials

PreLab Questions:

1. What is a phage library, and why are bacteria used to replicate viral DNA sequences?
2. What are the approximate physical dimensions of a virus, and how does this contribute to the use of a virus as a material?

<sup>\*</sup>Special thanks to Chung-Yi Chiang of the Biomolecular Materials Group for assistance with phage amplification in the development of these experiments.

# I. Introduction

A virus is a particle contains nucleic acids within a protective coat of proteins and lipids called the capsid, but does not possess the cellular machinery (nucleus and organelles) to replicate that RNA/DNA and thus to replicate itself. Instead, viruses are parasites that reproduce by infecting cells and hijacking the machinery of the cells to make copies of viral DNA and thus viral gene products. Strictly speaking, a virus infects eukaryotes (which contain a nucleus), whereas a bacteriophage or phage infects prokaryotes including bacteria (which do not contain a true nucleus).

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Figure 1. (a) TEM micrograph of bacteriophage called SP105. Phage are typically 20 – 800 nm in length, with a capsid diameter on the order of 8 – 80 nm. (b) Schematic of virus components.

See: <http://pathmicro.med.sc.edu/mayer/phage.htm>

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Before we understood how viruses and phages worked, these particles were not much help to humans. As you know, viral infections cause human illness ranging from the common cold to HIV, and are difficult to target with vaccination because of rapid genetic mutation within the body. However, we increasingly take advantage of the dramatic replication potential of viral nucleic acids and gene products by manipulating the genome and environment of the virus itself. This approach enables genetic engineering (by

using viruses to introduce new DNA into cells that can express these gene products, as you explored via plasmids in Laboratory Experiment 3), engineering of new crystals with the potential for added function (by patterning viruses on inorganic surfaces), and new inorganic material structures (by selecting viruses to recognize and/or sequester inorganic particles such as metals and semiconductors). Material-binding functions are engineered by using phage libraries, which are collections of cloned fragments of bacteriophage DNA. Each unique DNA sequence is one member of this library, and such libraries are commercially available for specific bacteriophages. The high aspect ratio (length/diameter) of viruses contributes to the capacity to form dense, anisotropic material phases.

In this laboratory experiment, you will learn how phage are selected and engineered as materials that exhibit specific functions, including binding to inorganic materials, formation of liquid crystals, and formation of virus-based fibers. To use viruses at the high concentrations required for use as materials, it is necessary to amplify (increase the number of) the phage significantly, via replication in bacteria. We completed this large-scale amplification with the help of graduate student Chung-Yi Chiang; the protocol is described on page 9, for your interest.

## II. Objectives

The goals of this laboratory experiment are to:

- Module 1: Biopanning. From a phage library, select phage that bind specifically to a single-crystal silicon wafer of specific crystallographic orientation, and amplify these Si-binding phage.
- Module 2: Gold binding. Identify the population of M13 phage that has been targeted to specifically bind Au nanoparticles.
- Module 3: Liquid crystals. Determine the concentration of phage required to form liquid crystals.
- Module 4: Viral fibers. Synthesize fibers comprised solely of viruses, and determine the conditions required for strong, tough viral fibers.