A Virus is a Molecular Machine

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Viruses are made of nucleic acids, proteins, and sometimes lipids. They depend on cells for their replication. They are important in our lives primarily because of the diseases they cause in us, in animals that we live with, and in plants that we use. Our bodies are full of viruses that live in our cells in latent forms like Herpes viruses or retroviruses, as infectious agents, or as the thousands of kinds of bacteriophages that co-exist with our amazing human microbiome. It has been said that there are more bacteriophages than any other life form on our planet (at around 10 to the 31st power) viruses! These viruses have developed amazing and diverse ways of building infectious machines using self-assembly and assisted self-assembly pathways that will be shown here.

Today's talk will focus on these bacteriophages, because they provide models for the assembly and structure of many viruses. They are easy to grow, they replicate rapidly in bacteria, and they can be purified without hazards to the virologists or those around them. Modern structural biology combining data from X-ray diffraction and cryo-electron microscopy has provided beautiful images of the molecular details of these intricate machines. We will show images of how the tailed bacteriophages attach to their host cells and position them for the attack on the cell, and then drive a hole into the cell to

inject their genome into the cell. Many of the illustrations will come from studies on bacteriophage T4. One of the features of these and other similar viruses is that the structures have very exact dimensions. How are these molecular machines made with such precision? Work from our laboratory several years ago showed that there is an assembly of protein molecules in T4 called the Tape Measure Protein (TMP) that is used by the virus assembly machinery to measure exactly the length of the bacteriophage tail, and that this mechanism is used by many other viruses to control length.

Almost all viruses face the problem of how to “package” their genome into a protective coat to survive the rigors of their exposure outside of the cell. Many of the bacteriophages have evolved a packaging machine to move their nucleic acid genome into a pre-formed protein coat called a capsid. We will show how this happens in large DNA viruses. The goal of this talk is to show visually the structure and assembly of these amazing molecular machines, and to give a hint of the new results in the field of Nano-technology. We will also discuss the medical relevance of bacteriophages. Many detailed references to the structures seen in this talk can be found in the recently published book:” Viral Molecular Machines”, Rossman and Rao, editors, Springer, 2012.