

Chapter 2

Virus Structure and Classification

2.1 COMMON CHARACTERISTICS OF VIRUSES

As described in Chapter 1, “[The World of Viruses](#)” viruses were initially characterized as filterable agents capable of causing disease. Since that time, advances in microscopy and scientific techniques have led to a better classification of viruses and their properties. Electron microscopy has allowed us to visualize viruses in great detail, while molecular and cellular assays have broadened our understanding of how viruses function and are related to one another. Taken together, we have learned that although they can be quite diverse, viruses share several common characteristics:

1. Viruses are Small in Size.

The smallest of viruses are about 20nm in diameter, although influenza and the human immunodeficiency virus have a more typical size, about 100nm in diameter. Average human cells are 10–30µm (microns) in diameter, which means that they are generally 100 to 1000 times larger than the viruses that are infecting them.

However, some viruses are significantly larger than 100nm. Poxviruses, such as the variola virus that causes smallpox, can approach 400nm in length, and filoviruses, such as the dangerous Ebola virus and Marburg virus, are only 80nm in diameter but extend into long threads that can reach lengths of over 1000nm. Several very large viruses that infect amoebas have recently been discovered: megavirus is 400nm in diameter, and pandoraviruses have an elliptical or ovoid structure approaching 1000nm in length. It is a common mistake to think that all viruses are smaller than bacteria; most bacteria are typically 2000–3000nm in size, but certain strains of bacteria called *Mycobacteria* can be 10times smaller than this, putting them in the range of these large viruses. So although a characteristic of viruses is that they are all small in size, this ranges from only a few nanometers to larger than some bacteria ([Fig. 2.1](#)).

2. Viruses are obligate intracellular parasites, meaning that they are completely dependent upon the internal environment of the cell to create new infectious virus particles, or **virions**.

All viruses make contact with and bind the surface of a cell to gain entry into the cell. The virus disassembles and its genetic material (made of nucleic acid) encodes the instructions for the proteins that will spontaneously assemble into the new virions. This is known as *de novo* replication, from the Latin for “from new.” In contrast to cells, which grow in size and divide equally in two to replicate, viruses use the cell’s energy and machinery to create and assemble new virions piece by piece, completely from scratch.

3. The genetic material of viruses can be composed of DNA or RNA.

All living cells, whether human, animal, plant, or bacterial, have double-stranded DNA (dsDNA) as their genetic material. Viruses, on the other hand, have **genomes**, or genetic material, that can be composed of DNA *or* RNA (but not both). Genomes are not necessarily double-stranded, either; different virus types can also have single-stranded DNA (ssDNA) genomes, and viruses with RNA genomes can be single-stranded or double-stranded. Any particular virus will only have one type of nucleic acid genome, however, and so viruses are not encountered that have both ssDNA and ssRNA genomes, for example.

Similarly to how the size of the virus particle varies significantly, the genome size can also vary greatly from virus to virus. A typical virus genome falls in the range of 7000–20,000 base pairs (bp) (7–20 kilobase pairs (kb)). Smaller-sized virions will naturally be able to hold less nucleic acid than larger virions, but large viruses do not necessarily have large genomes. While most viruses do not contain much nucleic acid, some dsDNA viruses have very large genomes: herpesviruses

Refresher: Orders of Magnitude and Scientific Notation

Virion size: Getting Smaller

1000 millimeters (mm) in a meter (m)	1 mm = 10^{-3} m
1000 micrometers (µm, or microns) in a millimeter	1 µm = 10^{-6} m
1000 nanometers (nm) in a micrometer	1 nm = 10^{-9} m

Virus genome size: Getting Bigger

1000 base pairs (nucleotide pairs, bp) in a kilobase pair (kb)	1 kb = 10^3 bp
1000 kb in a megabase pair (mb)	1 mb = 10^6 bp
1000 mb in a gigabase pair (gb)	1 gb = 10^9 bp