Virology

Definition

Viruses are obligate intracellular complexes consisting of protein and an RNA or DNA genome (smallest infectious agent).

They lack both cellular structure and independent metabolic processes. They replicate merely by using living cells based on the information in the viral genome.

Viruses are autonomous infectious particles that differ widely from other microorganisms in a number of characteristics: they have no cellular structure, consisting only of proteins and nucleic acid (DNA or RNA). They have no metabolic systems of their own, but rather depend on the synthetic mechanism of a living host cell, whereby the viruses exploit normal cellular metabolism by delivering their own genetic information, i.e., nucleic acid, into the host cell. The host cell accepts the nucleic acid and proceeds to produce the components of new viruses in accordance with the genetic information it contains.

Viruses infect bacteria (so-called bacteriophages), plants, animals, and humans.Viruses are differing from other cells (bacteria and other prokaryotes or eukaryotes), as:

Property	Viruses	Cells
Type of nucleic acid	**DNA or RNA but not both**	**DNA and RNA**
Proteins	**Few**	**Many**
Lipoprotein membrane	**Envelope present in some viruses**	**Cell membrane present in all cells**
Ribosomes	**Absent**	**Present**
Mitochondria	**Absent**	**Present in eukaryotic cells but not in prokaryotic cells**
Enzymes	**None or few**	**Many**
Multiplication by binary fission or mitosis	**No**	**Yes**

Virus Size & Structure

• Viruses range in size from that of large proteins (~20 nm, as Parvovirus) to that of the smallest cells (~300 nm, as Poxvirus). Most viruses appear as spheres or rods in the electron microscope.

• Shape of Viruses are Spherical, Rod-shaped, Brick-shaped, Tadpole-shaped, Bullet-shaped and Filament.

• Viruses contain **either DNA or RNA, but not both.**

• All viruses have a **protein coat called a capsid** that covers the genome. The capsid is composed of repeating subunits called capsomers. In some viruses, the capsid is the outer surface, but in other viruses, the capsid is covered with a lipoprotein **envelope** that becomes the outer surface. The structure composed of the nucleic acid genome and the capsid proteins is called the **nucleocapsid.**

• The repeating subunits of the capsid give the virus a symmetric appearance that is useful for classification purposes. Some viral nucleocapsids have **spherical (icosahedral) symmetry,** whereas others have **helical symmetry.**
• All human viruses that have a helical nucleocapsid are enveloped (i.e., there are no naked helical viruses that infect humans). Viruses that have an icosahedral nucleocapsid can be either enveloped or naked.

Viral Nucleic Acids

• The genome of some viruses is **DNA,** whereas the genome of others is **RNA.** These DNA and RNA genomes can be either **single-stranded** or **double-stranded.**
• Some RNA viruses, such as influenza virus and rotavirus, have a **segmented genome** (i.e., the genome is in several pieces).
• All viruses have one copy of their genome (haploid) except retroviruses, which have two copies (diploid).

Viral Proteins

• Viral surface proteins mediate **attachment to host cell receptors.** This interaction **determines the host specificity and organ specificity** of the virus.
• The surface proteins are the **targets of antibody** (i.e., antibody bound to these surface proteins prevents the virus from attaching to the cell receptor). This "neutralizes" (inhibits) viral replication.
• Viruses also have internal proteins, some of which are **DNA or RNA polymerases.**
• The **matrix protein** mediates the interaction between the viral nucleocapsid proteins and the envelope proteins.
• Some viruses produce **antigenic variants** of their surface proteins that allow the viruses to evade our host defenses. Antibody against one antigenic variant (**serotype**) will not neutralize a different serotype. Some viruses have one serotype; others have multiple serotypes.

Viral Envelope

• The viral **envelope** consists of a membrane that contains lipid derived from the host cell and proteins encoded by the virus. Typically, the envelope is acquired as the virus exits from the cell in a process called **budding.**
• Viruses with an envelope are less stable (i.e., they are more easily inactivated) than naked viruses (those without an envelope). In general, enveloped viruses are transmitted by direct contact via blood and body fluids, whereas naked viruses can survive longer in the environment and can be transmitted by indirect means such as the fecal–oral route.

There are four exceptions to the typical virus as described earlier:

(1) Defective viruses are composed of viral nucleic acid and proteins but cannot replicate without a "helper" virus, which provides the missing function. Defective viruses usually have a mutation or a deletion of part of their genetic material. During the growth of most human viruses, many more defective than infectious virus particles are produced. The ratio of defective to infectious particles can be as high as 100:1. Because these defective particles can interfere with the growth of the infectious particles, it has been hypothesized that the defective viruses may aid in recovery from an infection by limiting the ability of the infectious particles to grow.

(2) Pseudovirions contain host cell DNA instead of viral DNA within the capsid. They are formed during infection with certain viruses when the host cell DNA is fragmented and pieces of it are incorporated within the capsid protein. Pseudovirions can infect cells, but they do not replicate.

(3) **Viroids** consist solely of a single molecule of circular RNA without a protein coat or envelope. There is extensive homology between bases in the viroid RNA, leading to large double-stranded regions. The RNA is quite small (molecular weight 1 × 105) and apparently does not code for any protein. Nevertheless, viroids replicate, but the mechanism is unclear. They cause several plant diseases but are not implicated in any human disease.

(4) **Prions** are infectious particles that are composed **solely of protein** (i.e., they contain no detectable nucleic acid). They are implicated as the cause of certain "slow" diseases called **transmissible spongiform encephalopathies,** which include such diseases as Creutzfeldt-Jakob disease in humans and scrapie in sheep. Because neither DNA nor RNA has been detected in prions, they are clearly different from viruses. Furthermore, electron microscopy reveals filaments rather than virus particles. Prions are much **more resistant** to inactivation by ultraviolet light and heat than are viruses. They are remarkably resistant to formaldehyde and nucleases. However, they are inactivated by hypochlorite, NaOH, and autoclaving. Hypochlorite is used to sterilize surgical instruments and other medical supplies that cannot be autoclaved.

Classification of viruses

The taxonomic system used for viruses is artificial (i.e., it does not reflect virus evolution).

Holmes classification

Holmes (1948) used Carl Linnaeus's system of binomial nomenclature to classify viruses into 3 groups under one order, Virales. They are placed as follows:
Group I: Phaginae (attacks bacteria)
Group II: Phytophaginae (attacks plants)
Group III: Zoophaginae (attacks animals)

LHT System of Virus Classification

In 1962 Lwoff, R. W. Horne, and P. Tournier advanced acomprehensive scheme for the classification of all viruses consisting of phylum - class - order - family - subfamily - genus - species - strain/type. They subsequently formed the internat committee on the nomenclature of viruses accepted many principles of this system. The most important principle embodied in this system was that viruses should be grouped according to their shared properties rather than the properties of the cells or organisms they infect. Four main characteristics are used:
1. Nature of the nucleic acid: RNA or DNA.
2. Symmetry of the capsid.
3. Presence or absence of an envelope.
4. Dimensions of the virion and capsid.

ICTV classification

The International Committee on Taxonomy of Viruses began to devise and implement rules for the naming and classification of viruses early in the 1970. The ICTV is the only body charged by the International Union of Microbiological Societies with the task of developing, refining, and maintaining a universal virus taxonomy. Viral classification starts at the level of realm and continues as follows, with the taxonomic suffixes in parentheses
realm ...viria
subrealm ...vira
kingdom ...virae
subkingdom ...virites
phylum ...viricota
subphylum ...viricotina
class ...viricetes

subclass ...viricetidae

order ...virales
suborder ...virineae

family ...viridae
subfamily ...virinae
genus ...virus
subgenus ...virus

Baltimore's system for classification

The Baltimore system of virus classification categorizes viruses according to the various mechanisms of viral genome replication. The main concept is that all viruses must generate positive strand mRNAs from their genomes, in order to produce proteins and replicate themselves. The specific mechanisms whereby this is achieved differ for each type of virus. These various types of virus genomes can be broken down into seven different groups, which has different ways to achieve replication.

According to Baltimore classification, viruses are divided into the following seven classes:

Class I: Double stranded DNA viruses. Virus family in this group (Polyomavirus, Papillomavirus, Adenovirus, Hepadnavirus, Herpesvirus and Poxvirus).

Class II: Single stranded DNA viruses. Virus family in this group (Parvovirus).

Class III: Double stranded RNA viruses. Virus family in this group (Reovirus).

Class IV: (+) Sense Single stranded RNA viruses. Virus family in this group (Flavivirus, Hepevirus, Calcivirus, Picornavirus, Coronavirus and Tagovirus).

Class V: (-) Sense Single stranded RNA viruses. Virus family in this group (Orthomyxovirus, Paramyxovirus, Rhabdovirus, Filovirus, Arenavirus and Bunyavirus).

Class VI: RNA Reverse transcribing viruses. Virus family in this group (Retrovirus).

Class VII: DNA Reverse transcribing viruses. Virus family in this group (Deltavirus).