12- Viruses (Instructor: Şeref Tağı)

Viruses are small, obligate, intracellular particles; that is, most can be seen only with the electron microscope and they must infect and take over a host cell in order to replicate. This is because they lack the chemical machinery for generating energy and synthesizing large molecules. Viruses, therefore, must find an appropriate host cell in which they can replicate—and, as a result, often cause disease.

Despite their small size, which prevented them from being seen with light microscopes, the discovery of a filterable component smaller than a bacterium that causes tobacco mosaic disease (TMD) dates back to 1892.

Today, we can see viruses using electron microscopes and we know much more about them. Viruses are distinct biological entities; however, their evolutionary origin is still a matter of speculation. In terms of taxonomy, they are not included in the tree of life because they are acellular (not consisting of cells). In order to survive and reproduce, viruses must infect a cellular host, making them obligate intracellular parasites. The genome of a virüs enters a host cell and directs the production of the viral components, proteins and nucleic acids, needed to form new virüs particles called virions. A completely assembled and infectious virus outside its host cell is known as a virion.

New virions are made in the host cell by a ssembly of viral components. The new virions transport the viral genome to another host cell to carry out another round of infection.

Characteristics of Viruses
Infectious, acellular pathogens
Obligate intracellular parasites with host and cell-type specificity
DNA or RNA genome (never both)
Genome is surrounded by a protein capsid and, in some cases, a phospholipid membrane studded with viral glycoproteins
Lack genes for many products needed for successful reproduction, requiring exploitation of host-cell genomes to reproduce

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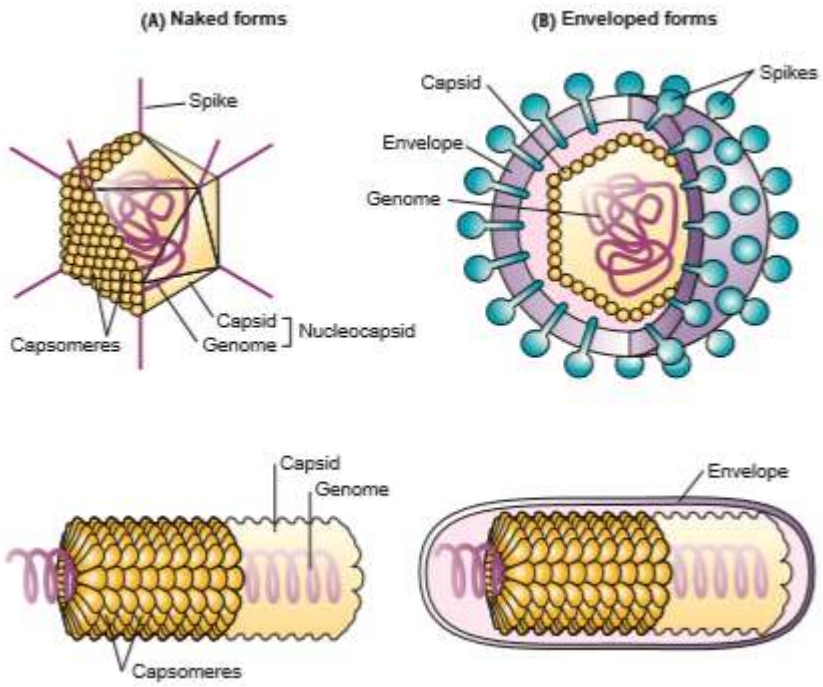
Viruses can infect every type of host cell, including those of plants, animals, fungi, protists, bacteria, and archaea. Most viruses will only be able to infect the cells of one or a few species of organism. This is called the host range. However, having a wide host range is not common

and viruses will typically only infect specific hosts and only specific cell types within those hosts. The viruses that infect bacteria are called bacteriophages, or simply phages. The word phage comes from the Greek word for devour. Other viruses are just identified by their host group, such as animal or plant viruses. Once a cell is infected, the effects of the virus can vary depending on the type of virus.

Viruses may cause abnormal growth of the cell or cell death, alter the cell's genome, or cause little noticeable effect in the cell. Viruses can be transmitted through direct contact, indirect contact with fomites, or through a vector: an animal that transmits a pathogen from one host to another. Arthropods such a smosquitoes, ticks, and flies, are typical vectors for viral diseases, and they may act as mechanical vectors or biological vectors. Mechanical transmission occurs when the arthropod carries a viral pathogen on the outside of its body and transmits it to a new host by physical contact. Biological transmission occurs when the arthropod carries the viral pathogen inside its body and transmits it to the new host through biting. In humans, a wide variety of viruses are capable of causing various infections and diseases. Some of the deadliest emerging pathogens in humans are viruses, yet we have few treatments or drugs to deal with viralin fections, making them difficult to eradicate. Viruses that can be transmitted from an animal host to a human host can cause zoonoses. For example, the avian influenza virus originates in birds, but can cause disease in humans. Reverse zoonoses are caused by infection of an animal by a virus that originated in a human.

Viruses have some unique features not seen with the living microorganisms. They have no organelles, no cytoplasm, and no cell nucleus or nucleoid . Instead, they are comprised of two basic components: a nucleic acid core and a surrounding coat of protein; thus, as Peter Medawar remarked (chapter opening quote), a virus is "just a piece of bad news [meaning they cause disease] wrapped up in protein." The viral genome of almost all viruses contains either DNA or RNA, but not both, and the nucleic acid occurs in either a double-stranded or a single-stranded form. Usually the nucleic acid is a linear or circular molecule, although in some instances (as in influenza viruses) it exists as separate, nonidentical segments. The viral genome is folded or coiled, which allows the viruses to maintain their extremely small size.



The Components of Viruses. (A) Naked viruses consist of a nucleic acid genome (either DNA or RNA) and a protein capsid. Capsomere units are shown on one face of the capsids. Spikes may be present on the capsid. (B) Enveloped viruses have an envelope that surrounds the nucleocapsid. Again spikes usually are present (Alcamo's 2011)

The protein coat of a virus particle, called a capsid, gives shape or symmetry to the virus . Generally, the capsid is subdivided into individual protein subunits called capsomeres

(the organization of capsomeres yields the viral symmetry) and the capsid with its enclosed genome is referred to as a nucleocapsid. The capsid also provides a protective covering for the viral genome because the construction of its amino acids resists temperature, pH, and other environmental fluctuations. In some viruses, special capsid proteins called spikes help attach the virus to the host cell and facilitate penetration of the cell. Viruses composed solely of a nucleocapsid are sometimes referred to as "naked" viruses. The nucleocapsids of many viruses are surrounded by a flexible membrane known as an envelope; the viruses are referred to as "enveloped" viruses . The envelope is composed of lipids and protein, similar to the host cell membrane; in fact, it is acquired from the host cell during replication and is unique to each type of virus. These viruses may lose their infectivity if the envelope is destroyed. Also, when the envelope is present, the symmetry of the capsid may not be apparent because the

Family	Strand Type*	Capsid Symmetry	Envelope or Naked Virion	Diameter (nm)	Disease Examples
DNA Viruses					
Poxviridae	Double	Complex	Envelope	170–300	Smallpox, monkeypox
Herpesviridae	Double	Icosahedral	Envelope	150–200	Cold sores, genital herpes, chickenpox, shingles, infectious mononucleosis
Adenoviridae	Double	Icosahedral	Naked	70–90	Common cold, viral meningitis
Papovaviridae	Double	Icosahedral	Naked	45–55	Warts, genital warts, cervical cancer
Hepadnaviridae	Double (w/RNA intermediate)	Icosahedral	Envelope	42	Hepatitis B, liver cancer
Parvoviridae	Single	Icosahedral	Naked	18–26	Fifth disease, gastroenteritis
RNA Viruses					
Reoviridae	Double	Icosahedral	Naked	60–80	Gastroenteritis
Picornaviridae	Single (+)	Icosahedral	Naked	28–30	Polio, some colds, hepatitis A
Caliciviridae	Single (+)	Icosahedral	Naked	35–40	Gastroenteritis
Togaviridae	Single (+)	Icosahedral	Envelope	60–70	Rubella, encephalitis
Flaviviridae	Single (+)	Icosahedral	Envelope	40–50	Yellow fever, dengue fever, hepatitis C, West Nile fever (encephalitis)
Coronaviridae	Single (+)	Helical	Envelope	80–160	SARS
Filoviridae	Single (–)	Helical	Envelope	80–10,000	Ebola and Marburg hemorrhagic fevers
Bunyaviridae	Single (–)	Helical	Envelope	90–120	Hantavirus pulmonary syndrome
Orthomyxoviridae	Single (–)	Helical	Envelope	90–120	Influenza
Paramyxoviridae	Single (–)	Helical	Envelope	150–300	Mumps, measles
Rhabdoviridae	Single (–)	Helical	Envelope	70–380	Rabies
Arenaviridae	Single (–)	Helical	Envelope	50–300	Lassa fever
Retroviridae	Single (+) (w/DNA intermediate)	Icosahedral	Envelope	80–130	AIDS, human adult T-cell leukemia

*(+) – positive-strand; (–) – negative-strand

Major Families of Human Viruses and Their Characteristic (Alcamo's, 2011)

envelope is generally a loose-fitting structure over the nucleocapsid. Many enveloped viruses also contain spikes projecting from the envelope. These proteins also function for attachment and host cell penetration.

Viruses from many different families cause disease in humans. A selection of viral families affecting humans, together with some of their characteristics, is presented in the table above. These viruses have been split into two board classes based on their genome type and strand type. DNA Viruses. Many viruses contain either single-stranded (ss) or double-stranded (ds) DNA genomes that are linear or segmented. The genomes are replicated by direct DNA-to-DNA copying using DNA polymerase, which requires most DNA viruses replicate in the host cell's nucleus. One exception is the poxviruses that replicate in the host cytoplasm, which means these viruses must carry the gene for their own DNA polymerase. RNA Viruses. A large number of viruses contain either ssRNA or dsRNA genomes, which are replicated by direct RNA-to-RNA copying. Again, the genomes can be linear or segmented. Some of the single-stranded viruses, such as the picornaviruses and coronaviruses, have their RNA genome in the

form of messenger RNA (mRNA). These RNA viruses are referred to as positive-strand (+ strand).

References:

1- Alcamo's Fundamentals of Microbiology, 2011, Ninth Edition (9 ed.) by Jeffrey C. Pommerville, Jones & Bartlett Publishers, Canada
2- “Download for free at https://openstax.org/details/books/microbiology.”