Viruses

Viruses are small, **non-cellular organisms** that contain only one type of nucleic acid and replicate only in living cells using host proteosynthesis . It differs from all other living organisms in the following points:

- they are organized only as particles, they are not organized as cells (they can be considered non-cellular)
- mature virions contain only one type of nucleic acid - always only DNA or RNA
- viruses multiply by the synthesis of their components (not by division) and therefore depend on the ribosomes of the host cell

They are characterized by **high species and organ specificity**. We distinguish between plant, animal and bacteriophage viruses, which attack bacteria. Some viruses are also significantly involved in the development of neoplasms, we call them oncoviruses. Viruses can be vectors that transmit genetic information between cells. It is used in genetic engineering and gene therapy.

History


Martinus Willem Beijerinck

A. Mayer was the first to experimentally transmit a viral disease in 1879–1882, he dealt with the tobacco mosaic disease (see Genetics in the Data). He managed to prove that the juice from the rubbed leaves can transmit the disease to healthy leaves. Because he failed to grow any bacteria from the infectious extract, he thought the causative agent was "enzyme-like contagion." His work was followed by D. Ivanovsky, who in 1892 managed to prove that the juice from infected leaves remains infectious even after filtration through bacteriological filters. Mayer's collaborator M. W. Beijerinck has shown that the diluted juice, after filtration, regains its original "strength" after multiplication in living plant tissue. He expressed the idea that the cause of the disease is not a toxin, but something completely different from the hitherto known bacteria, he called it a "virus".

Origin of viruses

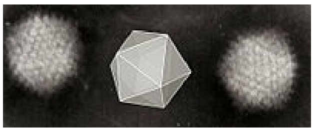
There are three main theories trying to explain the origin of viruses:

1. Most viruses originated and developed in parallel with primitive cells. Probably the first RNA (a structure capable of replicating itself) developed in two lines: viral and cellular. If true, RNA viruses would be older than cellular life forms.
2. The most complex viruses, poxviruses, are thought to have arisen by regressive development from single cells or from cellular organelles (mitochondria, chloroplasts).
3. Other viruses probably originated from cellular material that acquired the ability to exist in part independently. The independence of the RNA molecule, which encodes RNA polymerase and to which the protein coat gene was added, may have been the beginning of RNA virus formation. The emergence of DNA viruses was probably based on the independence of transposons or from a primitive cell in which the DNA had not yet been organized into chromosomes. If the gene mutation resulted in a protein capable of assembling into the icosahedral sheath, a virus could develop, the genome of which was further enriched by the addition of other genes.

Morphology of viruses

A Virion is a term used for one viral particle. They are bodies of various shapes. They can be spherical, rod-shaped, fibrous. The inner part of the virion is called the **nucleoid**. It is composed of **nucleic acid** and is surrounded by a protein shell **capsid**. The capsid is composed of protein subunits - **capsomeres** (1-10, 20,… proteins encoded by viral genes). Their shape allows them to attach to each other and form a larger unit. With regard to the type of symmetry, we distinguish two main groups of capsids: cubic and spiral (helicoidal). The unit is called a **nucleocapsid**. The simplest virions are only bare nucleocapsids (picornaviruses, papillomaviruses, adenoviruses). In addition to the capsid, **enveloped viruses** have an additional coat of bilayer proteins and lipids and virus-specific glycoproteins; these are built into the cell membranes of infected host cells and allow the identification of both virus and virus-infected cells.

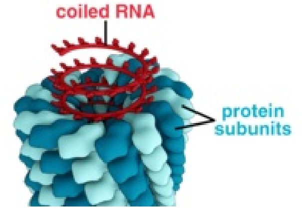
Viral capsids


Capsid of cubic symmertry in adenoviruses

- Capsids with cubic (icosahedral) symmetry form a regular icosahedral. It is a body with 12 vertices and 20 walls of equilateral triangles.
- Capsids with spiral (helicoidal) symmetry are difficult to distinguish from a nucleoid and therefore we speak of a nucleocapsid. It consists of a nucleic acid helix to which the capsomeres are closely aligned. The virus family is determined by electron microscopy according to the diameter and pitch of the thread.
- Viruses with complex symmetry, we classify them as flagellar bacteriophages, where the head is formed according to cubic symmetry, while flagella according to binary. Poxviruses, the largest animal viruses, have a nucleoid shaped like a

double-sided disk. Lenticular lateral bodies are placed in its concavities and as a whole it is wrapped in a wrapper.

Viral envelopes



Helicoid symmetry capsid in tobacco mosaic virus

In the vast majority of viruses, it consists of an **outer lipoprotein complex** and a **species-specific internal protein** (so-called **M-protein** anchoring the nucleocapsid). The lipoprotein complex consists of a lipid bilayer (derived from different parts of the host cells according to the site of origin of the virus) and viral glycoproteins. These glycoproteins consist of symmetrical formations called **peplomers**, usually protruding like protrusions from the viral envelope. Peplomers serve to facilitate the **adsorption** of viruses by the susceptible cell. Depending on the site of origin, viruses may be enveloped by the nuclear membrane (Herpesviruses), membranes derived from endoplasmic reticulum cisterns (Arenaviruses), or cytoplasmic membranes (Orthomyxoviruses).

Shape of virions


Rotavirus particles resembling gears

- Smaller viruses (picornaviruses) have a spherical shape.
- Capsometers can protrude from the virion surface (rotaviruses are similar to gears).
- Unwrapped larger viruses (adenoviruses) regularly have a icosahedral shape.
- Enveloped viruses are often spherical (retroviruses) or irregular (herpesviruses, orthomyxoviruses, paramyxoviruses, coronaviruses)
- The shape of rhabdoviruses resembles a projectile, poxviruses resemble Christmas trees, filoviruses are elongated and string-like.

Size

The largest viruses (poxviruses) measure around 300 nm and can therefore be observed under a light microscope. Influenza viruses measure about 100nm. While the smallest known viruses found in animals (picornaviruses, parvoviruses) measure around 20 nm.

Chemical composition

Genome

The genome is made up of **one molecule of nucleic acid** (DNA or RNA). In viruses, nucleic acid carries information for self-replication and synthesis of other viral proteins, as well as infectivity. Infectivity is a measure of the ability to express this information in host cells. Both types of nucleic acid can occur as double-stranded (dsDNA, dsRNA) or single-stranded (ssDNA, ssRNA) and the "chromosome" is either linear or circular. The amount of nucleic acid is very diverse, the DNA of poxviruses could encode the synthesis of one hundred proteins, while the RNA of picornaviruses could only four. Parvoviruses have such a low DNA content that they are unable to reproduce themselves and are dependent on other viruses (adenoviral satellites).

Viral proteins

- Most viral proteins are involved in **the construction of the capsid**, a smaller part serve as **enzymes**. Capsid proteins have the function of protecting the genome and, in the case of non-enveloped viruses, adhering to the surface of susceptible cells. The proteins in the marrow serve mainly to stabilize the nucleic acid.
- Lipids are present in enveloped viruses. They originate from host cell membranes, making them enveloped by viruses sensitive to ether and quaternary ammonium bases.

Viral reproduction

Upon entering the susceptible cell, viruses begin the reproductive cycle. **Susceptible host cells** use the transcriptional and translational apparatus for their reproduction. A susceptible cell is one in which a complete reproductive cycle takes place and new infectious virions are released. This process can take place under the picture of **intracellular infection**. In a non-perceptive cell, the cycle does not start, and in a non-permissive cell, the cycle ends prematurely. Viruses multiply in the host cell and **lyse it**. The released virions attack other cells. This is called the **lytic cycle**. Sometimes NKs do not replicate and **produce mature virions after the virus enters the host cell**. The virus genome integrates into and replicates with the host cell genome. We call this the **lysogenic cycle**. When the DNA of a virus is integrated into the chromosome of a host cell, we call it a **provirus**. In mixed infections, **genetic information recombines** with each other. The process contributes to the variability of the genotype and phenotype of the viruses.

Classification

The basic distinguishing feature of viruses is the nature of the host - according to this criterion there are viruses of bacteria (bacteriophages), protozoa, viruses of yeasts and fungi, plants, insects, and vertebrates. The classification system breaks down viruses according to the following parameters:

- type and nature of nucleic acid, number of strands, spatial arrangement, polarity
- capsid symmetry, shape and number of capsomeres, capsid folding site
- the existence of the envelope, the place where the virus obtains it in the cell, the sensitivity to the ether
- size of virion
- antigenic structure, infectivity

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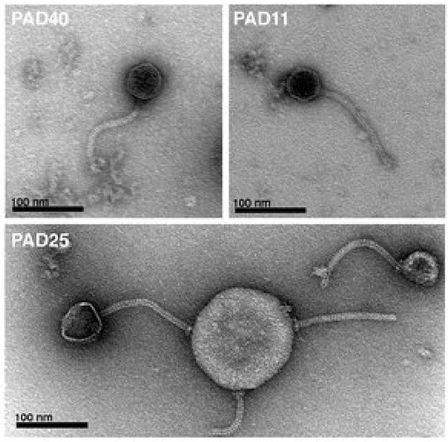
Classification according to the type and nature of the nucleic acid:

I	dsDNA	Herpesviridae, Papillomaviridae, Polyomaviridae, Poxviridae
II	ssDNA	Parvoviridae, Microviridae
III	dsRNA	Reoviridae
IV	(+)ssRNA	Picornaviridae, Coronaviridae, Flaviviridae
V	(-)ssRNA	Paramyxoviridae, Rhabdoviridae, Orthomyxoviridae
VI	ssRNA-RT	Retroviridae
VII	dsDNA-RT	Hepadnaviridae



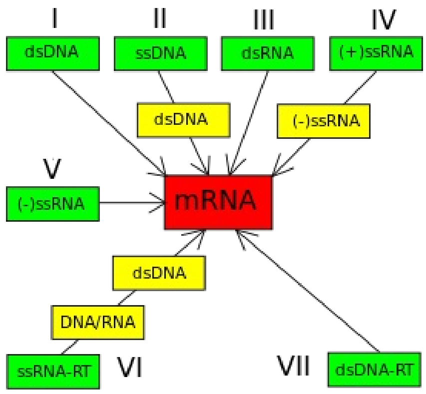
Electron microscopic image of bacteriophages of the Siphovirus and *P. acnes families*

Importance in medicine

Gene therapy is still under development. In gene therapy, we introduce a gene that is lacked into the cell through viruses. E.g. In hemophiliacs, people suffering from a blood clotting disorder that manifests itself in bleeding disorders, we introduce a gene that encodes a protein involved in blood clotting.

Viruses that are able to incorporate their genetic material into the host genome - such as adenoviruses - are used to introduce genes. These were originally isolated from the mucous membranes of the human respiratory tract. Adenoviruses cause, for example, respiratory diseases, conjunctivitis, and inflammation of the intestinal mucosa.

Another use of viruses in medicine is the preparation of **vaccines** - for example, the hepatitis A vaccine contains the non-infectious hepatitis A virus. One type of insect virus (baculovirus) is also used to make proteins. For example, proteins that are part of Cervarix (cervical cancer vaccine) are being prepared on the basis of this baculovirus system.



Baltimore classification

Links

Related articles

- Biochemistry of viruses
- DNA viruses
- RNA viruses
- Reproduction of DNA viruses
- Reproduction of RNA viruses
- Taxonomy of viruses

Bibliopgraphy

- BEDNÁŘ, Marek – SOUČEK, Andrej – FRAŇKOVÁ, Věra. *Lékařská mikrobiologie : Bakteriologie, virologie, parazitologie.* 1. edition. Praha : Marvil, 1996. 558 pp. ISBN 80-238-0297-6.

- VOTAVA, Miroslav – BROUKAL, Zdeněk. *Lékařská mikrobiologie pro zubní lékaře.* 1. vydání edition. Brno : Neptun, 2007. ISBN 978-80-86850-03-0.

- VOKURKA, Martin – JAN,. *Velký lékařský slovník.* Jessenius edition. Praha : Maxdorf, 0000. 1008 pp. ISBN 80-7345-058-5.

- ŠTEFÁNEK, Jiří. *Stefajir* [online]. [cit. 11. 2. 2010]. <https://www.stefajir.cz/>.