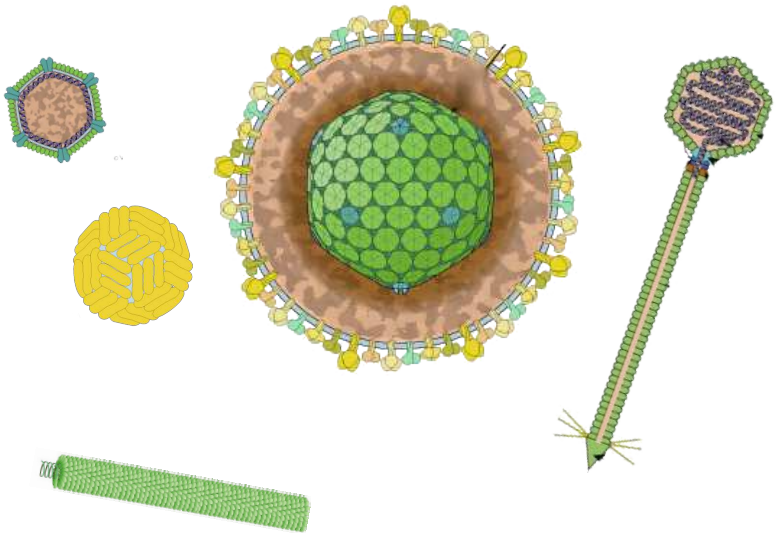
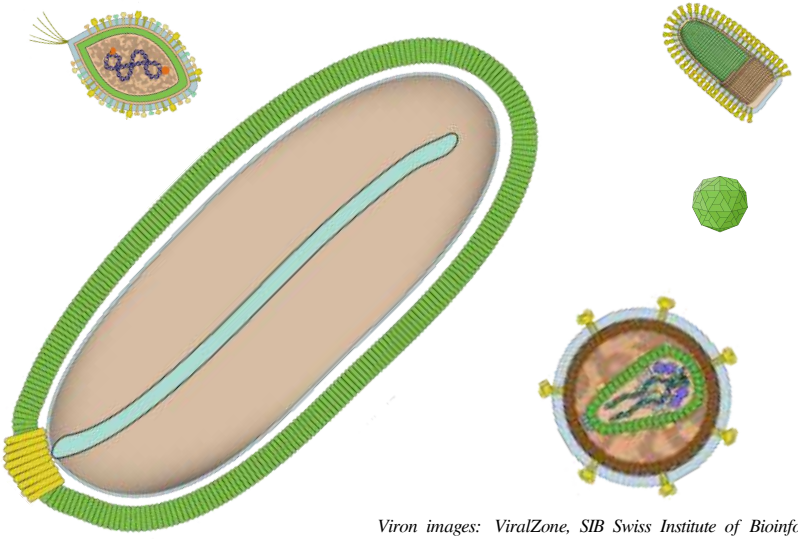


Viruses: what are they?



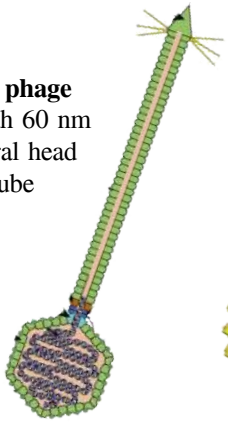
Viron images: ViralZone, SIB Swiss Institute of Bioinformatics

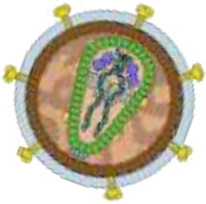
What are viruses made of?

Viruses are made up of a small amount of genetic material, either RNA or DNA, surrounded by a protective protein coat or capsid. The capsid can further be surrounded by an envelope.

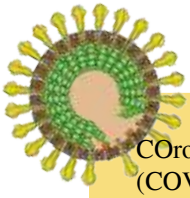
Viruses can come in various different shapes, most commonly helical (tubular cavity with proteins stacked around the genetic material), icosahedral (proteins arranged to form a 20-triangle faced 3D shape) and spherical. Some can have more complicated structures.

Lambda phage
DNA with 60 nm icosahedral head and tail tube



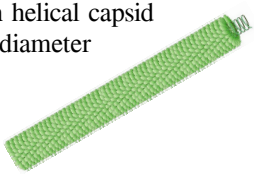


HIV-1
RNA with spherical envelope
100 nm in diameter



COronaVIrus Disease 2019 (COVID-19) is caused Severe Acute Respiratory Syndrome COronaVirus 2 (SARS-CoV-2). SARS-CoV-2 has RNA as its genetic material, and is packaged in a protective coat made of a lipid bilayer with proteins embedded in it. It is 80–100 nm in diameter.

Tobacco Mosaic Virus
RNA with helical capsid
18 nm in diameter

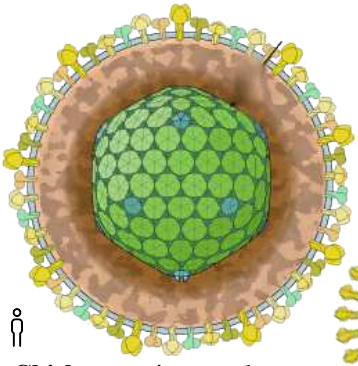


Viron images: ViralZone, SIB Swiss Institute of Bioinformatics

What do viruses infect?

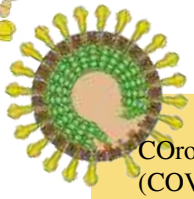
Viruses cannot reproduce by themselves. They need to infect cells of their host organisms to produce more viruses. Viruses likely infect every group of organisms: from bacteria and insects to plants and animals.

Different viruses infect different groups of hosts. Some are specific to a single species, some have life cycles that occur across a few species and some can infect whole families of organisms. Viruses can also be specific to kinds of cells that they can infect. Each organism can have multiple viruses that infect it, separately and simultaneously.



Chickenpox is caused by Varicella Virus. It is specific to humans and also causes shingles.

Cucumber mosaic virus or Cucumovirus is part of a group called Bromoviridae. These viruses can infect 1000 flowering plant species!



COronaVIrus Disease 2019 (COVID-19) is caused by Severe Acute Respiratory Syndrome COronaVirus 2 (SARS-CoV-2). SARS-CoV-2 which is part of a family of viruses called coronaviruses, that infect epithelial cells in the respiratory tracts of birds and mammals.

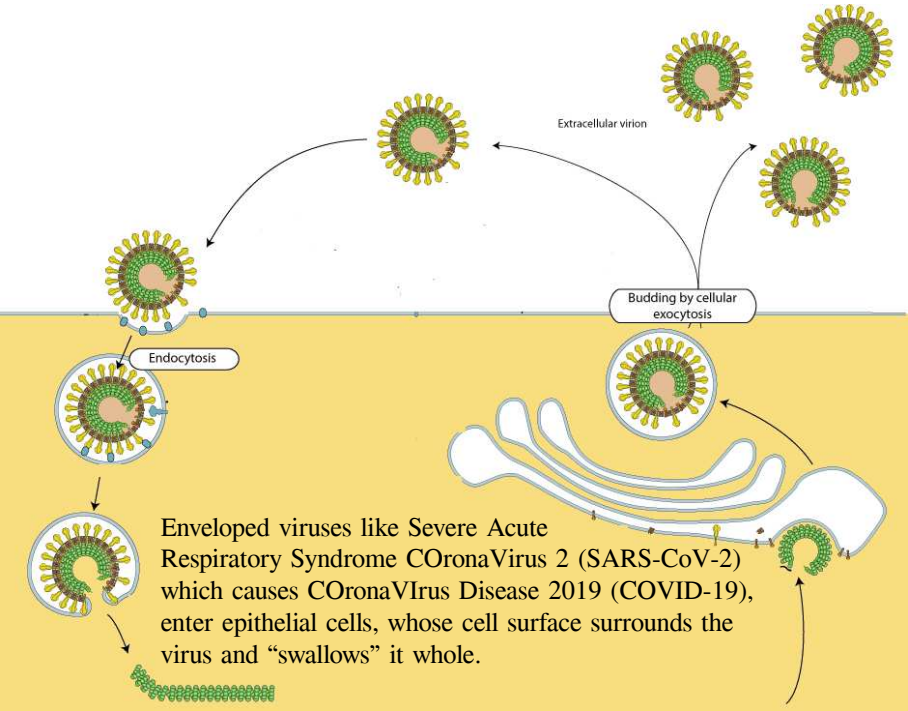
Rabies is caused by Lyssavirus. It can infect warm blooded animals including humans and dogs.

Icons: Freepik.com; Viron images: ViralZone, SIB Swiss Institute of Bioinformatics

Where do viruses reproduce?

Viruses need to get into a living cell to be able to make more viruses. The viral genome encodes instructions for the virus to enter a host cell, make more viruses and later exit it.

Depending on the structure of the virus and the host cell, viruses can enter and exit it in different ways. For example, in plants, some viruses can be injected into the cells by insects. Viruses that infect bacteria attach to the cell membrane or cell wall and inject their genetic material into the bacterial cell. Some viruses get extruded by the host cell processes, others burst and kill the host cell to be released.



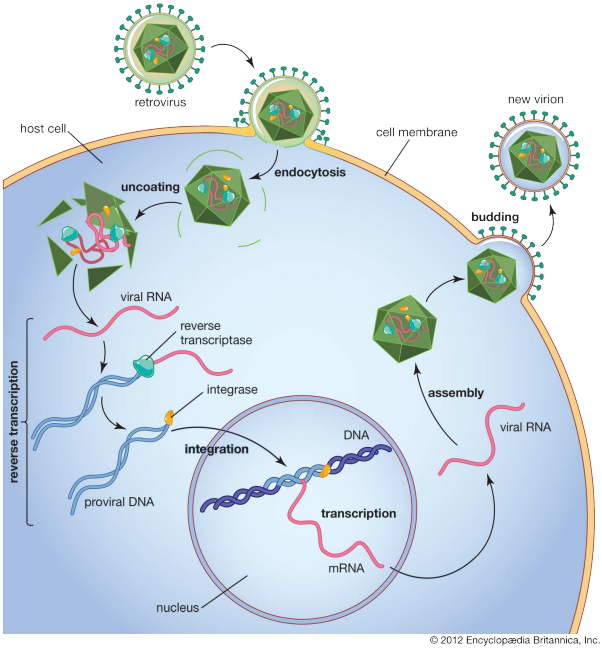
Enveloped viruses like Severe Acute Respiratory Syndrome COronaVirus 2 (SARS-CoV-2) which causes COronaVIrus Disease 2019 (COVID-19), enter epithelial cells, whose cell surface surrounds the virus and "swallows" it whole.

Viron images: ViralZone, SIB Swiss Institute of Bioinformatics

How do viruses reproduce?

Once the virus genetic material is inside the host cell, it can make copies of the viral genetic material and synthesize capsids and any other proteins that make up the viruses. The process of replication will depend on the type of genetic material of the virus: single or double stranded DNA or RNA. Individual viruses with their capsid protein coats are then assembled in the host cell.

Most cells replicate DNA to make more DNA. They also transcribe the DNA to make RNA and translate RNA to make proteins. This is called the central dogma. Some viruses have ways of getting around this linear process and many carry genes that encode enzymes for these processes.

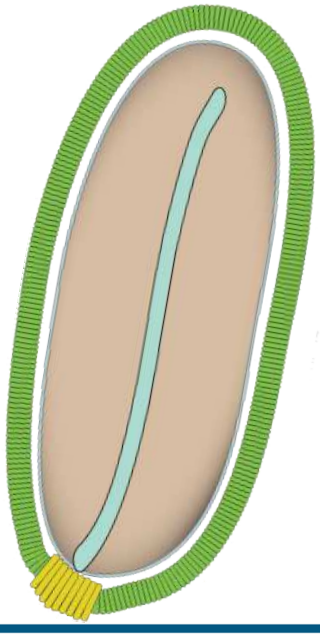


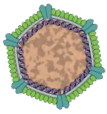
How long do they "survive"?

For a virus, survival is being able to infect a host cell even after being outside their host cells for some time. Viruses can "survive" for different periods of time, depending on the virus and environmental conditions like temperature, acidity and salinity. They tend to survive longer on water-resistant surfaces, such as stainless steel and plastics. Enveloped viruses are more sensitive to desiccation than naked viruses.

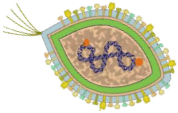
Some viruses, like bacteriophages, can integrate their DNA into the host organism's DNA in a process called the lysogenic cycle. Viral DNA is replicated along with the host cell and retains the potential to produce more viruses many many generations later!

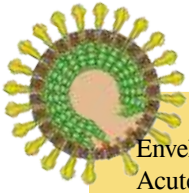
Pithovirus infects amoeba. The virus was isolated from permafrost and dated to be 30,000 years old!





Sphaerolipoviridae infects thermophilic bacteria





Fuselloviridae infects thermophilic archaea

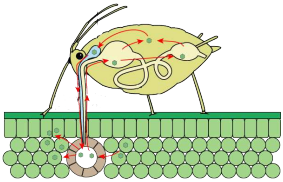
Enveloped viruses like Severe Acute Respiratory Syndrome COronaVirus 2 (SARS-CoV-2) that causes COronaVIrus Disease 2019 (COVID-19) survive for a short time outside cells. SARS-CoV-2 can last for a few hours on paper and cardboard and a few days on smoother surfaces like plastic and glass.

Viron images: ViralZone, SIB Swiss Institute of Bioinformatics

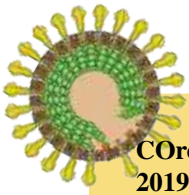
Where do viruses come from?

Viruses are all around you – in air, in water, on surfaces, on or inside other living beings. Most of them do not cause infections in humans. Even viruses that do infect humans can only infect you if they get into your cells. Even if they do get into you, a healthy immune system can usually fight off viral infections in some time.

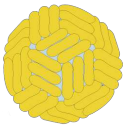
Viruses can also be transmitted between hosts by other organisms. Zoonotic transmission is when viruses that infect other animals are transferred to humans. Many viruses that infect bacteria have a wide host range, and evolve relatively quickly to infect other bacteria.



Plant viruses are often transported by insect vectors, either on or in their bodies. Some viruses can even reproduce inside these insects.



COronaVIrus Disease 2019 (COVID-19) is caused by a virus called Severe Acute Respiratory Syndrome COronaVirus 2 (SARS-CoV-2). SARS-CoV-2 is mainly transmitted from an infected individual through respiratory droplets containing viruses. These droplets can get into you either directly or if you touch a surface that has these droplets and then touch your nose or mouth.



Flavivirus causes Dengue fever is transmitted between humans through mosquitos.

Viron images: ViralZone, SIB Swiss Institute of Bioinformatics

Viruses in biological communities and ecosystems

Viruses that infect bacteria can help shape bacterial communities in our gut by shaping microbial composition, driving bacterial diversity in health and during disease. They are now considered to be an integral part of the human gut microbiome.

Plant defense in response to viruses can lead to a reduction in aphid performance. Some viruses can make some wingless aphids become winged, and so increase the transmission of the virus. Some wasps that lay eggs inside caterpillars (that feed on plants) have viruses that help the development of wasp eggs and larvae by decreasing the defense systems of both the caterpillar and plant.

Cyanophages are a group of viruses that infect cyanobacteria. Cyanobacteria or blue-green algae are photosynthesizing bacteria and are amongst the largest photosynthetic producers in the world. Cyanobacteria and other algae often form blooms that are toxic to marine and freshwater ecosystems. Cyanophages can infect these microorganisms and are thought to play an important role in the dynamics of cyanobacterial populations.

Evolutionarily, viruses are also thought to influence gene flow, adaptation and speciation across genera.

Viron images: ViralZone, SIB Swiss Institute of Bioinformatics