

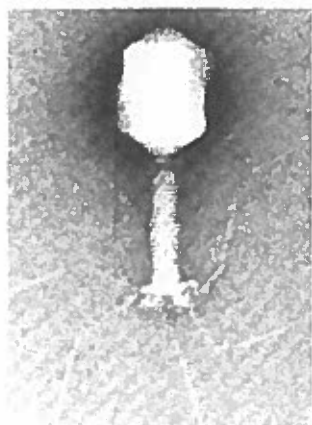
Viruses: The Ultimate Parasites Reading

How many childhood diseases can you recall having: mumps, measles, German measles? A generation ago or so ago, these diseases attacked mainly children and were extremely common. You probably have never had any of these diseases but you most likely have been vaccinated against all of them. Nowadays, vaccination of most infants and children has made these diseases rare. But the causes of childhood diseases have not been wiped out. They still pose a threat to those who have not been vaccinated.

Structure and shape of Viruses

Bacteria do not cause the diseases mentioned above. They are not caused by organisms at all, but rather by tiny, nonliving particles called viruses. Viruses are about one-half to one-hundredth the size of the smallest bacterium. Most biologists do not consider them to be alive because they don't fulfill all the criteria for life. They do not carry out respiration or grow or move. All viruses can do is reproduce—and they can't even do that by themselves. Viruses reproduce only inside a living cell. The cell in which they reproduce is called the host cell.

Because they are nonliving, viruses are not given Latin names, as are cellular organisms. Viruses often are named for the disease they cause—for example the rabies virus and polio virus. Others are named for the organ or tissue they infect—for example, adenoviruses were first detected in adenoid tissue at the back of the throat. In some cases, code numbers are used to distinguish several viruses infecting the same host. Seven viruses that infect the common intestinal bacterium, *Escherichia coli*, are named bacteriophage T1 through T7 (T stands for type). A bacteriophage is a virus that infects bacteria and is pictured to the left.



Viral Structure

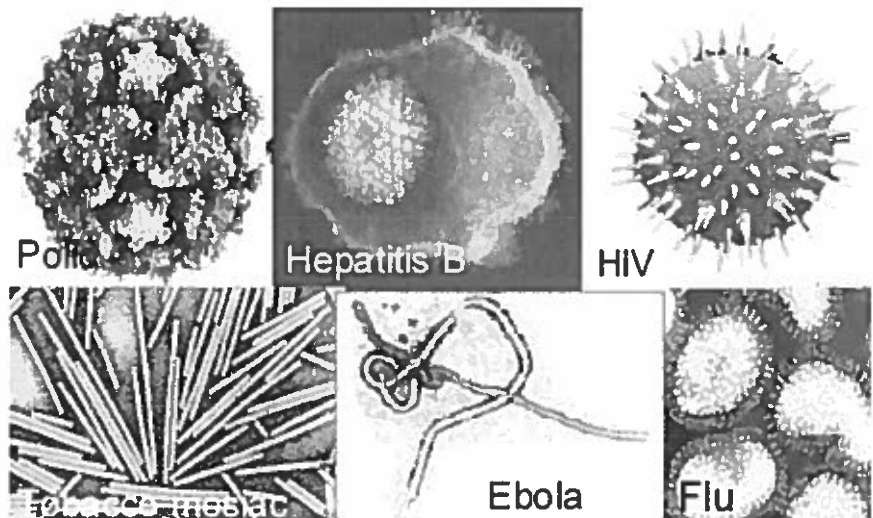
A virus consists of an inner core of nucleic acid surrounded by a capsid. The capsid consists of one or two protein coats. Some relatively large viruses, such as the human flu virus, may have another layer, called the viral envelope, surrounding the outer coat. This layer consists primarily of phospholipids.

The nucleic acid core of a virus contains the virus's genetic material. The nucleic acid in some viruses is DNA and in others it is RNA, but it is never both DNA and RNA. The nucleic acid consists of genes that contain coded instructions only for making copies of the virus. They code for nothing else.

The arrangement of the proteins in the capsid gives different kinds of virus's different shapes as shown in the picture to the right. These shapes play a role in the infection process.

Recognition of a host cell

Viral shape is important in viral reproduction. Before a virus can enter and reproduce in a cell, it must recognize and attach to a specific receptor site on the plasma membrane of the host cell. That's where the viral protein coat plays its role. A protein on the surface of a virus has a three-dimensional shape that matches the shape of the molecules in the plasma membrane of its host cell, like two interlocking pieces of a jigsaw puzzle. In this way, a virus recognizes its host cell. The two interlocking shapes allow the virus to land on the host and lock on, like two spaceships docking. The bacteriophage T4 uses the protein in its tail fibers to attach to the host cell it will infect. In other viruses, the attachment protein is in the envelope that surrounds the virus or in the protein coat.



Attachment is a specific process

Each attachment protein has its own particular shape due to its sequence of amino acids. Therefore, attachment is a specific process. As a result, most viruses can enter and reproduce in only a few kinds of cells. The T4 bacteriophage can infect only certain strains of *E. coli*. T4 cannot reproduce in human, animal, or plant cells, or even in other kinds of bacteria because it cannot attach to these cells. Similarly, tobacco mosaic virus can reproduce only in tobacco plant cells. Not only are viruses species specific, but some also are cell-type specific. For example, poliovirus infects only nerve cells of humans.

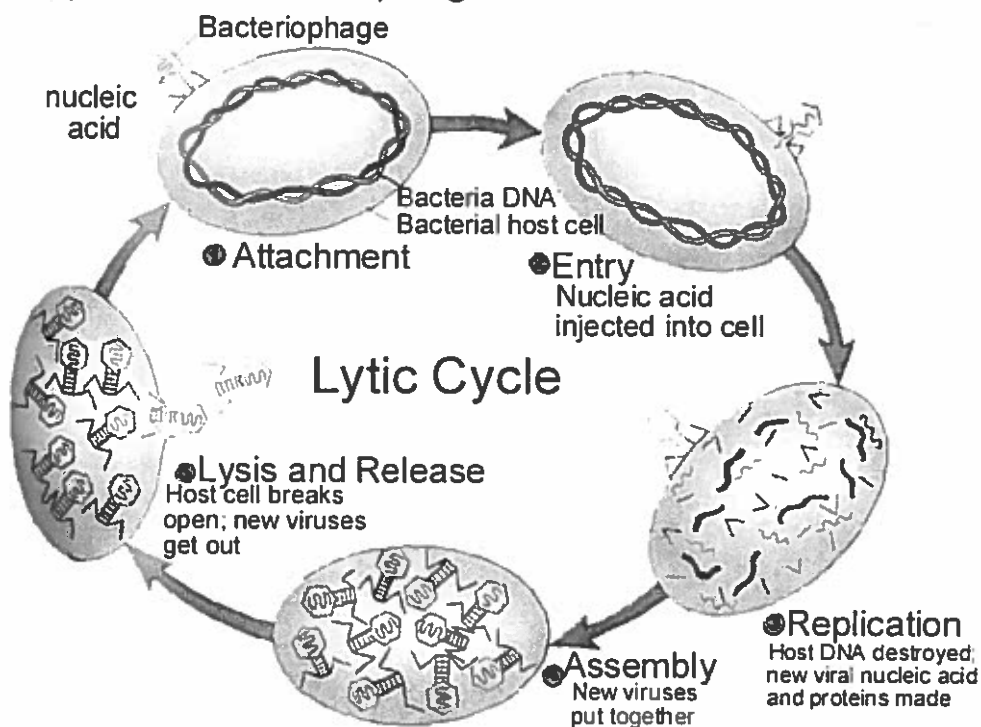
The fact that particular viruses can infect only a few kinds of cells has enormous significance. In the 1970s, the World Health Organization eradicated smallpox, a viral disease that has been one of the greatest killers in history. One reason why this eradication was possible was because the smallpox virus could infect only humans. It would have been much more difficult to eradicate a virus that could infect other animals as well.

Viral Reproductive Cycles

Once attached to the plasma membrane of the host cell, the virus must get inside and take over the cell's metabolism. Only then can the virus reproduce. Method of entry into a host cell depends on the shape of the virus. Some viruses are shaped so that they can inject their nucleic acid into the host cell like a syringe, leaving their coat still attached to the plasma membrane. Other viruses have a shape that can barge in by indenting the plasma membrane, which seals off and breaks free, enclosing the virus within a vacuole in the cell's cytoplasm. The virus then breaks out of the vacuole and release its nucleic acid into the cytoplasm.

Lytic cycle

Once inside the cell, the virus destroys the host's DNA. It reprograms the cell's metabolic activities to copy the viral genes and make viral proteins coats using the host's enzymes, raw materials, and energy. The nucleic acid and coats are assembled into new viruses, which burst from the host cell, usually killing it. The newly produced viruses are then free to infect and kill other host cells. This process is called a lytic cycle. The figure below shows a typical lytic cycle for a bacteriophage.

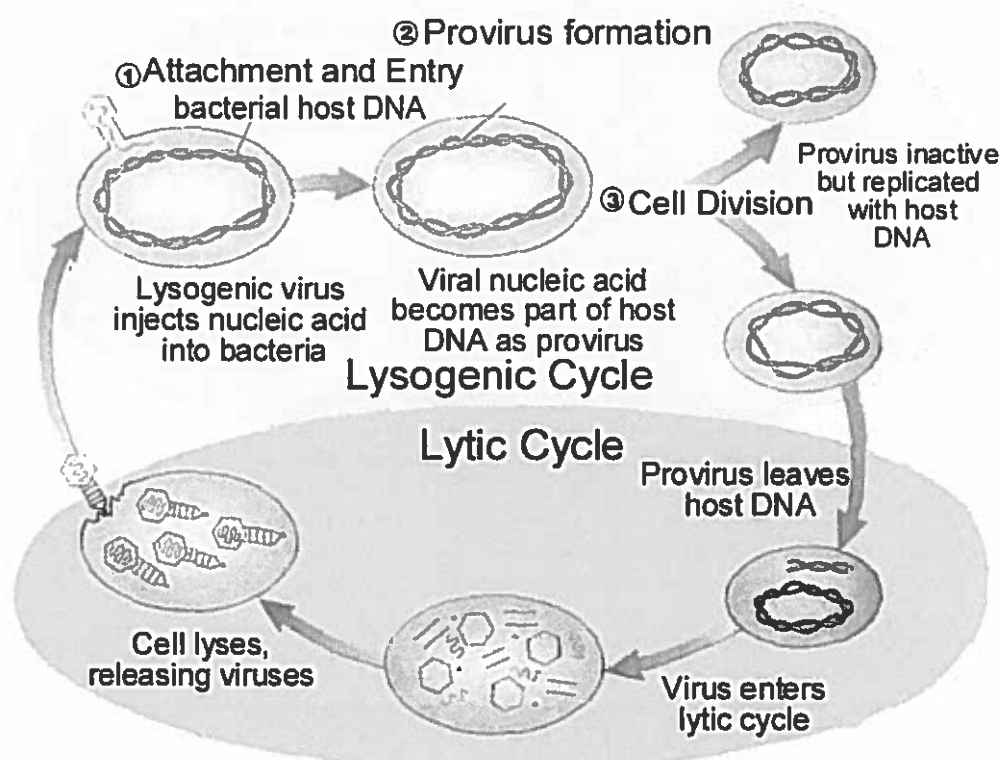


Lysogenic cycle

Viruses vary in the degree of damage they inflict on the host. Not all virus infections are fatal to their host cells. Some viruses can attack but not always kill a cell. These types of viruses go through a lysogenic cycle, a viral

reproductive cycle in which the viral DNA becomes integrated into the host cell's chromosome.

A Lysogenic cycle begins like a lytic cycle. As an example, let's look at a virus that contains DNA. The virus attaches to the plasma membrane of the host cell and injects its DNA into the cell. Events then become different from those in the lytic cycle. The two cycles are pictured below. Instead of destroying the host DNA and making new viruses, the viral DNA becomes part of the host DNA.



Once the viral DNA is inserted into the host cell chromosome, it is known as a provirus. It does not interfere with the normal functioning of the host cell, which is able to carry out its regular metabolic activity. Every time the host cell reproduces, the provirus is replicated right along with the host cell's chromosome. This means that every descendant of the host cell will have a copy of the provirus in its own chromosome. This lysogenic phase can continue undetected for many years. However, the provirus can pop out of the host cell's chromosome at any time. Then the virus starts reproducing and kills the host cell.

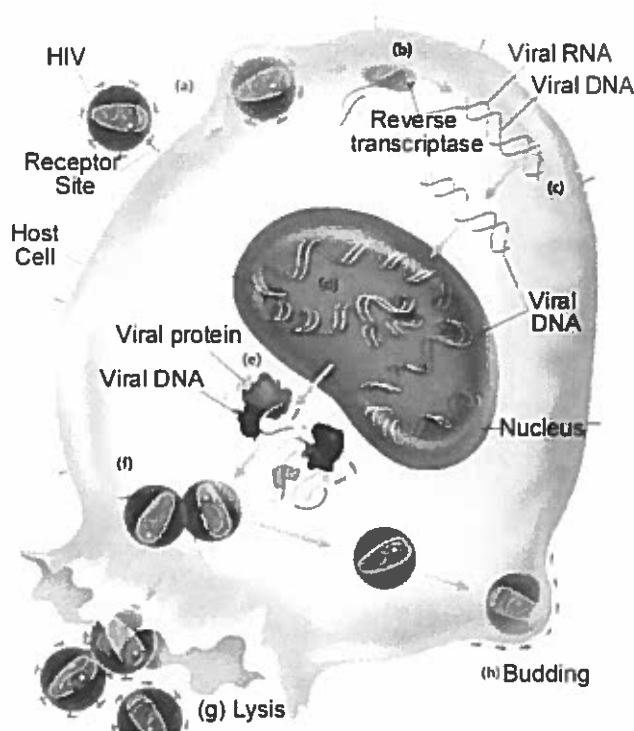
Provirus explain symptoms of disease

The lysogenic process explains why cold sores recur. Once you have had a cold sore, the virus causing it—herpes simplex 1—remains as a provirus in one of the chromosomes in your cells even after the cold sore has healed. When the virus pops out and enters a lytic cycle, you get another cold sore. No one knows the exact conditions that cause the provirus to pop out.

New virus particles may be released from the host cell by lysis—bursting the cell—or they may be released without lysis by a kind of budding process. Both processes are shown with the HIV virus in the picture on the next page. The budding process is a form of exocytosis. The plasma membrane engulfs the virus particles and then opens up to the outside, releasing them.

Sometimes, a provirus nestled in a host cell's chromosome will maintain a low level of activity by repeatedly producing small numbers of new viruses while the host cell continues to function normally. HIV can act in this manner. Small numbers of HIV viruses bud off from infected white blood cells. These viruses then can infect other white blood cells. However, at this time, the viruses do not kill the host cells.

You can see now why a person can be infected with HIV and appear to be perfectly healthy. As long as most of the infected cells are producing only a few viruses, the person will have no clinical symptoms. It also explains why most people infected with HIV will eventually get AIDS. As more and



more cells become infected, and as proviruses begin to pop out, enter a lytic cycle, and kill their host cells, there is a gradual loss of white blood cells, which are important to the body's self-protection process. This loss eventually results in the breakdown of the body's disease-fighting system that is characteristic of AIDS. It also explains why you can get AIDS from a person who appears to be perfectly healthy. A person infected with HIV who has no symptoms can still transmit the virus.

Lysogenic viruses and disease

Many disease-causing viruses go through lysogenic cycles. These include the herpes viruses that cause cold sores and genital herpes, and the virus that causes hepatitis B. Another such virus is the one that causes chicken pox. An attack of chicken pox, which usually occurs before age ten, gives lifelong protection from another invasion of chicken pox viruses. However, the virus remains dormant within nerve tissues. It may flare up later in life, causing a disease called shingles—a painful infection of the nerves that transmit impulses from certain areas of the skin.



Miscellaneous Virusie stuff

More than 400 viruses are known to infect plant cells, causing as many as 1000 plant diseases. In fact, the first virus to be identified was a plant virus—tobacco mosaic virus. Not all plant disease caused by viruses are fatal or even harmful. For example, some mosaic viruses cause a striking vegetation in the flowers of plants such as gladioli and pansies. The diseased flowers exhibit streaks of contrasting colors in their petals, as shown in the picture of the Rembrandt tulip to the left. These tulips created such a stir among the people of Europe in the 1600s that it became a contest to see who could have the most unusual color combinations. People in the Netherlands where "Tulipmania" was the most severe, would sell family businesses to invest in a prized tulip bulb. It was such a frenzy that the Dutch economy almost collapsed due to the quest for the most unusual tulip. The people did not know the striking colors were caused by a virus and could be transmitted by cutting an infected flower with a pair of scissors then cutting a healthy flower with the same pair of scissors. Today, true Rembrandt tulips do not exist but growers have bred safe substitutions that do not rely on viruses for their coloration.

It is hard to believe but there are disease-causing agents that are even simpler than viruses. They are viroids and prions. Viroids are the smallest known particles that are able to replicate. A viroid consists of a short, single strand of RNA and has no outer coat. These simple RNA molecules are able to disrupt plant cell metabolism and damage entire crops. Economically important plants that have been affected by viroids include potatoes, cucumbers, avocados, and oranges.

Prions are abnormal forms of proteins that clump together inside a cell. This clumping activity eventually kills the cell perhaps by blocking the cell's molecular traffic. Found on the surface of mammalian cells and in the brain of hosts, prions are composed of about 25 amino acids and have no associated nucleic acid. Prions have been linked to certain diseases of the brain in humans and animals, such as scrapie. Scrapie is a disease in sheep that is characterized by slow degeneration of the nervous system. As the nervous system decays, the animals develop tremors and scrape their bodies against fence posts and tree trunks. Bovine spongiform encephalopathy (BSE) or "mad cow disease" is a fatal brain disease of cattle that may be linked to prions. The prion that is thought to cause mad cow disease may be similar to one implicated in a human brain disorder called Creutzfeld-Jakob disease (CJD).