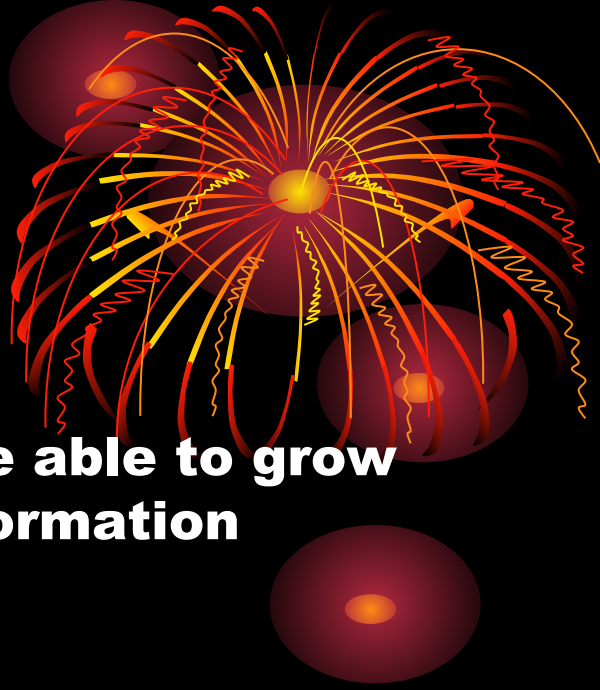
Viruses

What are Viruses

A virus is a non-cellular particle made up of genetic material and protein that can invade living cells.

Is a Virus Alive?



- All living things are made of cells, are able to grow and reproduce, and are guided by information stored in their DNA.
- **Viruses** are segments of nucleic acids contained in a protein coat. Viruses are not cells.
- Viruses are **pathogens**—agents that cause disease.
- Viruses do not grow, do not have homeostasis, and do **not metabolize.**

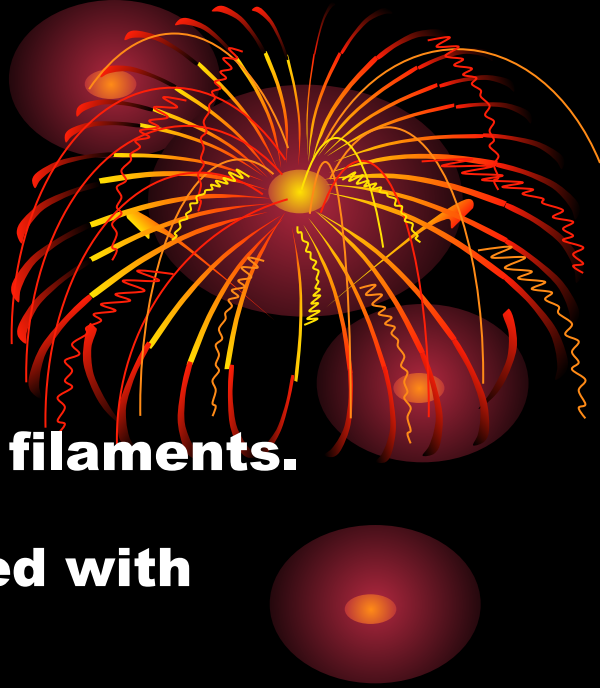
Discovery of Viruses

- Near the end of the nineteenth century, scientists were trying to find the cause of tobacco mosaic disease, which stunts the growth of tobacco plants.
- In 1935, biologist Wendell Stanley of the Rockefeller Institute purified tobacco mosaic virus (TMV) and determined that the purified virus is a crystal.
- Stanley concluded that TMV is a chemical rather than an organism.

Viral Structure

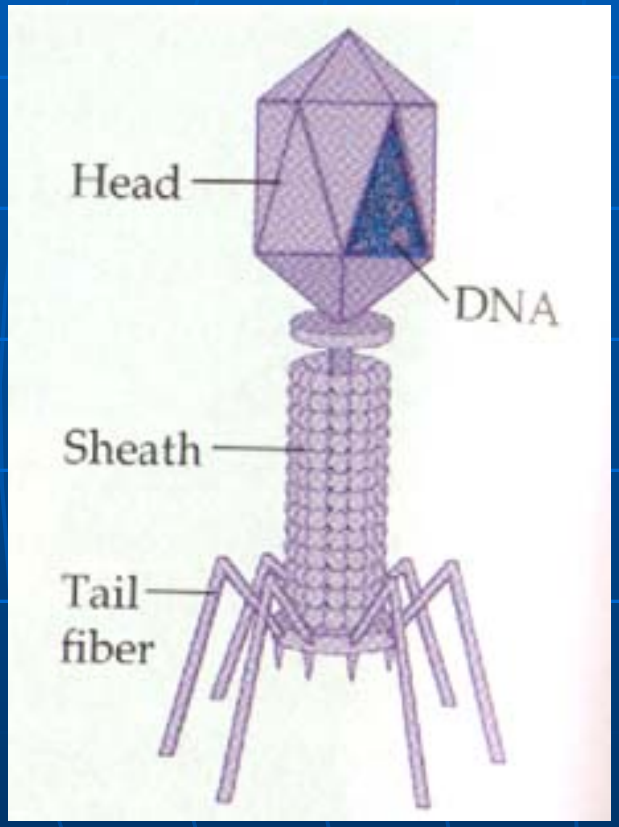
- The virus protein coat, or **capsid**, may contain either RNA or DNA, but not both.
- Many viruses have a membrane, or **envelope**, surrounding the capsid.
- The envelope helps the virus enter cells. It consists of proteins, lipids, and **glycoproteins**, which are proteins with attached carbohydrate molecules that are derived from the host cell.

VIRUS Structure

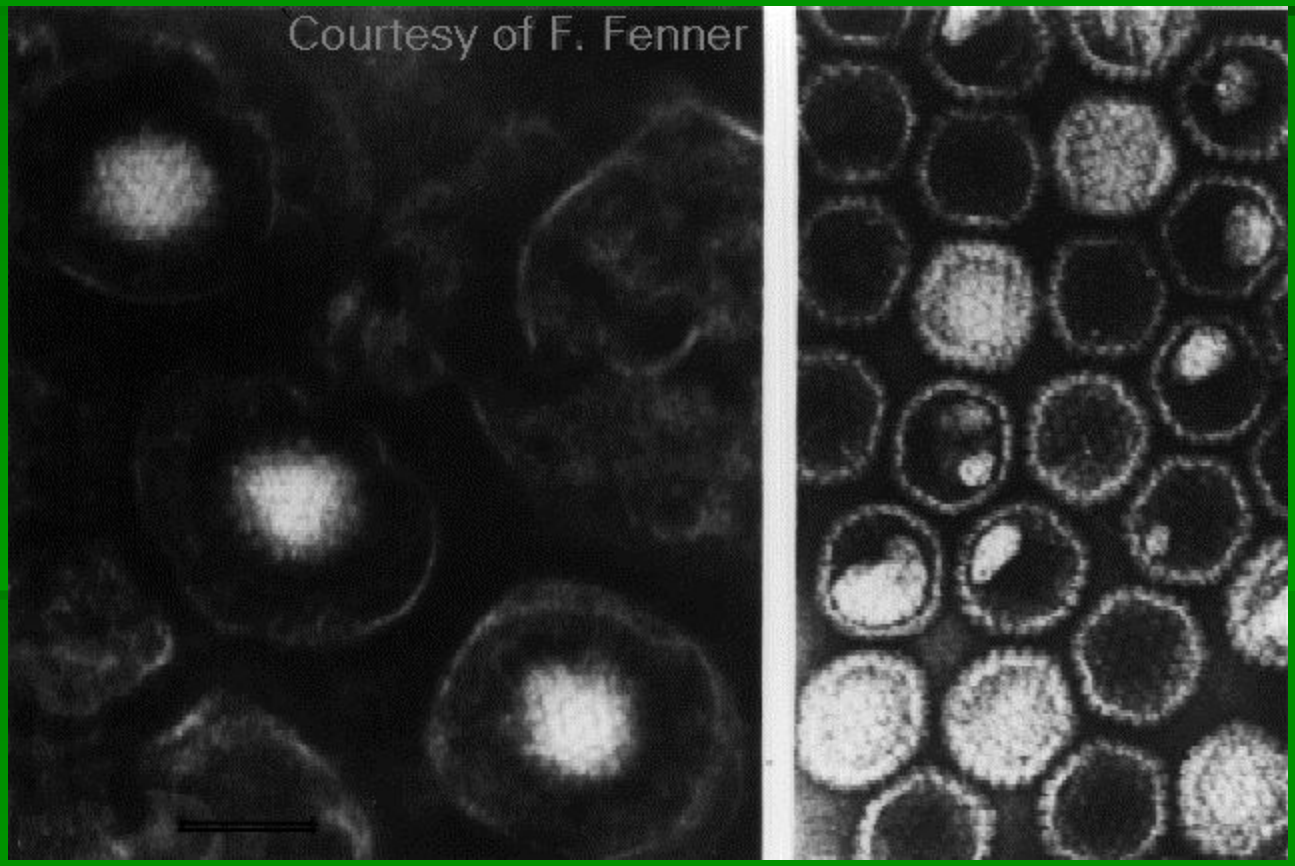


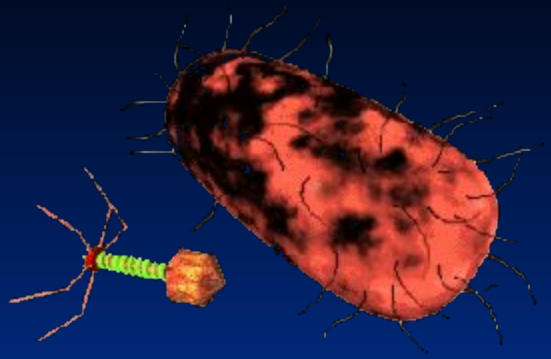
- Some viruses are long rods that form filaments.
- Spherical viruses are typically studded with receptors.
- A helical virus is rodlike in appearance, with capsid proteins winding around the core in a spiral.
- Viruses that infect bacteria, called **bacteriophages**, have a complicated structure. A T4 bacteriophage, for example, has a polyhedron capsid attached to a helical tail.

T4 Bacteriophage DNA virus

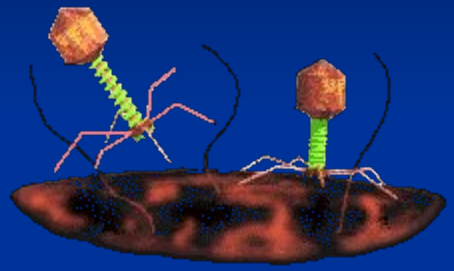


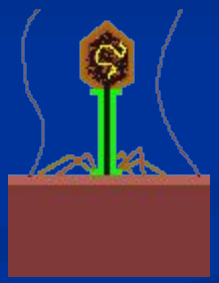
Herpes Virus (DNA Virus)



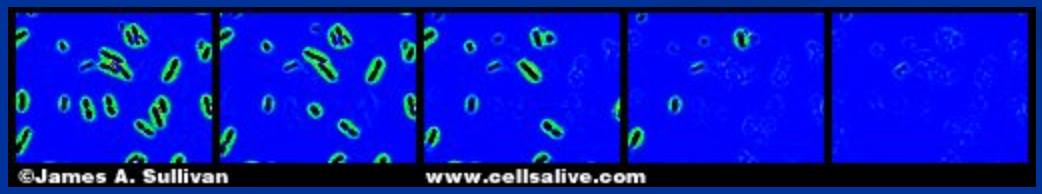


Bacteriophage T4 attacks a bacterium



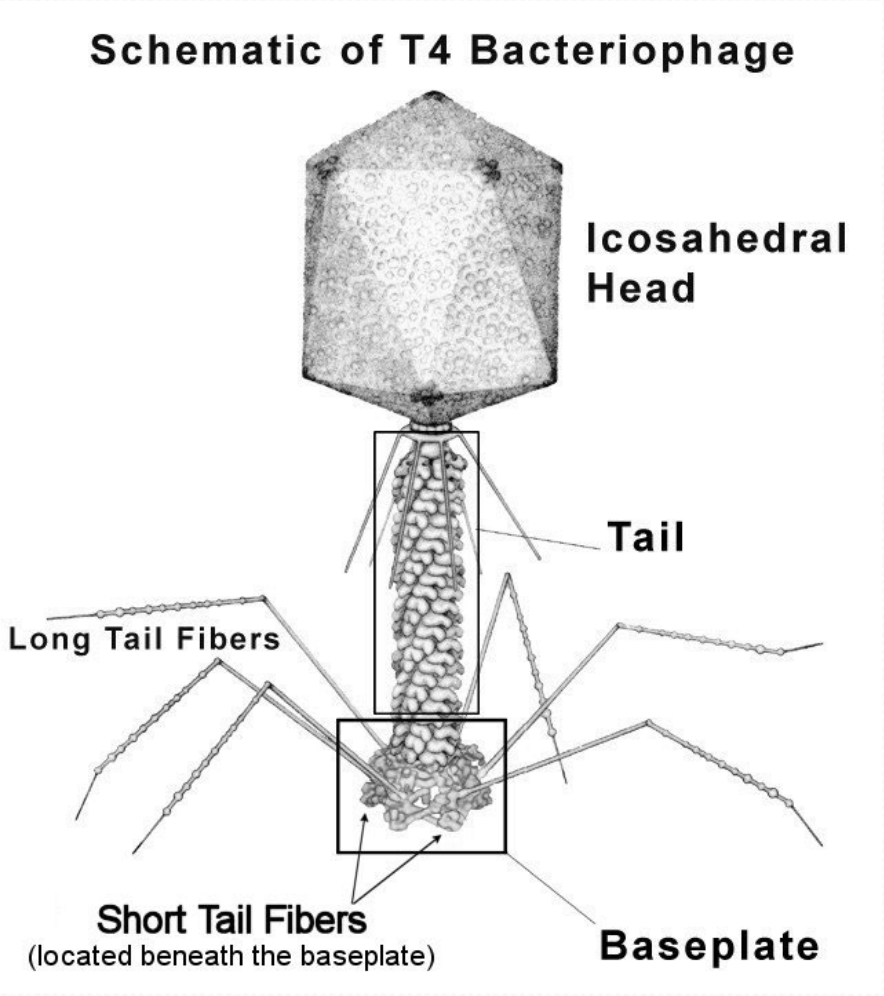


What it looks like in real life



The Structure Of a Virus

- Viruses are composed of a core of nucleic acid
- The Nucleic acid core is surrounded by a protein coat called capsid
- The Nucleic core is either made up of DNA or RNA but never both



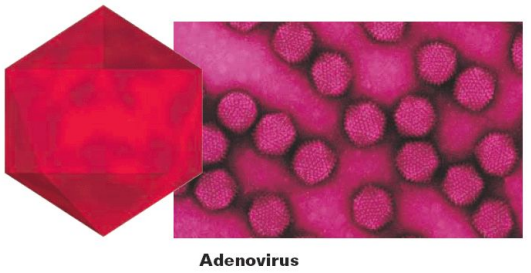
Viral Reproduction

Viruses must rely on living cells (host cells) for replication.

Before a virus can replicate, it must first infect a living cell.

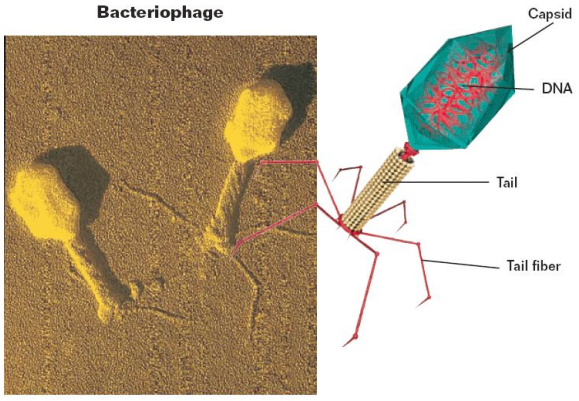
An animal virus enters its host cell by endocytosis.

A bacterial virus, or bacteriophage, punches a hole in the bacterial cell wall and injects its DNA into the cell

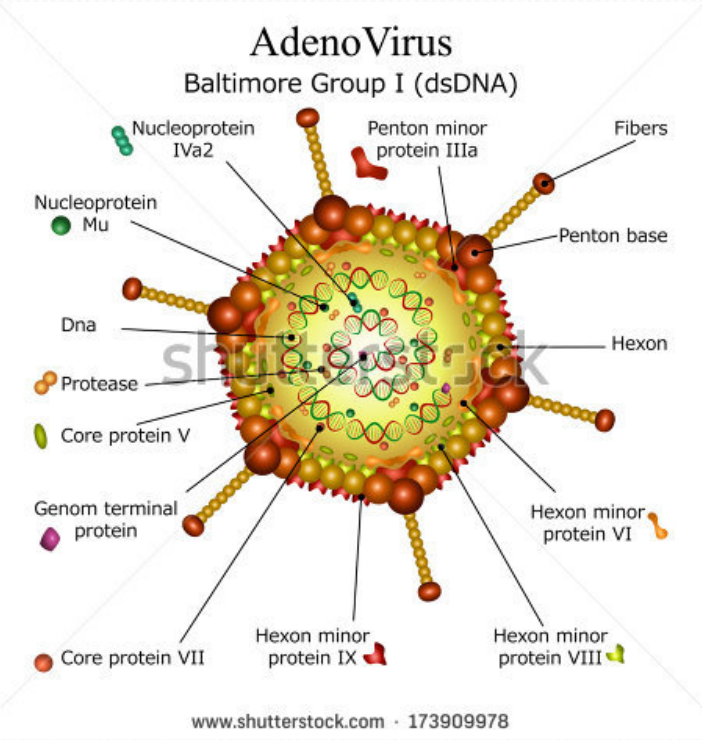


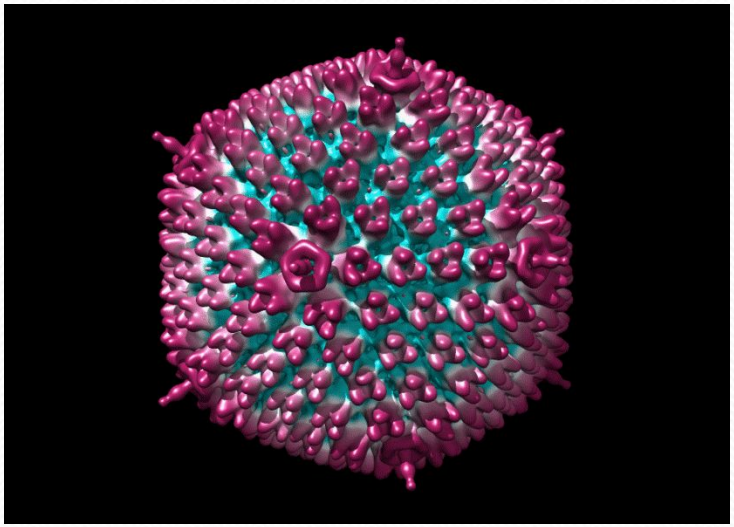
Adenovirus

Structures of Adenovirus and Bacteriophage



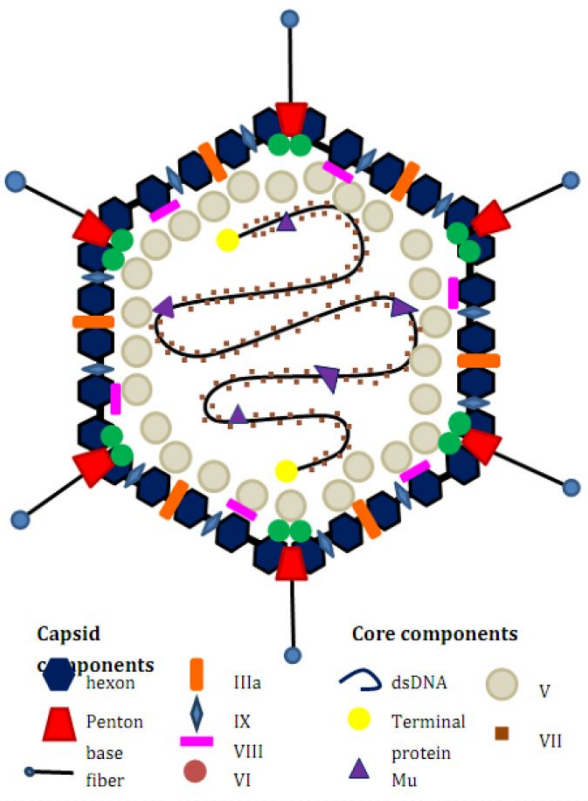
Adenoviruses (members of the family ***Adenoviridae***) are medium-sized (90–100 nm), nonenveloped (without an outer lipid bilayer) viruses with an icosahedral nucleocapsid containing a double stranded DNA genome. Their name derives from their initial isolation from human adenoids in 1953.
They have a broad range of vertebrate hosts; in humans, 57 distinct adenoviral serotypes have been found to cause a wide range of illnesses.





ADENOVIRUSES ARE COMMON VIRUSES THAT CAN CAUSE ILLNESS IN HUMANS. BUT, MOST ILLNESSES ARE NOT SERIOUS. ADENOVIRUSES MOST OFTEN CAUSE RESPIRATORY ILLNESS. THE VIRUSES MAY ALSO CAUSE FEVER, DIARRHEA, PINK EYE (CONJUNCTIVITIS), BLADDER INFECTION (CYSTITIS), OR RASH ILLNESS.

ANYONE CAN GET INFECTED WITH ADENOVIRU
INFANTS AND PEOPLE WITH WEAKENED IMMUN
SYSTEMS OR EXISTING RESPIRATORY OR CARI
DISEASE ARE AT HIGHER RISK OF GETTING SIC
FROM AN ADENOVIRUS INFECTION.
YOU CAN GET INFECTED WITH ADENOVIRUSES
BY HAVING CLOSE CONTACT WITH PEOPLE WH
ARE INFECTED WITH THESE VIRUSES OR THOS
ARE SICK. YOU CAN ALSO GET INFECTED BY
TOUCHING SURFACES OR OBJECTS THAT HAVE
ADENOVIRUSES ON THEM THEN TOUCHING YO
MOUTH, NOSE, OR EYES.

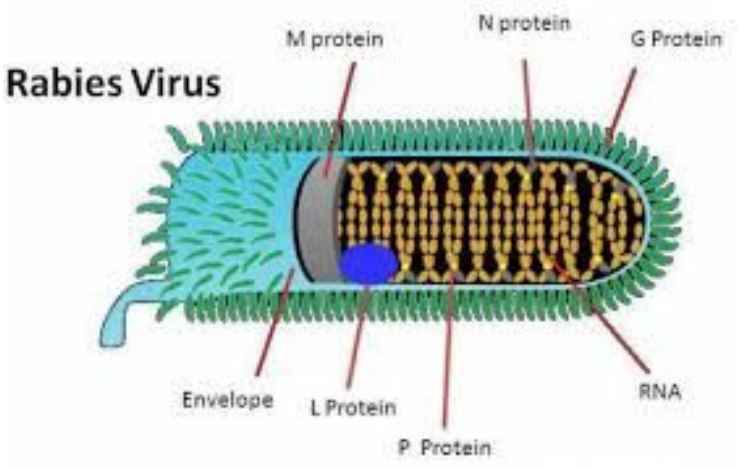


An **RNA virus** is a virus that has RNA (ribonucleic acid) as its genetic material. This nucleic acid is usually single-stranded RNA (ssRNA), but may be double-stranded RNA (dsRNA). Notable human diseases caused by RNA viruses include Ebola hemorrhoragic fever, Zika fever, influenza, hepatitis C, West Nile fever, polio, pneumonia and measles.

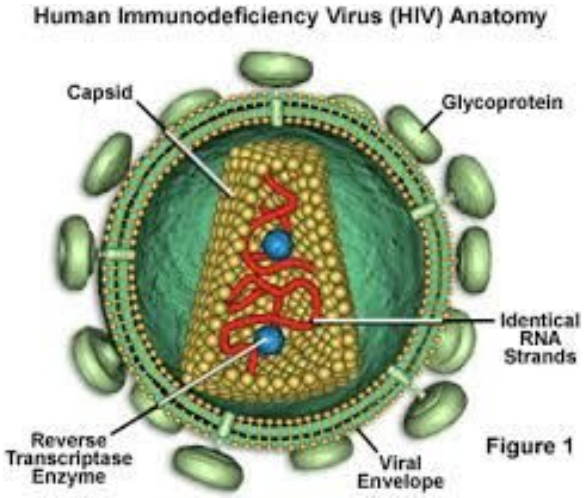
Viruses with RNA as their genetic material but that include DNA intermediates in their replication cycle are called retroviruses.

Notable human retroviruses include HIV-1 and HIV-2, the cause of the disease AIDS.

Another term for RNA viruses that explicitly excludes retroviruses is **ribovirus**.



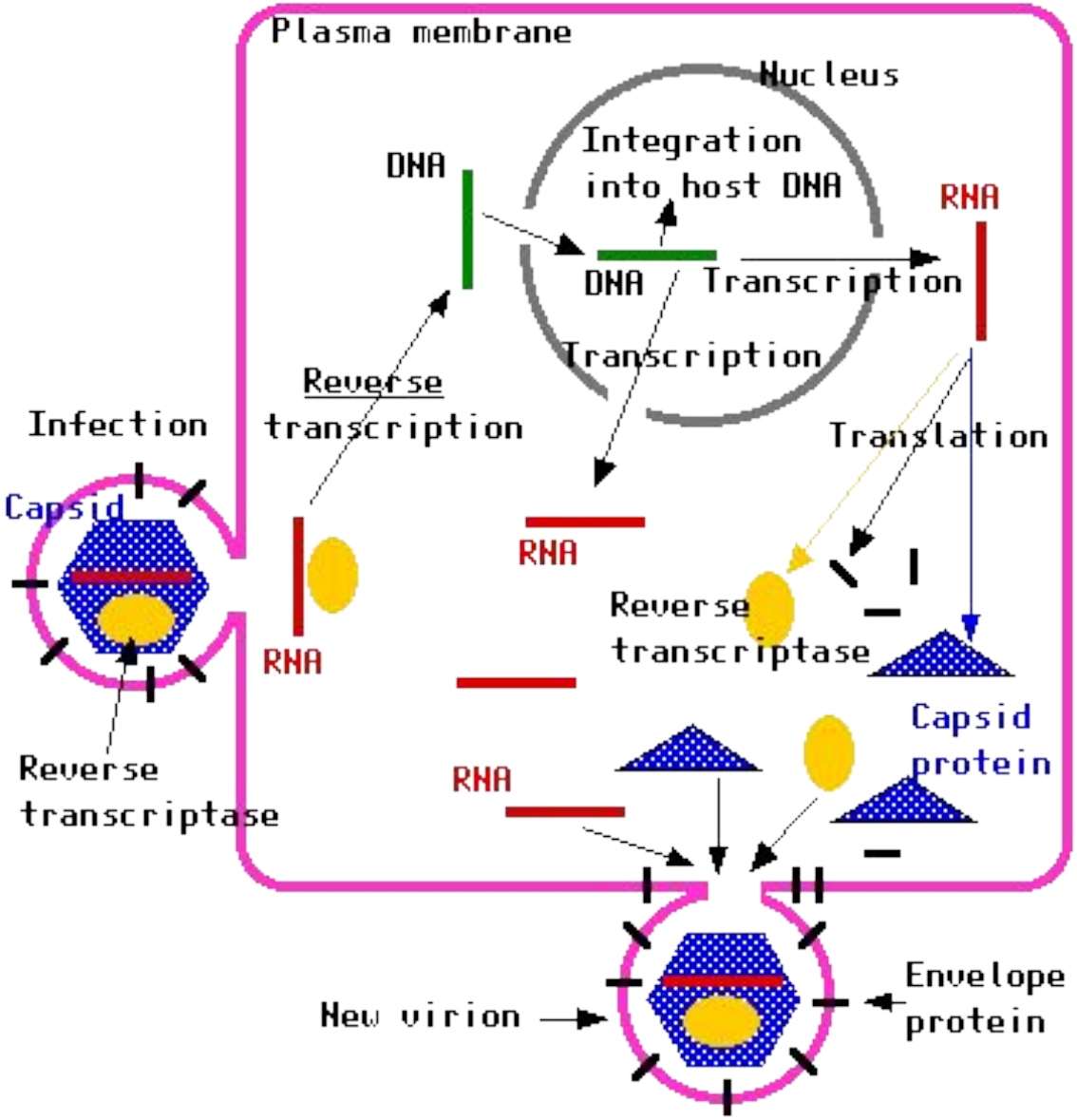
RNA ribovirus



HIV RNA retrovirus

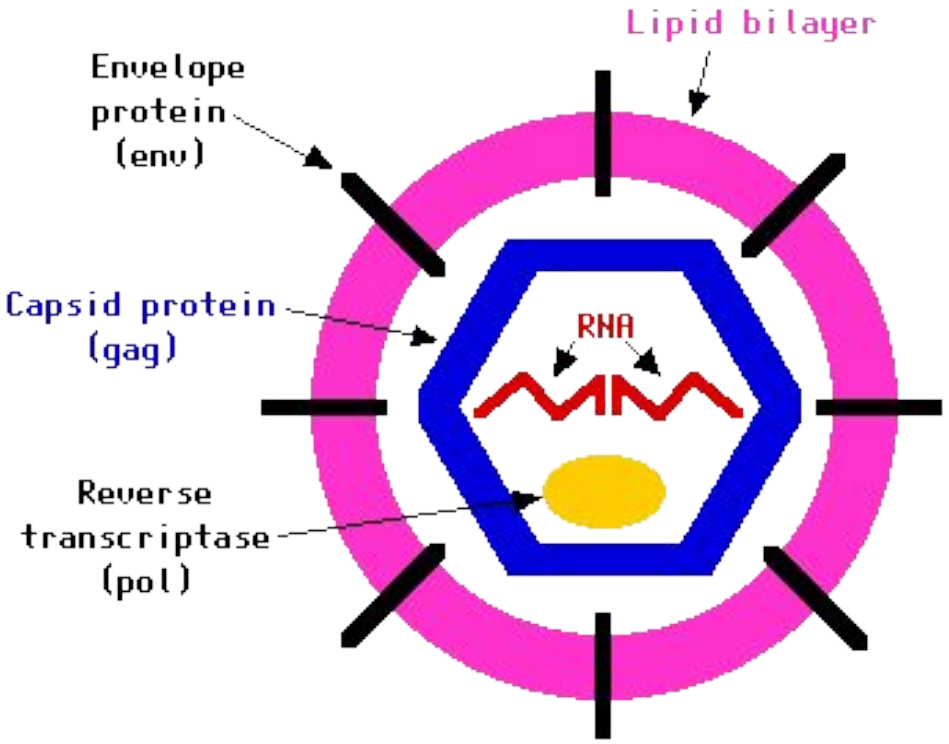
Retrovirus

- Change RNA into DNA.
- Example of a Retrovirus is HIV



A typical, "minimal" retrovirus consists of:

- an outer envelope which was derived from the plasma membrane of its host
- a capsid; a protein shell containing two molecules of RNA
- molecules of the enzyme reverse transcriptase



https://www.bing.com/videos/search?q=hiv+virus&&view=detail&mid=C7D8E76EF1E4D026F886C7D8E76EF1E4D026F886&&FORM=VRDGAR

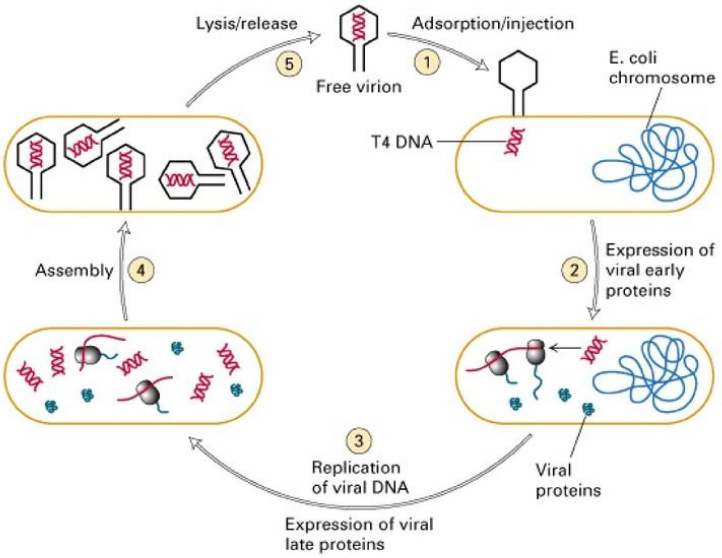
Lytic Cycle

In bacterial viruses, the cycle of viral infection, replication, and cell destruction is called the **lytic** cycle.

After the viral genes have entered the cell, they use the host cell to replicate viral genes and to make viral proteins, such as capsids.

The proteins are then assembled with the replicated viral genes to form complete viruses. The host cell is broken open and releases newly made viruses.

Ciclo litico di un batteriofago

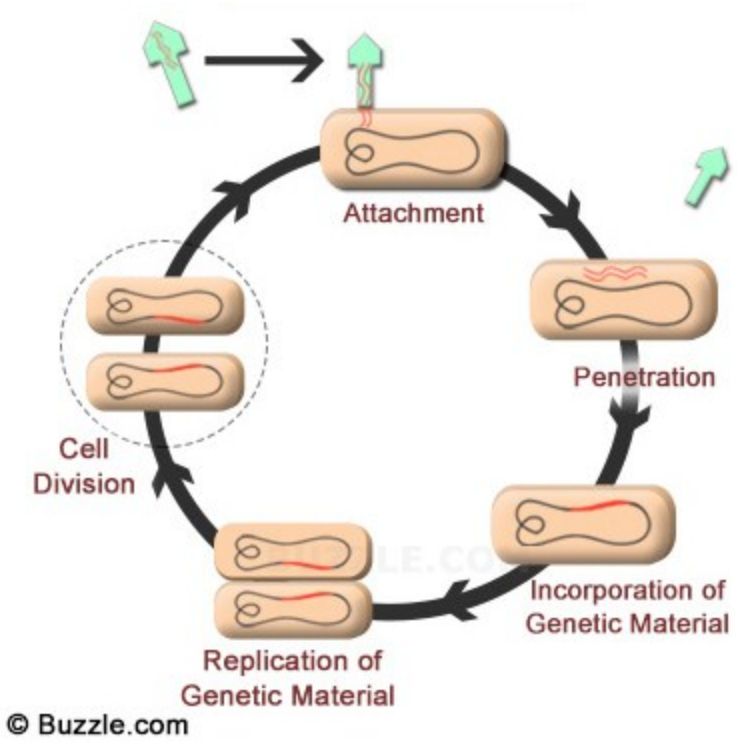


Lysogenic Cycle

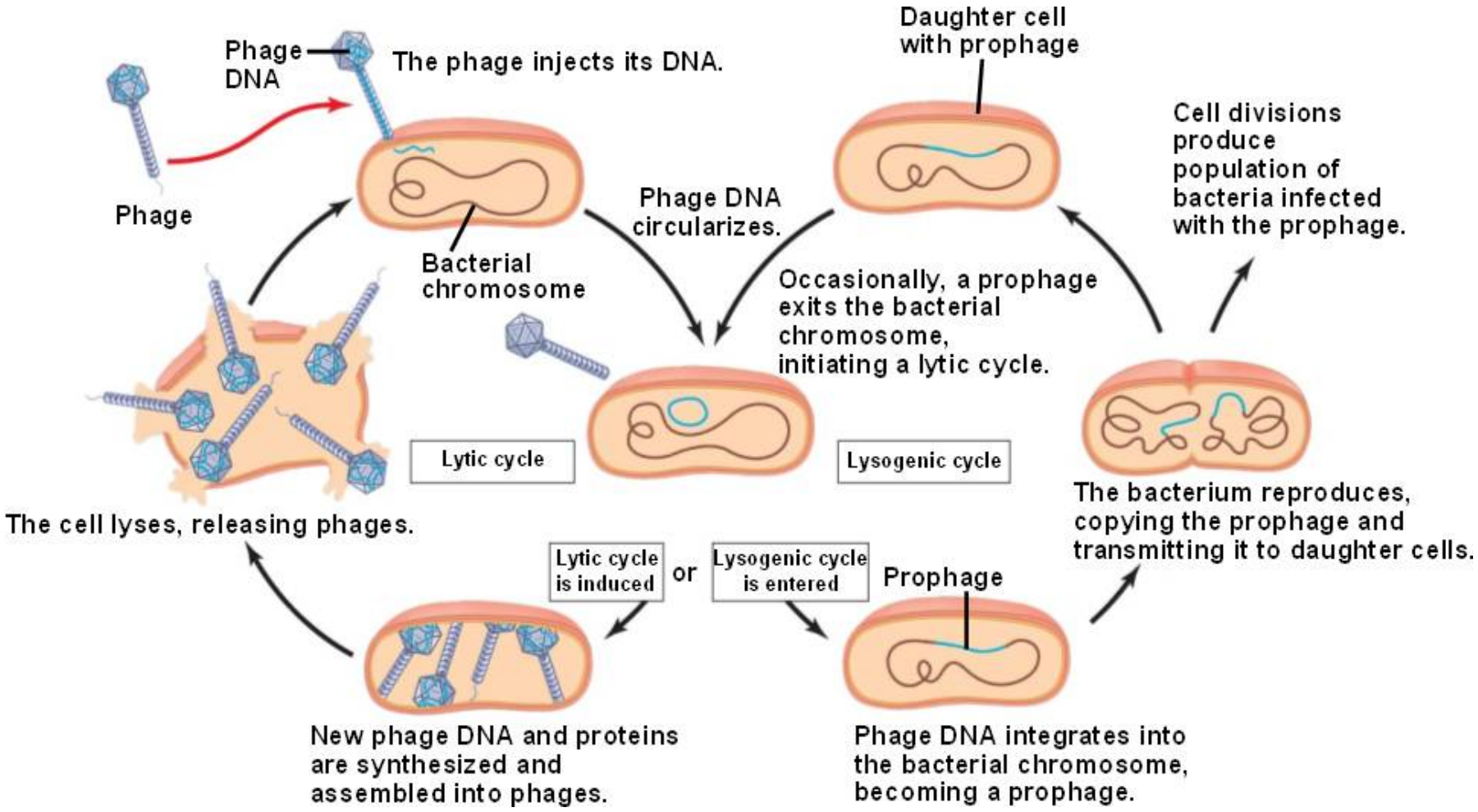
During an infection, some viruses stay inside the cells but instead of producing virus particles, the viral gene is inserted into the host chromosome and is called a **provirus**.

Whenever the cell divides, the provirus also divides, resulting in two infected host cells.

In this cycle, called the **lysogenic** cycle, the viral genome replicates without destroying the host cell.



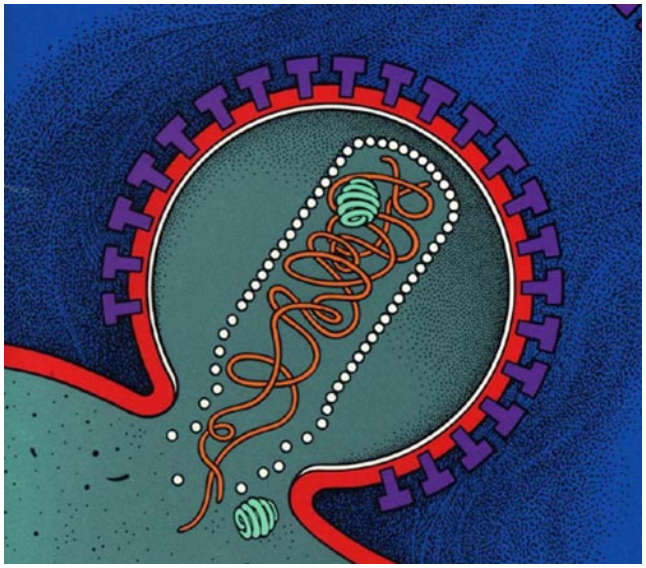
Cycle of Lytic and Lysogenic

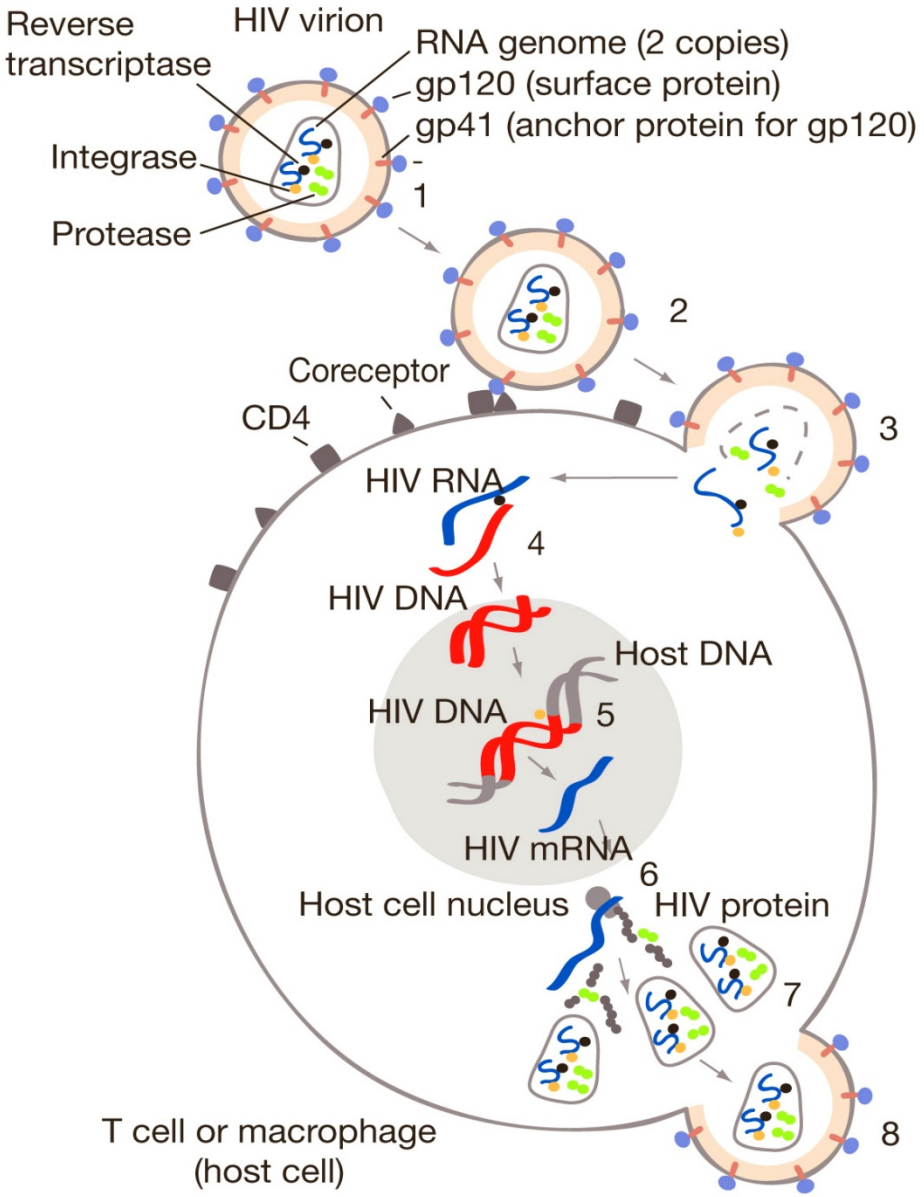


https://www.bing.com/videos/search?q=virus+lytic+cicle&&view=detail&mid=D73614551A9352DF1DE8D73614551A9352DF1DE8&&FORM=VDRVRV

The Human Immunodeficiency Virus

HIV, like all viruses, is an intracellular parasite.
Parasitizes macrophages and T-cells of immune system
Uses cells enzymatic machinery to copy itself. Kills host cell in process.
Host cell membrane and viral coat fuse and virus contents enter cell.





1) HIV's extracellular, or virion stage

2) HIV's gp120 protein binds to CD4 and coreceptor on host cell

3) HIV's RNA genome, reverse transcriptase, integrase, and protease enter host cell

4) Reverse transcriptase synthesizes HIV DNA from HIV's RNA template

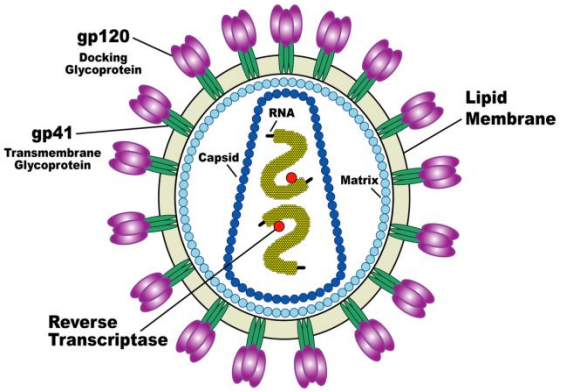
5) Integrase splices HIV DNA into host genome. HIV DNA is transcribed to HIV mRNA by the host cell's RNA polymerase

6) HIV mRNA is translated to HIV precursor proteins by host cell's ribosomes. Protease cleaves precursors into mature viral proteins

7) New generation of virions assembles inside host cell

8) New virions bud from host cell's membrane

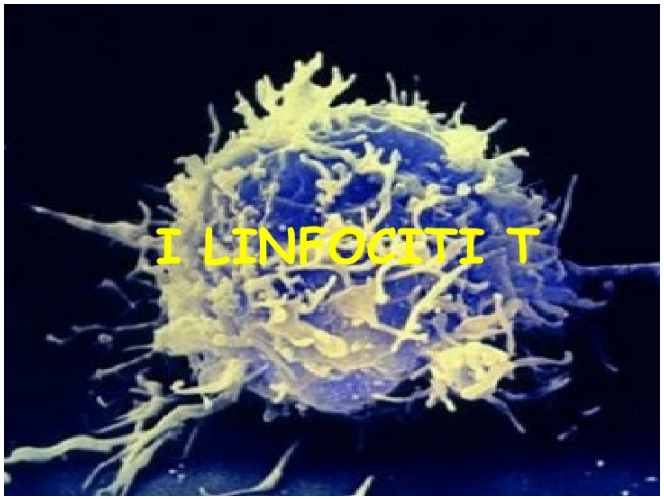
How HIV causes AIDS



HIV invades immune system cells especially helper T cells.
These helper T cells have a vital role in the immune system.
When a helper T cell is activated (by having an antigen [a piece of foreign protein] presented to it, it begins to divide into memory T cells and effector T cells.

Why is HIV hard to treat?
Viral disguise

Killer T cells deplete helper T cells (those that produce memory cells that can remember and recognize HIV).
Loss of helper T cells is costly, but the immune system now primed to recognize and attack the viral protein.
What's the problem?



Why is HIV hard to treat?
Viral disguise

Virus mutates and the proteins on its outer surface change.
These new surface proteins are not recognized by the immune system's memory cells.
Mutant virus particles bearing new surface proteins survive immune system attack and begin new round of infection

Each round of infection reduces numbers of helper T cells because they are infected by virus and destroyed.

Furthermore, because each lineage of T cells has a limited capacity for replication, after a finite number of rounds of replication the body's supply of helper T cells becomes exhausted. The immune system eventually is overwhelmed and collapses.

https://www.bing.com/videos/search?q=hiv+virus&&view=detail&mid=E9A807FFAC8E2DFA3C8BE9A807FFAC8E2DFA3C8B&&FORM=VDRVRV
https://www.bing.com/videos/search?q=hiv+virus&&view=detail&mid=A5CD786BD95BC665655CA5CD786BD95BC665655C&&FORM=VRDGAR

Several different types of drugs have been developed to treat HIV.

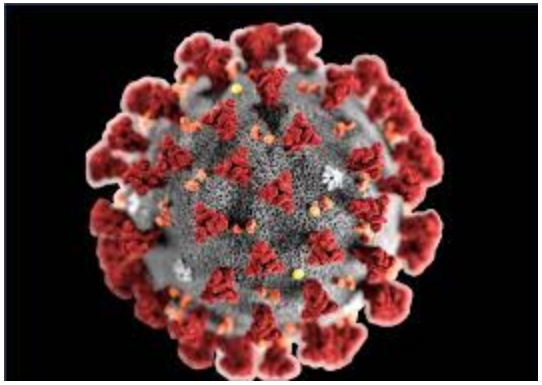
- Reverse transcriptase inhibitors (ex. AZT).
- Protease inhibitors (prevent HIV from producing final viral proteins from precursor proteins).
- Fusion inhibitors prevent HIV entering cells.
- Integrase inhibitors prevent HIV from inserting HIV DNA into host's genome.

Most successful approach has been to use multi-drug cocktails (referred to as HAART [Highly Active Anti-Retroviral Treatments]

HAART cocktails usually use three different drugs in combination (ex. two reverse transcriptase inhibitors and a protease inhibitor).

Multi-drug treatments have proven very successful in reducing viral load and reducing mortality of patients.

CORONAVIRUS



Coronaviruses cause acute, mild upper respiratory infection (common cold).

Structure

Spherical or pleomorphic enveloped particles containing single-stranded (positive-sense) RNA associated with a nucleoprotein within a capsid comprised of matrix protein. The envelope bears club-shaped glycoprotein projections.

Classification

Coronaviruses are classified on the basis of the crown or halo-like appearance of the envelope glycoproteins, and on characteristic features of chemistry and replication. Most human coronaviruses fall into one of two serotypes: OC43-like and 229E-like.

Multiplication

The virus enters the host cell, and the uncoated genome is transcribed and translated. The mRNAs form a unique “nested set” sharing a common 3′ end. New virions form by budding from host cell membranes.

Pathogenesis

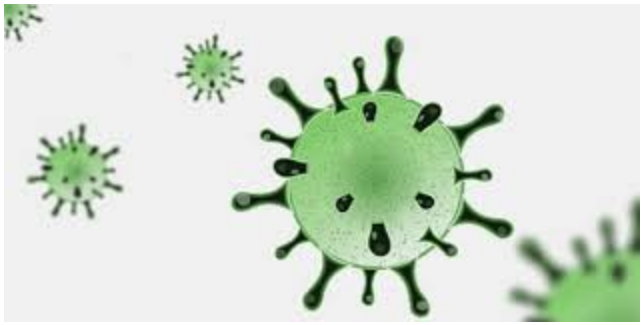
Transmission is usually via airborne droplets to the nasal mucosa. Virus replicates locally in cells of the ciliated epithelium, causing cell damage and inflammation.

Host Defenses

The appearance of antibody in serum and nasal secretions is followed by resolution of the infection. Immunity wanes within a year or two.

Epidemiology

Incidence peaks in the winter, taking the form of local epidemics lasting a few weeks or months. The same serotype may return to an area after several years.



The **coronavirus disease** 2019 (COVID-19) is a new type of pneumonia caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection. COVID-19 is affecting millions of patients, and the infected number keeps increasing.

According to World Health Organization (WHO) statistics on March 2020, the mortality rate among confirmed COVID-19 cases was 3.4%. As of May 2020, according to WHO, the mortality rate is nearly 5.9%.

In Italy, however, the mortality rate is more than 13%.

The SARS-CoV-2 coronavirus is a type of single-stranded RNA virus that belongs to the coronaviruses family.

Coronaviruses can be divided into four genera: *Alphacoronavirus* (αCoV), *Betacoronavirus* (βCoV), *Gamma coronavirus* (γCoV), and *Deltacoronavirus* (δCoV).

Currently, seven coronaviruses are known to infect human, including two alphacoronaviruses and five betacoronaviruses .
During the past two decades, three previously unknown betacoronaviruses (SARS-CoV, MERS-CoV, and SARS-CoV-2) have emerged.
These deadly coronaviruses cause lower respiratory tract infections, resulting in acute pneumonia, respiratory distress, cytokine storms, multiple organ dysfunctions, and even patient death.

Clinical Treatment of COVID-19

Currently there is no specific drug available to block SARS-CoV-2 infection or to kill the viruses. The treatment strategy is mainly determined by the clinical characteristics and severity of the disease, and different patients receive different treatments based on their conditions.

Generally, patients are treated with strengthening support therapy to maintain sufficient caloric intake and water and electrolyte balance. Strategies including oxygen therapy, antiviral therapy, immunotherapy, organ support, and complication prevention are used for the prevention and control of acute respiratory distress syndrome, cytokine storms, organ failure, and secondary hospital infections.

https://www.youtube.com/watch?v=i0ZabxXmH4Y

The known transmission pathways of SARS-CoV-2 in humans include the following:

(1)inhaling tiny droplets carrying virus,

(2) close contact with virus carriers,

(3) contact with a surface contaminated by SARS-CoV-2,

(4) aerosol transmission.

After the membrane fusion, the viral RNA genome is released into the cytoplasm of the host cells.

After RNA replication, the structural proteins N, S, E, and M are translated S, E, and M proteins insert into the endoplasmic reticulum (ER) and move to the endoplasmic reticulum-Golgi intermediate compartment to form the mature viruses with the viral genome and N protein.

After that, viruses are transported to the cell surface and then released out of the cells by exocytosis