Introduction

Viruses are abundant in nature and can infect and parasitize all living organisms from bacteria to mammals. They are considered to be very simple biological entities composed of a small number of macromolecules produced by, and thus derived from, the organism they infect. Viruses cause many diseases of international importance. Amongst the human viruses, smallpox, polio, influenza, hepatitis, human immunodeficiency virus (HIV-AIDS), measles and the Severe acute respiratory syndrome(SARS), coronavirus are particularly well known. While antibiotics can be very effective against diseases caused by bacteria, these treatments are ineffective against viruses and most control measures rely on vaccines or relief of the symptoms to encourage the body's own defense system. Viruses also cause many important plant diseases and are responsible for huge losses in crop production and quality in all parts of the world.

For Your Information

In just ten minutes, a virus may take over a cell, copy itself hundreds of times, and kill the cell. Some viruses have a calculated replication time of about 70 seconds. By comparison, the fastest bacterial replicators only double their biomass every 20 minutes or so.

5.1 Status of viruses

Viruses lie on the border line between living and non living things. Viruses are considered as living because viruses possess DNA or RNA. They have the ability of reproduction. They can undergo mutation and genetic recombination and also possess the ability to infect other living things and show irritability.

Apart from these living characters viruses possess some non living characters. They are sub cellular or non cellular structure. They do not respire or excrete, can be crystallized and stored in much the same way as chemicals.

5.2 Discovery of the virus

By the late 1800's pioneer bacteriologists like **Louis Pasteur, Robert Koch** had demonstrated that bacteria cause many diseases of man and other organisms. However, causal agents of some diseases puzzled them. One such disease was tobacco mosaic disease. The agent of this disease could be transmitted from an

infected organism to a healthy organism of the same kind . This was first demonstrated in 1892 by a Russian biologists named **Iwanowsky.**

By 1900 similar disease, producing substances had been discovered in many organisms, both plants and animals. In 1898 it was demonstrated that virus from the blisters produced on the diseased stock could transmit foot and mouth disease of cattle. It was given the name filterable viruses, the viruses that can pass through a filter from which bacteria cannot pass.

By 1930 most people believed that the viruses are small particles not visible through compound microscope. In 1935 **W.M. Stanley** prepared an extract of tobacco mosaic virus. Under the compound microscope, the isolated viruses appeared as silvery crystals composed of many rod – shaped structures. Isolated, purified extracts from the cells of the hosts revealed that TMV as dead particles. This started a debate whether viruses living or dead? **W.M. Stanley** took purified TMV, dissolved it in water and rubbed it on the leaves of healthy tobacco plants. The leaves soon showed the mottle condition, characteristics of TMV disease. It was found that viruses had reproduced itself in living cells of the host. This proved that viruses had some living charactertics

5.3 Classification of Viruses

Viruses can be broadly classified based on morphology and the type of host they infect. On the basis of morphology there are three classes of viruses,

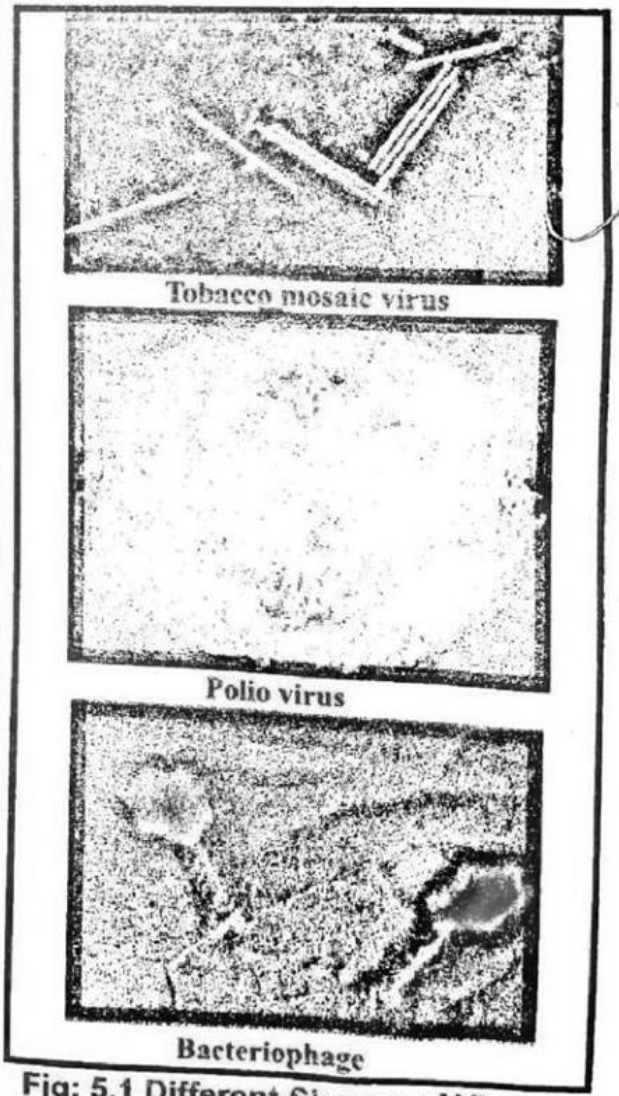
a. Spherical Virus. e. g. Polio virus
b. Tadpole shaped virus. e.g. Bacteriophage.
c. Rod shaped virus. e.g. tobacco mosaic virus.

Viruses can be classified on the basis of host:

a. Animals viruses: They are parasites of animals and human beings and causes diseases in them. Common diseases in man are polio, small pox, measles, mumps and influenza etc.

b. Plant viruses: These are parasite on plants and cause diseases in them.

c. Bacteriophage (phage): This virus is parasite only on bacteria.



Fig; 5.1 Different Shapes of Viruses

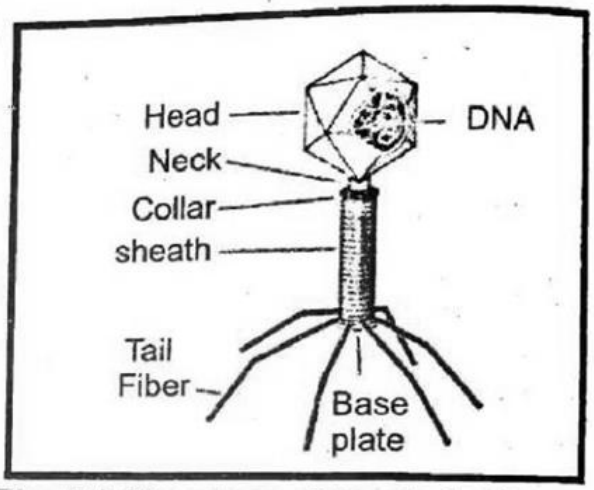
5.4 Structure of the soone Representative Viruses

5.4.1 Structure of Bacteriophage

Bacteriophage (phage) are obligate intracellular parasites that multiply inside bacteria by making use of the host biosynthetic machinery. Bacteriophages have many different sizes and shapes. The basic structural features of bacteriophage are as follows:

1. Size -. Most phages range in size from 24-200 nm in length.

2. Head or Capsid - All phages contain a head structure which can vary in size and shape. Some are icosahedral (20 sides) others are filamentous. The head or capsid is composed of many copies of one or more different proteins. Inside the head is found the nucleic acid (DNA or RNA). The head acts as the protective covering for the nucleic acid.



Fig; 5.2 Structure of Bacteriophage

3. Tail - Many but not all phages have tails attached to the phage head. The tail is a hollow tube through which the nucleic acid passes during infection. The size of the tail can vary and some phages do not even have a tail structure.

In the more complex phages like T4 have a base plate and one or more tail fibers attached to it. The base plate and tail fibers are involved in the attachment of the phage to the bacterial cell. Not all phages have base plates and tail fibers. In these instances other structures are involved in attachment of the phage particle to the bacterium.

5.4.2 The Structure of HIV

HIV stands for Human Immunodeficiency Virus. Like all viruses, HIV cannot grow or reproduce on its own. In order to make new copies of itself it must infect the human cells. Outside of a human cell, HIV exists as roughly spherical particles; the surface of each particle shows numerous spikes.

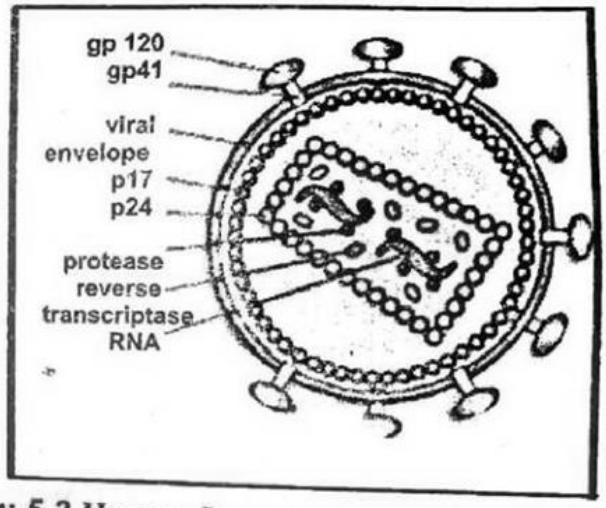
Tidbit

An HIV particle is around 100-150 billionths of a metre in diameter. That's about the same as: 0.1 microns 4 millionths of an inch one twentieth of the length of an E. coli bacterium one seventieth of the diameter of a human CD4+ white blood cell.

Unlike most bacteria, HIV particles are too small to be seen through an ordinary microscope. However they can be seen clearly with an electron microscope. HIV particles surround themselves with a coat of lipo protein known as the viral envelop (or membrane). Projecting from this are around 72 little spikes, which are formed from the proteins (gylcoprotein) gp120 and gp41. Just below the viral envelope is a layer called the matrix, which is made from the (matrix) protein p17.

The proteins gp120 and gp41 together make up the spikes that project from HIV particles, while p17 forms the matrix and p24 forms the core.

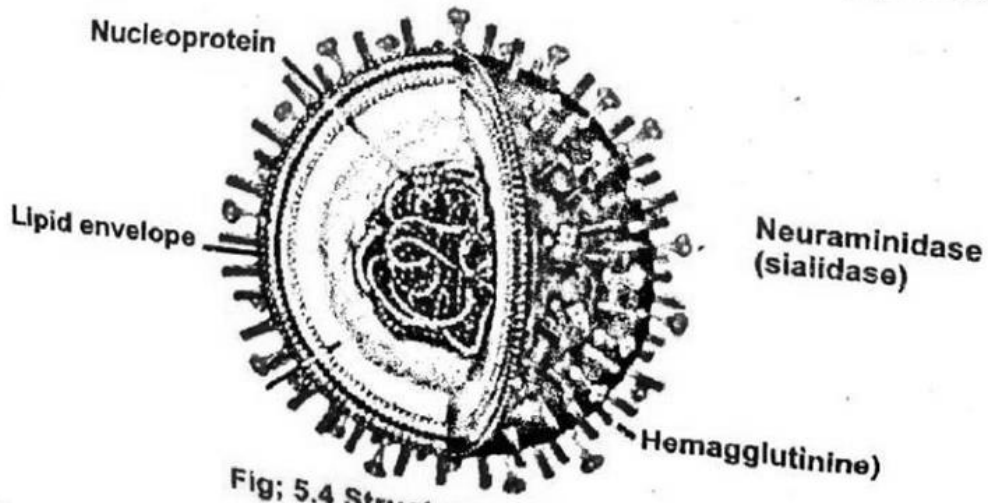
The viral core (or capsid) is usually bullet-shaped and is made from the protein p24. Inside the core are three enzymes required for HIV replication called reverse transcriptase, integrase and protease. Also held within the core is HIV's genetic material, which consists of two identical strands of RNA.HIV belongs to a special class of viruses called retroviruses.



Fig; 5.3 Human Immunodeficiency virus

5.4.3 Structure of Flu Virus

Influenza is an RNA virus which may exist in different shapes from round balls to long, spaghetti-like filaments. The genome of this virus is associated with five different viral proteins and is surrounded by a lipid membrane, which means that influenza belongs to the "enveloped" group of viruses. Eight separate pieces of ribonucleic acid (RNA)make up the influenza virus genome and each piece of RNA specifies the amino acid sequence of one and sometimes two of the virus's proteins.



Fig; 5.4 Structure of Flu Virus

5.5 Parasitic Nature of Viruses

5.5.1 Virus Evasion of Immune Responses

Viruses have evolved many mechanisms by which they can tackle the immune system. Some of the prominent ways are as under:

- Any foreign agent entering the body faces phagocytosis which is carried out by macrophages and neutrophils. In certain viruses capsules, protein, and fibrin coats do not bind the adhesion molecules used by macrophages and neutrophils so they are safe from being phagocytosed
- Some viruses cover, like bacteria, their cell walls with host proteins. So in this way body immune system is unable to recognize them as foreign body.
- Many viruses produce mutants (antigenic variations) at regular basis. And vaccine developed to control the spread of one mutant virus becomes ineffective against the new mutant so controlling them is a continuous challenge. For example influenza virus and HIV.

5.5.2 *Virus and the Host*

Viruses do not possess any life sustaining characteristics, and do not require any nutrients. In fact, without proper host viruses lie dormant indefinitely. However, viruses are specific to a certain kind of cell. They also have preferred ways of entrance into their hosts. A virus' method of entry is very specialized, and it is one of the main ways a virus is able to locate it's victims. Take, for example, a virus that targets host cells located in the stomach. If a person inhaled such virus particles they would not be harmed. On the other hand, if any virus molecules were ingested into the stomach, the hosts would immediately be infected. Some viruses even require cells to be in certain stages of life. These viruses may prefer actively dividing cells or cells that are younger.

Interpreting and Recording

Record the symptoms of flu in any individual. Make a list of names of at least five viruses each in plants and animals that are specific for a specific host.

5.6 Life Cycle of a Bacteriophage

The virus that infects and becomes parasite on the bacterium is called Bacteriophage. There are many strains of the phage but only one kind of phage will attack only one strain or one species of bacteria. There are two types of life cycles of the phage namely lytic cycle and lysogenics cycle.

a. *Lytic cycle*

In this cycle the phage is regarded as virulent or master and the bacterial cell(host)is regarded as slave. In lytic cycle the phage first attaches itself by its tail to the cell wall of bacterium at a point called **receptor site**. The phage contains an *enzyme called lysosome, which digest the cell wall of bacterium.* Thus an opening is formed in the bacterial cell wall. The phage contracts and injects its DNA inside the host while the protein coat and the tail remain outside.

Inside the bacterial cell the phage DNA takes over the biosynthetic machinery of the host to synthesize its own DNA and protein molecule. The phage multiplies and increases in number. The daughter phages exert pressure on the cell wall of bacterium. Thus the bacterial cell ruptures (lysis occurs) and release the daughter phages, which are now ready to attack new bacteria and start their cycle again. This type of life cycle in which the bacterium cell bursts is called lytic cycle of the phage.

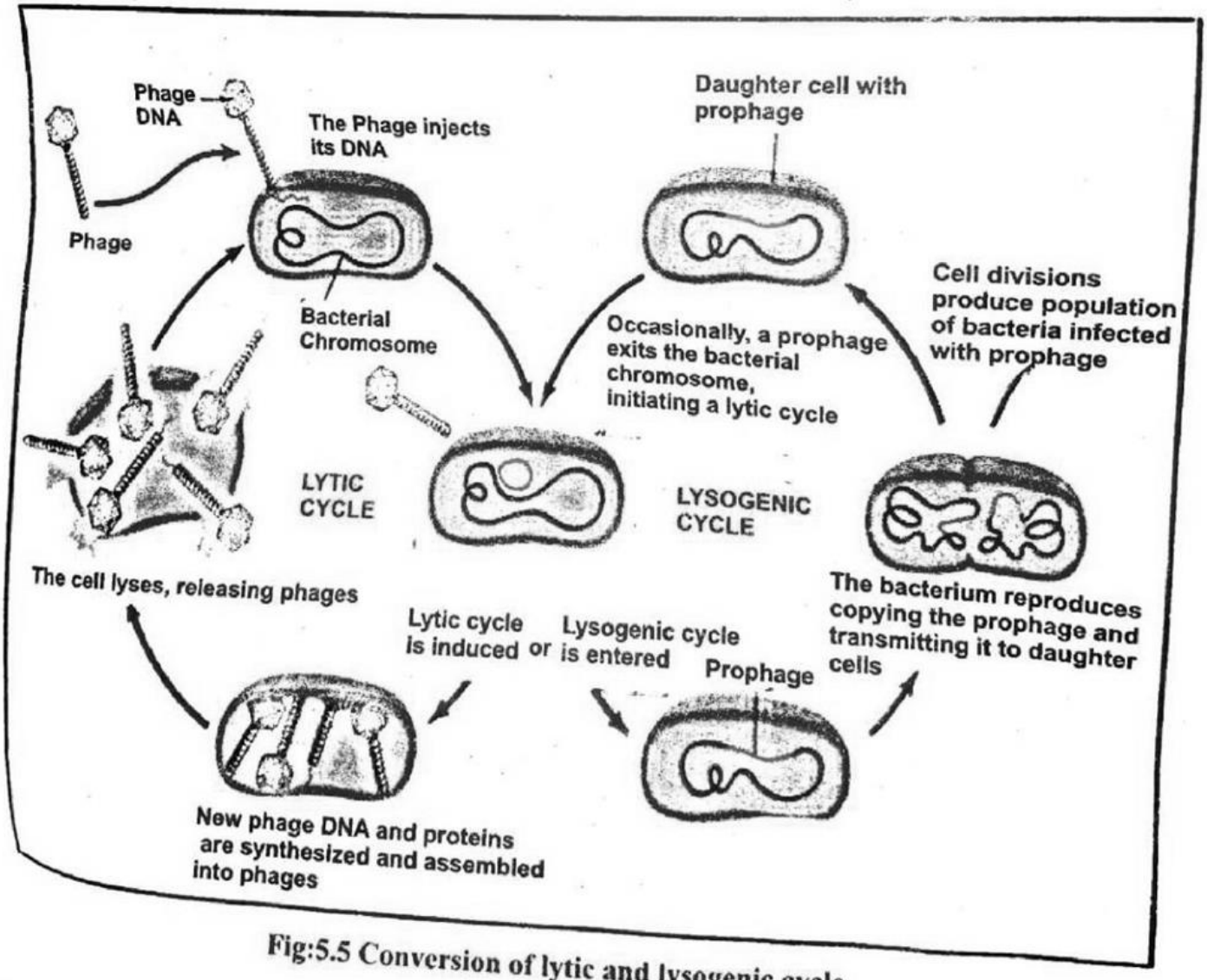


Fig:5.5 Conversion of lytic and lysogenic cycle

b. Lysogenic cycle

In this cycle, the phage does not kill or destroy the bacterium(host). Both the phage and bacterium live and multiply in a peaceful coexistence. In this case the phage becomes a harmless guest and the bacterium acts as a host. Sometimes when the phage DNA enters the bacterial cell, instead of taking over the control of biosynthetic machinery of the host it becomes associated and mixed up with the bacterial chromosome in a friendly atmosphere. In this condition the bacterium continues to live and reproduces normally. The phage DNA passes to each daughter cell of bacterium in all successive generations.

Thus the number of phages increases without any harm or damage to the bacterium cell. Therefore this relation is called guest- host relation. This type of cycle is called lysogenic cycle. Sometimes, however, the phage-DNA is separated from the bacterial chromosomes and becomes re-activated to become virulent and hence destroy the bacterial cell and starts the lytic cycle again.

5.7 Usage of Bacteriophage in Genetic Engineering

Isolated genes cannot replicate themselves, a gene to be cloned must be inserted into the DNA of suitable cloning vector like bacteriophages. Virus DNA molecule is used to transfer a DNA fragment from a test tube into a living cell. Cloning vectors are capable of multiplying inside of living cells.

Phages can be used as cloning vectors to introduce recombinant DNA into bacterial cells. Once inside a cell, the recombinant DNA may begin replication and new phages, each containing the gene of interest, are formed. The bacterial cellular machinery synthesizes the vector system proteins and DNA, but the bacterium is destroyed when the phages are released.

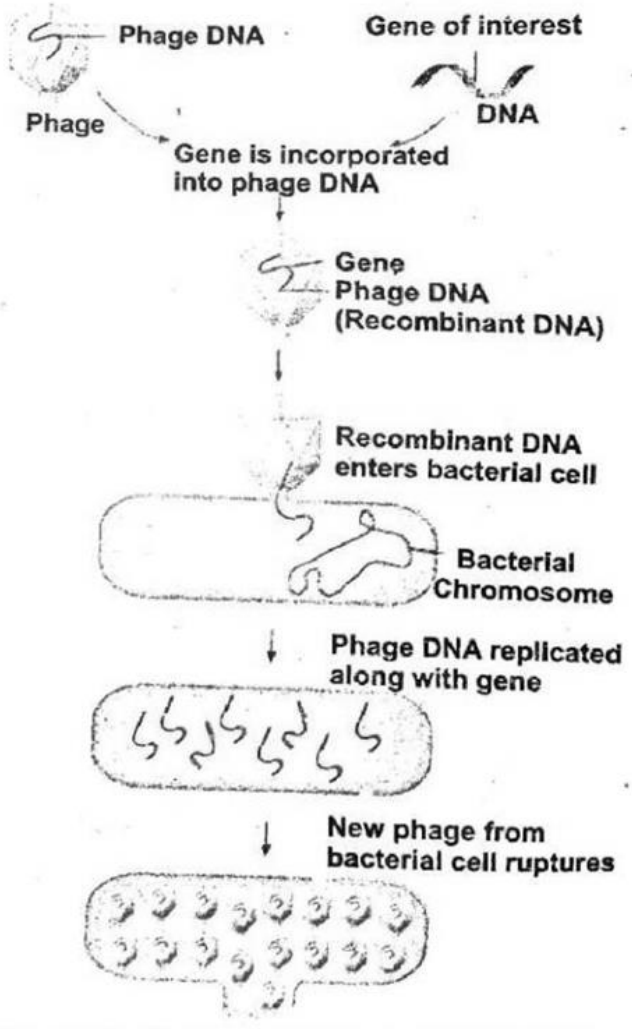


Fig 5.6 Usage of bacteriophage in genetic engineering

5.8 AIDS and HIV Infection

AIDS stands for Acquired Immune Deficiency Syndrome. AIDS is a serious condition that weakens the body's immune system, leaving it unable to fight off illness.

AIDS is the last stage in a progression of diseases resulting from a viral infection known as the Human Immunodeficiency Virus (HIV or AIDS virus). The disease include a number of unusual and severe infections, cancers, severe weight loss, diseases affecting the brain and central nervous system

The immune system is a network of cells, organs and proteins that work together to defend and protect the body from potentially harmful, infectious microorganisms. The immune system also plays a critical role in preventing the development and spread of many types of cancer.When the immune system is missing one or more of its components, the result is an immunodeficiency disorder AIDS.

Lymphocytes (white blood cells) are one of the main types of immune cells that make up the immune system. There are two types of lymphocytes: B cells and T cells. (T cells are also called CD4 cells, CD4 T cells, or CD4 cell lymphocytes). B cells release antibodies (proteins) into the body's fluids to attack antigens (foreign proteins such as bacteria, viruses or fungi). T cells directly attack and destroy infected or malignant cells in the body.

There are two types of T cells: helper T cells and killer T cells. Helper T cells recognize the antigen and activate the killer T cells. Killer T cells then destroy the antigen. When HIV is introduced into the body, this virus is too strong for the helper T cells and killer T cells. The virus then invades these cells and starts to reproduce itself, thereby not only killing the CD4 T cells, but also spreading to infect otherwise healthy cells. The HIV virus cannot be destroyed and lives in the body undetected for months or years before any sign of illness appears.

Gradually, over many years or even decades, as the T cells become progressively destroyed or inactivated, other viruses, parasites or cancer cells (called "opportunistic diseases") which would not have been able to get past a healthy body's defense, can multiply within the body without fear of destruction.

5.8.1 Life cycle of human immunodeficiency virus

1. HIV binds, fuses to immune system cells, releases its RNA.
2. HIV RNA converted to HIV DNA during reverse transcription.
3. Viral DNA enters host cell nucleus and is integrated into host cell chromosomal DNA.

4. HIV RNA is made and viral protease processes protein for viral assembly
5. Newly made HIV buds from the cell and is ready to infect other cells

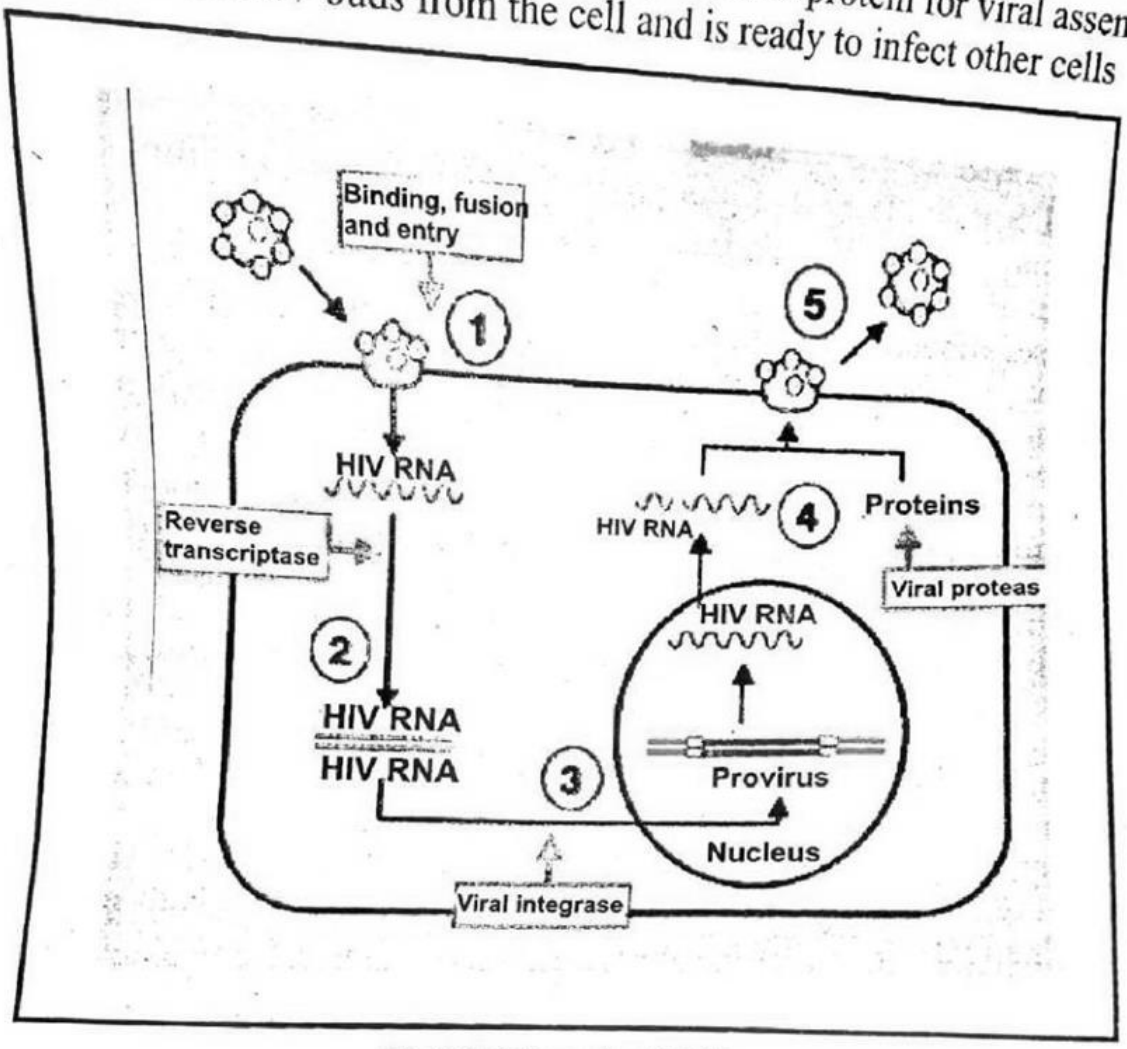


Fig 5.7 Life cycle of HIV

6. The HIV particles are then released or 'bud' from the cell. The enzyme protease plays a vital role at this stage of the HIV life cycle by chopping up long strands of protein into smaller pieces, which are used to construct mature viral cores.

The newly matured HIV particles are ready to infect another cell and begin the replication process all over again. In this way the virus quickly spreads through the human body. And once a person is infected, they can pass HIV on to others in their bodily fluids

5.8.2 Symptoms of HIV

The earliest symptoms include: fever, rash, muscles aches and swollen lymph nodes and glands. However, for most people, the first symptoms of HIV will not be apparent.

Prevention

In general, to prevent viral hepatitis we should:

- Follow good hygiene and avoid crowded, unhealthy living conditions.
- Take extra care, particularly when drinking and swimming especially areas with poor sanitation and water quality.
- Wash hands thoroughly after using the toilet and before eating.
- Use antiseptic cleansers to clean toilet used by someone in the family who develops hepatitis.

For Your Information

For viral hepatitis, the incubation period (the time it takes for a person to become infected after being exposed) varies depending on which hepatitis virus causes the disease:
·For hepatitis A, the incubation period is 2 to 6 weeks.
·For hepatitis B, the incubation period is between 4 and 20 weeks.
·For hepatitis C, it's estimated that the incubation period is 2 to 26 weeks.

Coronaviruses (CoV) are a large family of viruses that cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). A novel coronavirus (nCoV) is a new strain that has not been previously identified in humans. Most estimates of the incubation period for COVID-19 range from 1-14 days, most commonly around five days.

Treatment

When symptoms are severe or laboratory tests show liver damage, it's sometimes necessary for hepatitis to be treated in the hospital. Here's a quick look at the treatments available for the various hepatitis viruses: There are no medications used to treat hepatitis A because it's a short-term infection that goes away on its own.

Hepatitis B can sometimes be treated using medications. The treatment of hepatitis C has improved significantly with the use of two medications, only one of which is approved for use in children. In those adults who have just been infected with hepatitis C (by accidental needle injury, for example), combination therapy with the two drugs is the treatment of choice and can eliminate the virus in about 50% of the people infected.

b. Herpes

The herpes simplex virus, also known as HSV, is an infection that causes herpes. The herpes simplex virus is a contagious virus that can be transmitted from person to person through direct contact. There are two types of the herpes simplex virus.

- **HSV-1:** primarily causes oral herpes, and is generally responsible for cold sores and fever blisters around the mouth and on the face.
- **HSV-2:** primarily causes genital herpes, and is generally responsible for genital herpes outbreaks.

Symptoms

Herpes can appear in various parts of the body, most commonly on the genitals or mouth region.

Treatment

Doctor may prescribe an antiviral medicine in the form of an ointment or pills.

c. Polio

Poliomyelitis (polio) is a highly infectious viral disease, which mainly affects young children. It is caused by infection with the poliovirus. The virus spreads by direct person-to-person contact, by contact with infected mucus or phlegm from the nose or mouth, or by contact with infected feaces. The virus enters through the mouth and nose, multiplies in the throat and intestinal tract, and then is absorbed and spread through the blood and lymph system. The time from being infected with the virus to developing symptoms of disease, incubation ranges from 5 - 35 days (average 7 - 14 days).

Signs and Symptoms

Paralytic polio, as its name implies, causes muscle paralysis - and can even result in death. In paralytic polio, the virus leaves the intestinal tract and enters the bloodstream, attacking the nerves. In abortive or asymptomatic polio, the virus usually doesn't get past the intestinal tract. The virus may affect the nerves governing the muscles in the limbs and the muscles necessary for breathing, causing respiratory difficulty and paralysis of the arms and legs.

Treatment

The goal of treatment is to control symptoms while the infection runs its course.People with severe cases may need lifesaving measures, especially breathing help.Treatments include; antibiotics for urinary tract infections, medications (such as bethanechol) for urinary retention, moist heat (heating pads, warm towels) to reduce muscle pain and spasms, pain killers to reduce headache, muscle pain, and spasms (narcotics are not usually given because they increase the risk of breathing difficulty) and physical therapy, braces or corrective shoes, or orthopedic surgery to help recover muscle strength and function.

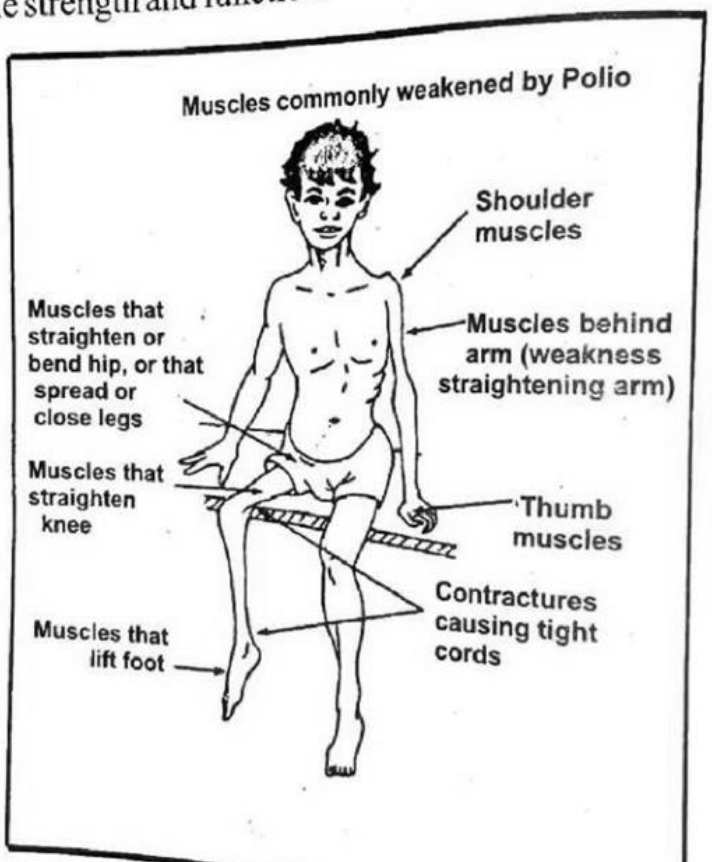


Fig: 5.8 Muscles are commonly weakened by Polio.

TIDBIT

The oral polio vaccine (OPV) administered to children during house-to-house polio campaigns in Pakistan is 100% safe, effective and is the essential tool available to protect all children against polio. It has no common side effects and has been used all over the world to protect children against polio virus.

Prevention

Polio immunization (vaccine) effectively prevents poliomyelitis in most people (immunization is over 90% effective).

d. Leaf curl disease of cotton

Cotton leaf curl disease is caused by a complex of begomovirus species, all of which incite similar symptoms in cotton and are transmitted by the whitefly *Bemisia tabaci*.

Symptoms

The first symptoms of infection in cotton appear within 2-3 weeks of inoculation and are initially characterised by deep downward cupping of the youngest leaves. This is followed by either upward or downward curling of the leaf margins and swelling, darkening and formation of enations on the veins, which frequently (depending on cultivar) develop into cup-shaped, leaf-like structures.

5.10 Prions

Prions are infectious protein particles thought to be responsible for a group of transmissible neurodegenerative diseases. Most evidence indicates that the infectious prion proteins are modified forms of normal proteins coded for by a host gene in the brain. It is thought that the normal prion protein, expressed on stem cells in the bone marrow and on cells that will become neurons, plays a role in the maturation of neurons.

In Scrapie the central nervous system of sheep and goats is affected. The transmission of scrapie is mainly due to the unhygienic way of feeding unhealthy or infected food.

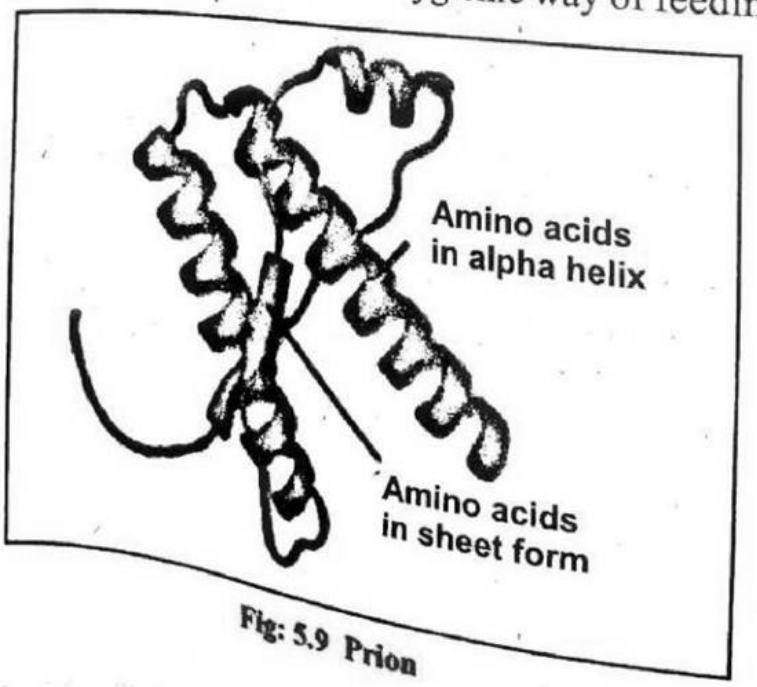


Fig: 5.9 Prion

Humans are susceptible to several prion diseases. Some of these are given below.

CJD: Creutzfeld-Jacob Disease

It is a fatal degenerative brain disorder. Early symptoms include memory problems, behavioral changes, poor coordination, and visual disturbances.

GSS: Gerstmann-Straussler-Scheinker

This disease is a rare genetic degenerative brain disorder. A common symptom is a progressive loss of coordination that may present as unsteadiness of gait, difficulty walking, dementia and clumsiness.

FFI: Fatal familial Insomnia

It is a very rare sleep disorder. It affects the thalamus and its main symptom is insomnia, speech problems and dementia.

Alpers Syndrome

Alpers syndrome is a neurological disorder. It Symptoms include increased muscle tone with exaggerated reflexes (spasticity), seizures, and dementia.

5.11 Viroids

Viroids are even more simple than viruses. They are small, circular, single-stranded molecules of infectious RNA lacking even a protein coat. They are the cause of a few plant diseases such as potato spindle-tuber disease,cucumber pale fruit, citrus exocortis disease, and cadang-cadang disease of coconuts.

The only human disease known to be caused by a viroid is hepatitis D. The first viroid discovered was the potato spindle tuber viroid (PSTV) I which causes a disease in potatoes. It has been reported that the infectious agent for the disease was not a conventional virus but free RNA. PSTV is a circular RNA molecule whose nucleotide sequence and secondary structure has been established.

TIDBIT

Virions range in size from approximately 20 nanometres (0.0000008 inch) to 250 nanometres and are of various shapes.

KEY POINTS

- Viruses are unique -- they have been classified as both living and nonliving at various points in the history of biology.
- A virus particle, also known as a virion, is essentially a nucleic acid (DNA or RNA) enclosed in a protein shell or coat.
- Viruses cannot reproduce or express their genes without the help of a host.
- Bacteriophage (phage) are obligate intracellular parasites that multiply inside bacteria by making use of the host biosynthetic machinery.
- All phages contain a head structure which is composed of many copies of one or more different proteins. Inside the head is found the nucleic acid (DNA or RNA).
- HIV belongs to a special class of viruses called retroviruses
- Influenza is an RNA virus. Hemagglutinin (HA) and neuraminidase (NA) are stuck onto the lipid envelope of the influenza virus and both play a crucial role in the infection of the epithelial cells of the upper respiratory tract.
- Viruses have evolved many ways of evading the immune system.
- Viral reproduction is most fully understood through studying viruses that infect bacteria, known as bacteriophages (or, commonly, phages). The lytic cycle and the lysogenic cycle are two fundamental reproductive processes that have been identified.
- The lytic cycle is a five-stage cycle which consists of attachment penetration, replication, assembly and lysis.
- Phages can be used as cloning vectors to introduce recombinant DNA into bacterial cells.
- AIDS is the last stage in a progression of diseases resulting from a viral infection known as the Human Immunodeficiency Virus
- The earliest symptoms of **HIV infection** occur when the body begins to form antibodies against the virus between six weeks and three months after infection with the HIV virus
- There is no cure for HIV infection or AIDS nor is there a vaccine to prevent HIV infection. However, new medications not only can slow the progression of the infection.

EXERCISE ?

A. Choose the correct answer in the following questions.

1. T-series bacteriophage can be recognized by its:
   a. irregular shape
   b. rounded shape
   c. tadpole shape
   d. rhomboidal shape

2. The infective nature of virus is due to:
   a. protein coat
   b. nucleic acid
   c. envelope
   d. tail fibres

3. Which of the following is not associated with prions?
   a. Neurodegenerative disease
   b. Leaf curl disease
   c. Toxic proteins
   d. Alper's syndrome

4. Which statement is true of viroids?
   a. They are single-stranded RNA particles.
   b. They are single-stranded DNA particles
   c. They reproduce only outside of the cell.
   d. They belong to begomovirus.

5. Which one of the following enzymes is present in the bacteriophage?
   a. Succinic dehydrogenase
   b. Lysozyme
   c. Protease
   d. Urease

6. An infectious RNA particle without protein coat:
   a. viroid
   b. virion
   c. virusoid
   d. prion

7. Which body system is most directly concerned with vaccination?
   a. Digestive
   b. Circulatory
   c. Respiratory
   d. Immune

8. Tobacco mosaic virus is:
   a. spherical shaped
   b. cuboidal
   c. rod shaped
   d. oval shaped

9. Which one of the following is a disease caused by viroids?
   a. Creutzfeld-Jacob Disease
   b. Gerstmann-Straussler-Scheinker
   c. Fatal familial Insomnia
   d. cadang- cadang disease

B. Write short answers to the following questions.

1. Give a brief status of viruses in classification.

2 Differentiate between a retrovirus and a typical bacteriophage.

3. What are the consequences of a viral DNA becoming incorporated into a human egg or sperm cell?

4. How do viruses suppresses the immune system in human body?

5. Why do viruses need a host cell?

6. List down the main steps in the life cycle of HIV.

7. How lymphocytes maintain a healthy immune system in human body?

C. Write detailed answers to the following questions.

1. Explain how a virus manages to survive inside a host cell protected from the immune system?
2. Describe the role of bacteriophage in genetic engineering.
3. Describe some common control measures against the transmission of HIV.
4. Describe the causative agent, symptoms, treatment and prevention of leaf curl virus disease of cotton.
5. Write a brief note on prions and viroids.

Projects

- Collect information from the internet and make a report exhibiting the relationship of viral out break and linked to it the global economic losses with special reference to havoc created by corona virus at the dawn of 2020 A.D.
- Make a presentation explaining the correlating the social and cultural values of a country with the prevalence of AIDS.