CHAPTER 5

ACELLULAR LIFE

Major Concepts:

Number of allotted teaching periods: 10

5.1 Viruses: Discovery and Structure (2 Periods)

5.2 Parasitic Nature of Virus (2 Periods)

5.3 Life cycle of Bacteriophage (1 Period)

5.4 Life cycle of Human Immunodeficiency Virus (HIV) (2 Periods)

5.5 Viral Diseases (2 Periods)

5.6 Prions and Viroids (1 Period)

You or any one of your family members must have suffered from common cold in which there is watering of eyes, dry throat, production of watery mucus from nose and it is difficult to breath through nose. You must have heard about influenza in which there is raised temperature, headache, dry cough etc. Everyday you read in the newspapers about bird flu, plio, swine flu, dengue fever etc. All these and many other diseases are caused by the infectious agents called **viruses**. The viruses are pathogens, which cause diseases in animals and plants.

5.1 VIRUSES-DISCOVERY AND STRUCTURE

Viruses are not cells, they are not capable of independent replication, can synthesize neither their own energy nor their own proteins and are too small to be seen in the light microscope.

Viruses-Living or Nonliving

Viruses are a link between living and nonliving worlds. They show the characteristic of both living and nonliving things. The living characteristics of viruses are: (1) Viruses occur in different varieties or strains. (2) They have

their own genetic material. The DNA or RNA can undergo mutation. (3) They reproduce using the metabolic machinery of the host cell they infect. (4) They get destroyed by ultraviolet rays.

The nonliving characteristics of viruses are: (1) They lack cellular structure, coenzyme and enzyme system and do not have metabolic activity of their own. (2) They can be crystallized and stored in bottles. (3) They do not respire. Viruses are nonliving infectious particles. They enter living organism and cause disease. They do not have a cellular structure, which is the basis of all life.

History of Virus

The word virus is derived from a Latin word venom meaning 'poison'. The study of virus is known as **virology**.

Tobacco Mosaic Disease was thought to be caused by bacteria. In 1892 **Iwanowsky** extracted the juice from the leaves of tobacco having tobacco mosaic disease. In order to remove bacteria the juice was passed through a very fine filter made of porcelain (a fine earthenware, white thin). He then rubbed the filtered juice on the leaves of healthy plants, expecting no disease to develop, but the healthy leaves soon showed the symptoms of the disease.

By 1900, similar disease producing substance had been discovered in both plants and animals. The name filterable viruses were given to these substances i.e. the viruses that can pass through a filter which has pores too small for bacteria to pass through are called **filterable viruses**.

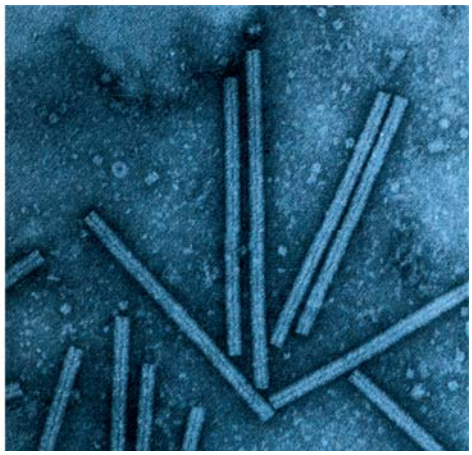


Fig: 5.1 (a) Tobacco Plant Infected with Virus (b) Ultra Structure of Tobacco Mosaic Virus

Classification of Virus

Virus classification is based mainly on phenotypic characteristics, including morphology, nucleic acid type, mode of replication, host organisms, and the type of disease they cause.

Baltimore Classification

David Baltimore, a Nobel Prize-winning biologist, devised the Baltimore classification system, which places viruses into one of seven groups. These groups are designated by **Roman numerals** and separate viruses based on their mode of replication, and genome type. Viruses can be placed in one of the seven following groups:

Group	Nature & Examples
I	Double-stranded DNA viruses: e.g HSV1 (oral herpes), HSV2 (genital herpes), VZV (Varicella zoster virus) (chickenpox), Poxviridae (smallpox)
II	Single-stranded DNA viruses: e.g. family Parvoviridae and bacteriophage.
III	Double-stranded RNA viruses: e.g. Rotavirus
IV	Positive-sense single-stranded RNA viruses: e.g picornaviruses, Hepatitis A virus, Hepatitis C virus and rubella virus.
V	Negative-sense single-stranded RNA viruses: e.g. influenza virus, measles, mumps and rabies.
VI	Reverse transcribing Diploid single-stranded RNA viruses: e.g. HIV
VII	Reverse transcribing Circular double-stranded DNA viruses: e.g. hepatitis B

Viruses are also classified on the bases of their hosts e.g. plant viruses, bacteriophage viruses and animal viruses. **Plant viruses** occur as parasites in plants e.g. tobacco mosaic viruses attack leaves on tobacco plant. This is an RNA virus with a helical capsid. **Bacteriophage** attack bacteria. It is a DNA virus with a polyhedral head and a helical tail. **Animal Viruses** occur as parasites in animals. Human immunodeficiency viruses attacks human being. It is an RNA virus.

Shape and Size of Virus

Viruses vary in shapes. The polio virus particles are little spheres that look like tiny golf balls. Tobacco mosaic virus is a rod shaped and helical virus, while some phage viruses look like tadpoles. So viruses have several shapes, such as spherical, needle like and cubical. Most forms are **icosahedral** with upto twenty sides. Viruses can be seen only under electron microscope. Viruses vary in size from 17nm to 1000nm.

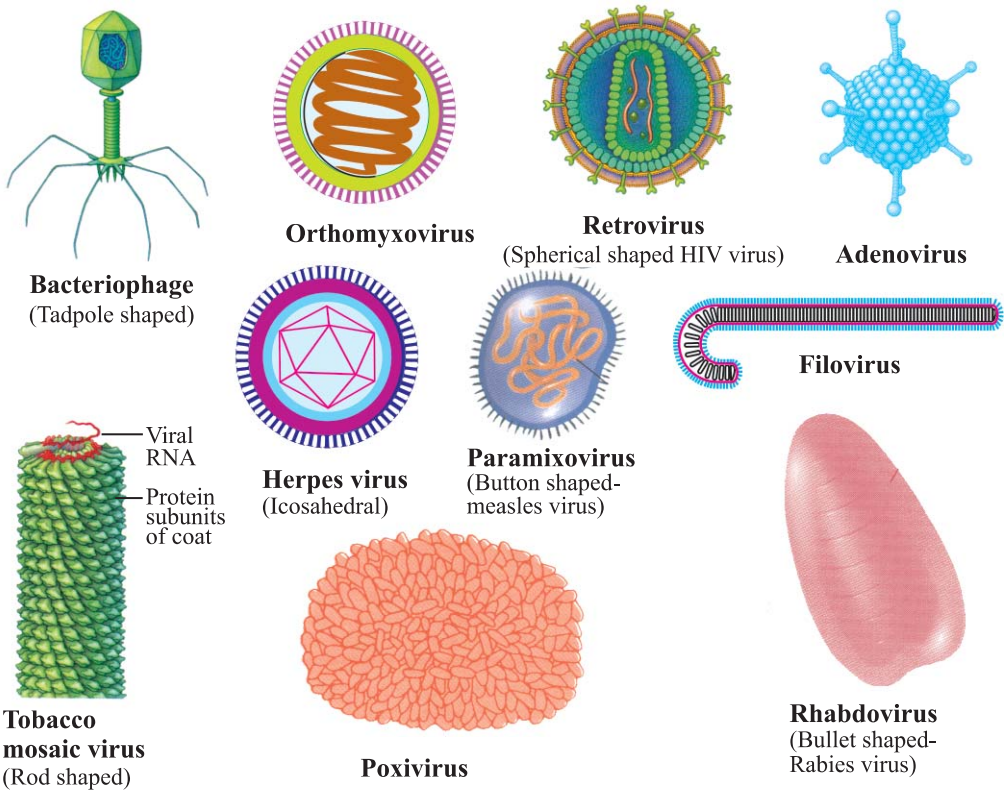
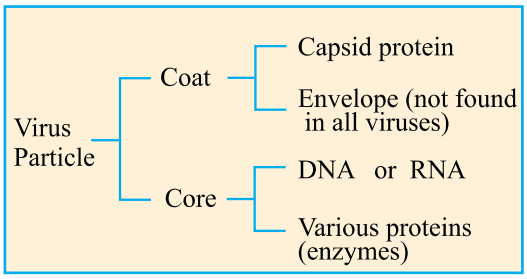


Fig: 5.2 Shapes and Types of viruses

Structure of Model Viruses

Viruses have a very simple structure. The **core** is the genetic matter, which is either DNA or RNA, which may be single stranded or double stranded. The **capsid** is the protective coat of protein surrounding the core. **Nucleocapsid** is the combined structure formed by the core and capsid. A few viruses have an additional lipoprotein layer around the capsid derived from the cell surface membrane of the host, called **envelope**. Capsids are often built up of identical repeating subunits called **capsomers**. There are two

forms of symmetry in virus capsid. When the capsomers are arranged in 20 triangles, it is called **iocosahedral**. When the capsomers are arranged in a hollow coil that appears rod shaped, it is called **helical**.



Now we will discuss the structure of bacteriophage, flu virus and HIV to explain the structure of model viruses.

Bacteriophage

The word phage means 'eater'. A bacteriophage or simply phage consists of nucleic acid, capsid, end plate, tail and tail pin. The interior **core** is the nucleic acid. The phage has DNA which is also known as its **genome**. The outer coat of protein surrounding the nucleic acid is called **capsid** or head. The head is hexagonal and made up of protein subunit the **capsomers**. The tail is hollow tubular and made up of proteins. It consists of six fibres. The protein sheath around the tail is contractile. The fibres are attached to end plate or **base plate**. It is the last part of the tail. The end plate has **tail pins**.

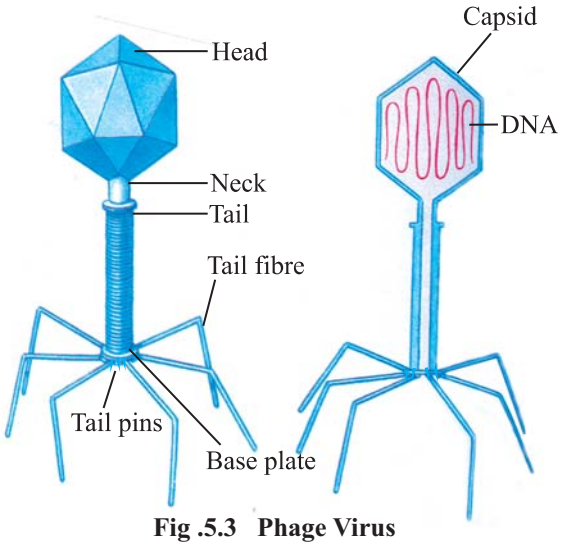


Fig .5.3 Phage Virus

Influenza or Flu Virus

Influenza virus exists in three forms called A, B, C. Influenza viruses are the only members of orthomyxovirus family. The term 'myxo' refers to the observation that these viruses interact with mucin

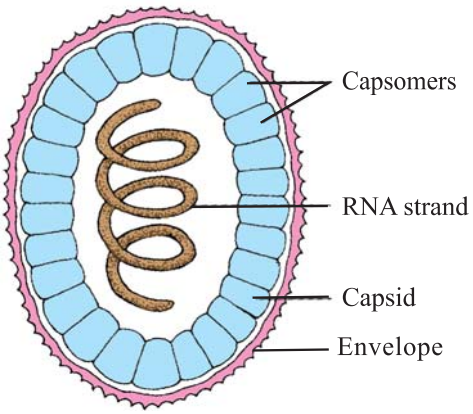


Fig: 5.4 Influenza virus (Orthomyxovirus)

(glycoproteins) and 'ortho' is added to distinguish them from the paramyxovirus. Influenza virus is composed of a segmented single-stranded **RNA genome**, a helical nucleoprotein and an outer lipoprotein envelope. The **virion** (the complete, mature and infectious, particle is known as virion) contains an RNA dependent RNA polymerase, which transcribes genome into mRNA. The genome is therefore not infectious. The envelope is covered with hemaglutinin and a neuraminidase, both are the type specific antigens.

Science Titbits

Although we can often refer to the causative agent of cold as "the cold virus" there are actually more than 200 viruses that cause cold. Developing a vaccine against the infection is not practical.

Science, Technology and Society Connections

Describe the limitations of the vaccine for the common cold/flu virus.

Human Immunodeficiency Virus

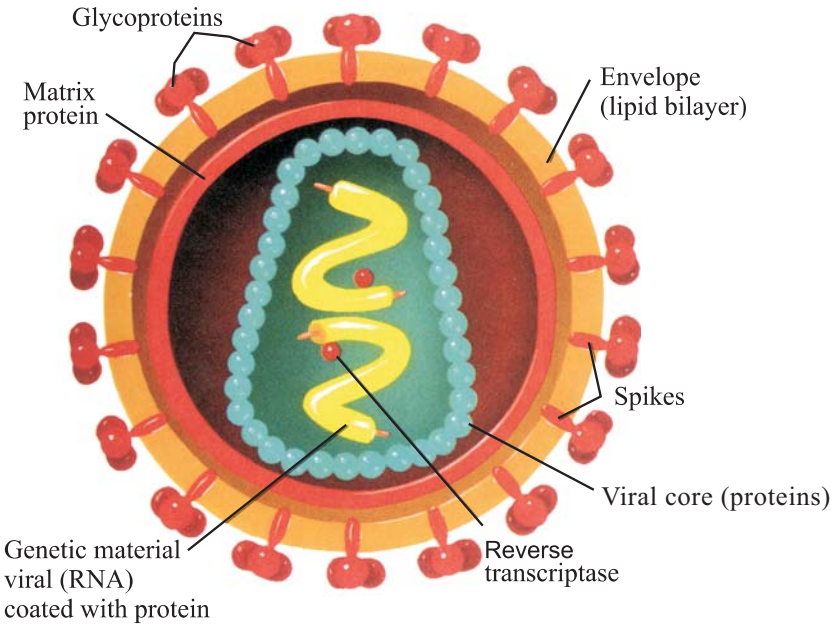


Fig: 5.5 Human Immunodeficiency Virus (HIV) (cross section)

Human Immunodeficiency Virus (HIV) is a retrovirus and spherical in shape. The **core protein** is somewhat cone shaped. It is surrounded by a **envelope** (lipid bilayer) derived from the host cell membrane. The virus core contains: (1) Two identical molecules of single stranded RNA and is said to be diploid. (2) Three viral enzymes-protease, reverse transcriptase and integrase. The viral core (nucleocapsid or capsid) is composed of protein. The viral core is surrounded by a matrix protein which lies underneath the virion envelope. The viral envelope has glycoprotein spikes.

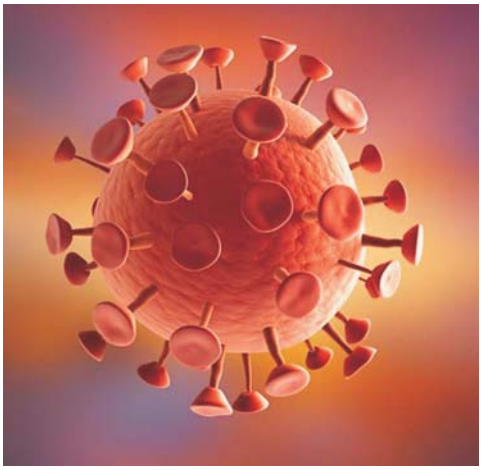


Fig: 5.6 Human Immunodeficiency Virus (HIV)

Skills: Interpreting and Recording

- Make a list of names of five plant and animal viruses that have DNA or RNA.
- Draw labelled diagrams of bacteriophage, flu virus and HIV.

Science, Technology and Society Connections

Justify how the invention of Electron Microscopy revolutionized the science of microscopic organisms.

5.2 PARASITIC NATURE OF VIRUS

Viruses are obligate parasites, which means they cannot multiply outside a living cell. Viruses infect all sorts of cells, from bacterial cells to human cells.

Specificity of Viruses on their Hosts: Viruses are highly specific to their host. Bacteriophage infects only bacteria, the tobacco mosaic virus infects only tobacco plants and rabies virus infects only mammals. Some human viruses even specialize in a particular tissue. HIV will enter only certain blood cells, the poliovirus reproduces in spinal nerve cells, the hepatitis viruses infect only liver cells. The specificity of attachment determines the host range of the virus. Some

viruses have a narrow range, whereas others have quite a broad range. For example, poliovirus can enter the cells of only humans and other primates whereas rabies virus can enter all mammalian cells, herpes simplex virus type 1 attaches to the fibroblast growth factor receptor, rabies virus to the acetylcholine receptor and human immunodeficiency virus to the CD4 protein on helper T lymphocytes. What could cause this remarkable parasite-host cell correlation?

Science Titbits

To maintain animal viruses in the laboratory, they are sometimes injected into live chick embryos. Today, host cells are often maintained in tissue culture by simply placing cells in a glass or plastic container with appropriate medium.

It is now believed that viruses are derived from the cell they infect; the nucleic acid of viruses came from their host cell genomes. Therefore, viruses must have evolved after cells came into existence and new viruses are probably evolving even now.

How do Viruses complete their Life Cycles?

Viruses are Obligate Parasites. Reproduction of Viruses occurrs in the living cells of the host. Viruses cannot reproduce on their own. They must invade cell, take over the cell's internal machinery and instruct the machinery to build enzymes and new viral structural proteins. Then they copy the viral genetic material enough times so that a copy be placed in each newly constructed virus. Finally they leave the host cell. The invading virus also blocks the synthesis of any host DNA, RNA or protein. This features forces the host cell to construct only viral proteins and copies of the viral genetic material. For reproduction viruses must complete the following five steps: (1) Adsorption and penetration, (2) Uncoating of virus, (3) Transcription, translation and replication, (4) Viral assembly, (5) Release of virion.

(1) Adsorption and Penetration: Viruses may be engulfed by their host cell (endocytosis). Some viruses have surface protein that bind to receptors on the host cell's membrane and stimulate endocytosis. Other viruses are coated with an envelope that can fuse with the host cell membrane.

(2) Uncoating. The nucleic acid is released from the capsid into the nucleus or cytoplasm.

(3) Transcription, Translation, Replication: For RNA viruses these usually take place in cytoplasm and for DNA viruses these usually take place in the nucleus.

(4) Viral Assembly: The viral genetic material and enzymes are surrounded by their protein coat.

(5) Release of Virions: Viruses emerge from the cell by "budding" from the cell membrane or by bursting the cell.

How a Virus Survives Inside a Host Cell, Protected from the Immune System?

Viruses circumvent (to surround) the host immune response by: (1) Blocking complement activation e.g. vaccinia (vacca virus) or using complement receptor to enter B lymphocytes e.g. Espein Barr Virus (EBV). (2) Inhibiting interferon induced antiviral response e.g. adenovirus, EBV and HIV (3) Blocking production of cytokines or response to cytokines e.g. cowpox, adenovirus. (4) Suppressing major histocompatibility complex e.g. adenovirus (5) Reducing B-cell activation e.g. EBV. (6) Changing their own genetic constitution so rapidly that vaccines/antibodies of host against them become ineffective.

How Virus Employs to Pass Over Unfavourable Conditions When it Does Not Have a Host to Complete its Life Cycle?

Virus does not have acellular, cellular or spore forms as parasites. When there is no host or when there are unfavourable conditions, outside the cells viruses may form crystals e.g. Tobacco Mosaic Virus (TMV). Some remain in saliva e.g. EBV (cause mononucleosi lesion on the tongue), in respiratory droplets e.g. Influenza A virus, measles virus, Varicella zoster virus (chicken-pox), in respiratory aerosol e.g. small-pox virus, in the faeces e.g. adenoviruses.

Skills: Interpreting and Recording

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

Swine flu is an infection by any one of several types of swine flu virus. A virus subtype H1N1, H1N2, and H3N2 are the most common strains world wide. The H1N1 viral strain implicated in the 2009 flu pandemic among humans often called swine flu. Its vaccine is available.

5.3 LIFE CYCLE OF A BACTERIOPHAGE

The virus which lives in a bacterium as parasite is called **bacteriophage** or **phage**. Bacteriophages show two types of relationships with the host: Master-slave relationship i.e. Lytic cycle and Host-guest relationship i.e. Lysogenic cycle.

Lytic Cycle

It is a **master slave relationship.** The process of lytic cycle of a phage virus consists of the following stages:

The head determines what kind of cell the virus particle will be able to attach and assists the insertion of the core into the host cell. One of the bacteriophage makes contact with the cell surface of *Escherichia coli* (*E.coli*) bacteria.

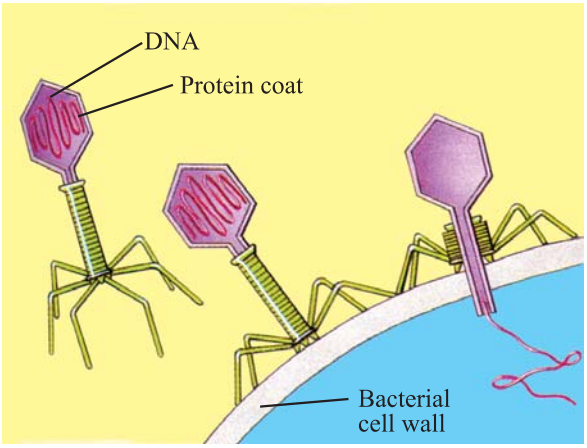


Fig. 5.7 Insertion of Core into the Bacterium

Proteins in its tail fibres 'recognize' proteins on the bacterial cell surface. The protein sheath contracts and the contents of the bacteriophage head are injected into the bacterium.

Once within the cell, some of the **bacteriophage genes** take up the control and use host's RNA polymerase (enzyme), tRNA, ribosomes etc. to produce enzymes that will make many copies of the phage DNA.

As fresh copies of **phage DNA** accumulate, the proteins of the capsid are being formed, as per other genes of the invader phage. The proteins then collect around the nucleic acid forming the six sided head and tail. New viruses appear within 12 to 15 minutes after infection.

The rest of the genes of the invader phage form the enzyme called **lysozyme**. The lysozyme attacks the bacterial cell wall from the inner side. Eventually the cell ruptures about 30 minutes after the insertion of the phage DNA, and releases new viruses. The cycle is now complete and ready to be repeated. This cycle of the phage is called lytic cycle.

Lysogenic Cycle

The lysogenic cycle is a **host guest relationship**, which is a peaceful relationship. Certain DNA containing bacterial viruses referred to as temperate bacteriophage can infect a cell without producing progeny viruses or damaging the host. This association is called lysogeny i.e. host guest relationship. It occurs by the following mechanism:

After penetration, the viral DNA directs production of proteins that specially bind to the virus DNA and turn off replication of viral DNA.

The viral DNA then integrates into and becomes a physical part of the host chromosome. The integrated virus DNA is now called a phage, or prophage.

The viral DNA replicates whenever the bacterial chromosome doubles, so all the progeny cells inherit one copy of the prophage in the chromosome and thus carry the potential for producing lysogenic or temperate bacteriophage.

This cycle of phage is called the **lysogenic cycle**. Sometimes the phage becomes reactivated and reproduces like lytic phase.

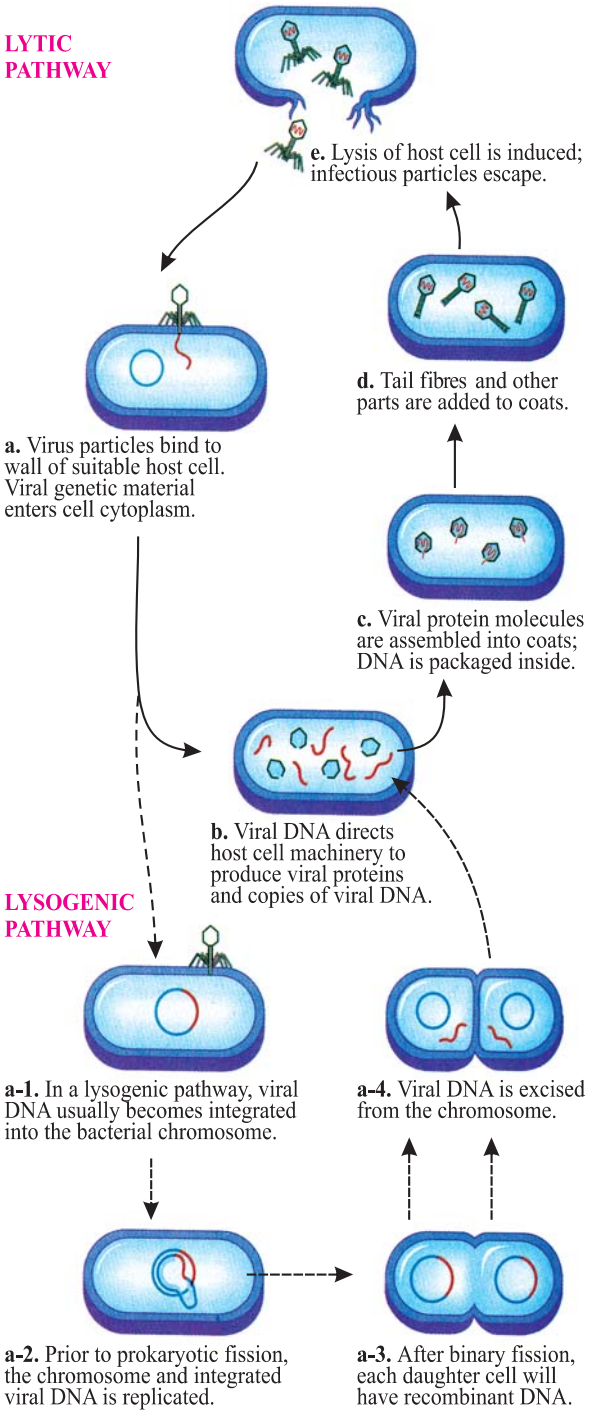


Fig: 5.8 Life Cycle of a Bacteriophage

Usage of Bacteriophage in Genetic Engineering

Genetic engineering can produce cells that contain recombinant DNA and are capable of producing new and different protein. **A. Harshey** and **M. Chase** used bacteriophage to prove DNA as the hereditary material.

Bacteriophage known as lambda can be used as vectors for carrying foreign DNA. After lambda attacks a cell the DNA is released from the virus and enters bacteria. Here it may direct the reproduction of many more viruses. Each virus in the bacteriophage clone contains a copy of the foreign gene. A clone is a large number of cloned bacteriophages that are identical to the original virus. A genome is the full set of genes of an individual. A genomic library is a collection of bacteria or bacteriophage clones; each clone contains a particular segment of the DNA from a foreign cell.

When you make a genomic library an organism's DNA is simply sliced up into pieces and the pieces are put into vectors (plasmids or viruses), that are taken up by the host bacteria. The entire collection of bacteriophage clones or bacteria that results therefore contains all the genes of the organism.

Phage library:Viral DNA is removed from a bacteriophage such as lambda and is used to make recombinant DNA. The virus containing the recombinant DNA infects a host bacterium. Cloning is achieved when the virus reproduces and then leaves the host cell.

Science Titbits

Virus studies helped to establish molecular genetics. Now molecular genetics helps us to understand viruses

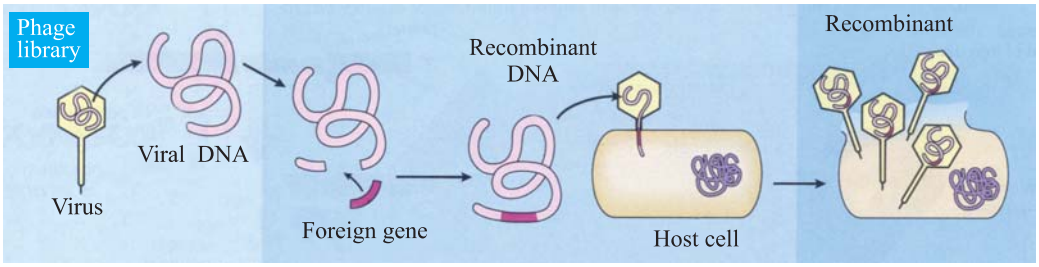


Fig: 5.9 Way of Preparation of a Genomic Library

Skills: Interpreting and Recording

- Make a list of the sequence involved in the lytic life cycle of a bacteriophage.

5.4 LIFE CYCLE OF HIV

HIV is a retrovirus. It causes acquired immune deficiency syndrome or AIDS. It was identified in 1984 by research team from Pasture Institute in France and National Institute of Health in USA. In 1986 the virus was named HIV. Luc Montagnier director of the World Foundation for AIDS research and prevention and Francoise Barre-Sinoussi of the Pasteur Institute were awarded Nobel Prize in 2008 for discovering the virus.

Life Cycle: The primary hosts of HIV are certain immune cells. These are macrophages and lymphocytes. HIV encounters the white blood cells collectively called T4 cells. How does HIV recognize T4 cells? Or what is the reason of specification of HIV on its host cells? The initial step in the penetration or entry of HIV into the cell is the binding of the virion (glycoprotein) 120 envelope protein to the CD4 protein (a receptor) on the surface of T4 cells. The virion gp 120 protein then interacts with a second protein on the cell surface one of the **chemokine receptors**.

Next the fusion of the viral envelope with the cell membrane takes place and the virion enters the cell by endocytosis. Once inside the host cell, the HIV particle sheds its protective coat i.e. **uncoating** occurs. This leaves the double stranded viral RNA in the cytoplasm along with virus enzymes. The enzyme called **reverse transcriptase** synthesizes a double strand of DNA complementary (cDNA) to virus RNA. The cDNA then **integrates** into the host cell DNA. The viral DNA can integrate at different sites in the host cell DNA and multiple copies of viral DNA can integrate. Integration is mediated by a virus encoded endonuclease (integrase).

The integrated DNA is now called **provirus**. Viral mRNA is transcribed from the proviral DNA by the host cell RNA polymerase and translated into several **large proteins**, which are then cleaved by the virus-encoded **protease** to form the virion structural proteins. The immature virion forms in the cytoplasm and cleavage by the viral protease occurs as immature virion buds from the cell membrane. It is this cleavage process that results in mature, infectious virion.

Immunity is primarily the result of the action of the B lymphocytes and T lymphocytes (white blood cells). T lymphocytes are also known as T cells. There are different types of T cells e.g. helper T cells, which regulate immunity by enhancing the response of other immune cells. The virus attacks helper T cells and certain other cells and causes deficiency of the human immune system. The patient becomes increasingly susceptible to other diseases. HIV preferentially infects and kills helpers

(CD4) T lymphocytes and the virus does not cause any disease itself. As the virus affects the human immune system, so the virus has been named Human Immunodeficiency Virus (HIV).

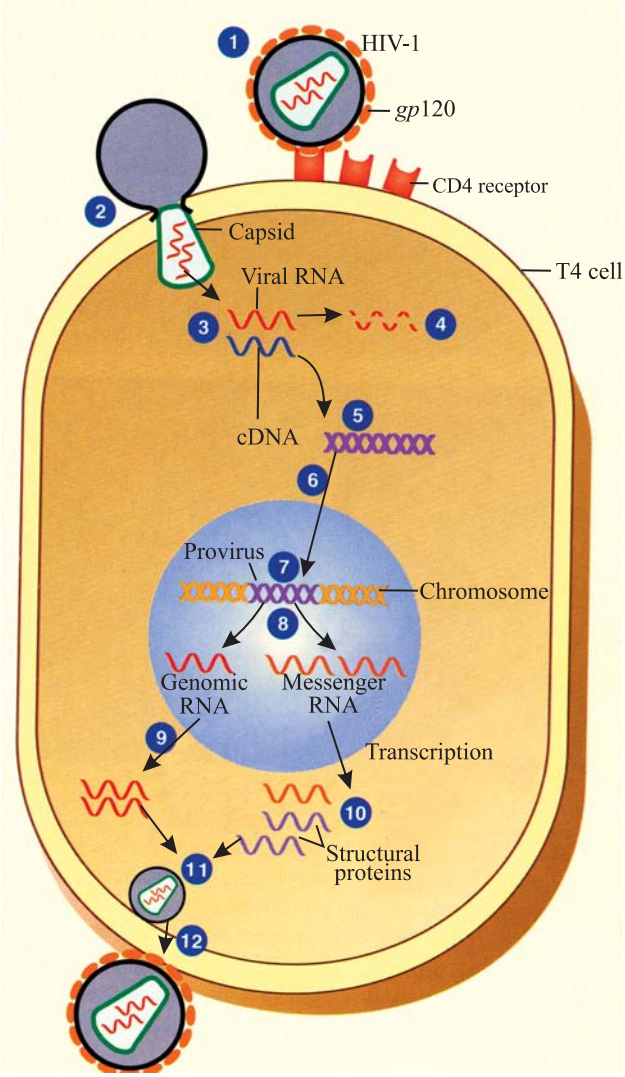


Fig: 5.10 Life Cycle of HIV (Retrovirus) 1. Attachment: Spike combines with receptor. **2. Penetration:** Virus enters cell and uncoating occurs. **3. Reverse transcription:** Produces cDNA strand. **4. Break down:** Viral DNA breaks down. **5. Replication:** Produces double-stranded cDNA. **6. Integration:** Viral DNA passes on when cell reproduce. **7. Provirus:** The integrated DNA is known as provirus. **8. Transcription:** Produces many strands of mRNA. **9. Biosynthesis:** Genomic RNA is formed. **10. Formation of protein:** Structural proteins are formed. **11. Maturation:** Assembly of viral components. **12. Release:** Budding gives virus an envelope.

Symptoms of AIDS

An HIV infection can be divided into 3 stages: Asymptonic Carrier, AIDS Related Complex (ARC), Full Blown AIDS.

Asymptonic Carrier: Symptoms that may include are fever, chills, aches, swollen lymph glands and an ichy rash. These symptoms disappear and there are no other symptoms for nine months or longer. Although the individual exhibit no symptoms during this stage, he or she is highly infectious. The standard HIV blood test for the presence of antibody becomes positive during this stage.

AIDS Related Complex (ARC): The most common symptoms of ARC are swollen lymph glands in the neck, armpit or groin that persist for months. Other symptoms include night sweats, persistent cough, flu, and persistent diarrhoea, loss of memory, inability to think clearly, loss of judgment and depression.

Full Blown AIDS: In this final stage, there is severe weight loss and weakness due to persistent diarrhoea and usually one of several opportunistic infections. These are called opportunistic infections because the body can usually prevent them, only a severely weakened immune system gives the opportunity to get started. For example Pneumocystis carinii pneumonia, Kaposi sarcoma (a form of cancer) etc are opportunistic infection.

Opportunistic Diseases that may Attack an AIDS Victim

HIV does not cause any disease nor kills any person. It only destroys T-cells of immune system. The decrease in the human immune system results in the inability of the body to fight diseases. Getting this opportunity of less or no immune system i.e. weak defence system a person suffering from AIDS is attacked by diseases called opportunistic diseases. e.g., Kaposi's sarcoma (cancer or lesion on skin) is the most common opportunistic malignancies associated with HIV and are considered AIDS defining illness.

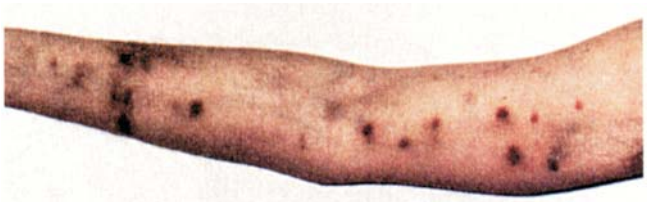


Fig. 5.11 This photograph shows the multiple lesions of the skin cancer, Kaposi's sarcoma, on the arm of a patient with AIDS.

Critical Thinking

How do retroviruses differ from other animal viruses?

Treatments of AIDS

The aims of HIV treatment is to reduce the viral load to an undetectable level as long as possible and to reduce transmission by using antiviral drugs.

Treatment: The decision to start therapy is a major one. It is dependent upon the symptom status of the patient, the CD4 count, the **viral load** (it is the quantity of virus at which it is detected in an organism) and wishes of the patient. Starting therapy early will allow the potential development of drug resistance and thereby reduce drug options for the future. Currently, there is clear move to delay therapy until there are clinical or immunological indications to commence and not just on the basis of high viral load. Nevertheless, the risk of HIV related opportunistic infection increases and treatment is less effective. The higher the viral load the faster the CD4 count falls. So a potent combination is always used, i.e. they are often on more than 10 different medications. AIDS patients are now surviving for prolonged period.

Critical Thinking

Why antibiotics do not work against viruses?

Control Measures against the Transmission of HIV

It can be controlled by preventing transfer of body fluid (blood, serum, semen etc), from patient to unaffected person. The following behaviour of precautionary measure will prevent AIDS: (1) Do not use used syringes and needles. (2) For blood transfusion, blood must be used after proper screening for HIV. (3) Do not share toothbrushes, blades and towels with any one. Special care to be taken at barber's shop or hair cutting saloons, beauty saloons. (4) Surgical instruments must be properly sterilized. (5) AIDS is primarily a sexually transmitted disease. Refrain from immoral sexual activities and follow Islamic teachings to pass healthy, neat and clean life. (6) Mother having HIV should not feed their babies. Shaking hands, hugging,

Skills: Interpreting and Recording

- Predict from the given data the incidence and prevalence of AIDS over a period of next five months.

GLOBAL SUMMARY, UNAIDS 2008 STATISTICS

Number of people living with HIV in December 2007

Adults: 30.8 million, Women: 15.5 million, Children <15: 2.5 million.

AIDS Death in 2007: Adults: 1.7 million, Children <15: 330 000

Courtesy: *NACP, Pakistan & The News International, Islamabad, 01-12-09 (World AIDS Day).*

coughing or sneezing and swimming in the same pool do not transmit HIV. One cannot get AIDS from inanimate objects such as toilets, door knobs, telephones, office machines and house hold furniture. AIDS is not transmitted by mosquitoes and other insects.

AIDS in Pakistan

The first case of AIDS in a Pakistani citizen was reported in 1987 in Lahore. In 1993, the first recognized transmission of HIV infection through breastfeeding in Pakistan was reported in the city of Rawalpindi. Currently classified by WHO/UNAIDS high-risk country for the spread of HIV infection, Pakistan has recently witnessed changes in the epidemiological trends of the disease owing particularly to rapid rise in infection among injecting drug users. According to UNAIDS estimates, in 2009 there are 6000 registered cases and 97400 to 1,25,000 of estimated cases, or 0.1 percent of the adult population in Pakistan, are infected with HIV although cases reported to the National AIDS Control Programme are less. Data analysis indicates that most infections occur between ages of 20-44 years, with men outnumbering females by a ratio 5 : 1.

Skills: Interpreting and Recording

- **List the factors responsible for the spread of AIDS.**

Factors for Vulnerability to AIDS

a) High risk behaviour among Injecting Drug Users (IDUs)

b) Unsafe practices among sex workers and men who have sex with men (MSM).

d) Inadequate blood transfusion screening and high level of professional donors.

e) HIV infected mother can pass to the fetus via the placenta or to an infant via the mother's milk.

f) By use of contaminated needles of syringes, dental surgical instruments. Instruments used, and sharing of used towels at barber's saloons or beauty saloons.

Science, Technology and Society Connections

Correlate the social and cultural values of a country with prevalence of AIDS.

5.5 VIRAL DISEASES

In this section we will describe causative agent, symptoms, treatment, transmission and prevention of hepatitis, herpes, polio and cotton leaf curl disease.

Hepatitis

There are several types of hepatitis A,B,C,D,E, and G hepatitis (L. *itis* inflammation) is an inflammation of liver.

Hepatitis "A"

Cause: Hepatitis A virus (HAV) causes hepatitis A. It is a typical enterovirus. It has a single stranded, RNA genome and a nonenveloped icosahedral nucleocapsid.

Transmission: HAV is transmitted by the fecal-oral route.

Symptoms: Fever, anorexia, nausea, vomiting and jaundice are typical. Dark urine, pale feces are seen.

Treatment and Prevention: No antiviral therapy is available. Active immunization with a vaccine containing inactivated HAV is available. Vitamin "B" complex if anorexia is marked and medicine for jaundice is given. Observation of proper hygiene e.g. sewage disposal and hand washing after bowel movements is of prime importance.

Hepatitis "B"

Cause: It is caused by HBV. It has a partially stranded double stranded DNA, icosahedral nucleocapsid core and an envelope.

Symptoms: It is similar to hepatitis A, but more severe which can lead to cirrhosis and death.

Transmission: The three main modes of transmission are via blood, sexual contact and perinatally from mother to newborn.

Treatment and Prevention: Alpha interferon and some nucleoside analogues are effective against HBV. Vaccine is highly effective in preventing hepatitis "B". All blood transfusion should be screened.

Science Titbits

HBV can also be transmitted through surface contact with dried blood or other potentially infectious materials while HIV dries up on dry surface so it is not transmitted.

Hepatitis "C"

Cause: It is caused by HCV. It is an enveloped virion, having single stranded positive polarity RNA. (see glossary)

Transmission: It is primarily transmitted via blood.

Symptoms: Fever, anorexia, nausea, vomiting and jaundice are common. Dark urine, pale faces are seen. Cirrhosis of liver may occur.

Treatment and Prevention: A combination of alpha interferon and ribavirin is the treatment choice for chronic hepatitis C. No vaccine is available. Blood transfusion should be screened as preventive measure.

Hepatitis "D"

Cause: It is caused by D virus or delta virus. It is a defective virus i.e. it can replicate only in cells infected with HBV.

Transmission: HDV is transmitted by the same means as is HBV.

Symptoms: As in hepatitis B but more severe.

Treatment and Prevention: Treatment, immunization and prevention same as HBV.

Hepatitis "E"

HEV is a nonenveloped, single stranded RNA virus. It is transmitted through water. Clinically it resembles hepatitis "A". There is no antiviral treatment and vaccine.

Hepatitis "G"

In 1996 hepatitis G virus was isolated. The role of HGV in the causation of liver disease has yet to be established.

Herpes

Cause: It is caused by herpes simplex virus type-1 and type-2. They have double stranded DNA and icosahedral core surrounded by lipoprotein coat.

Transmission: HSV-1, is transmitted primarily in saliva, whereas HSV-2 is transmitted by sexual contact.

Symptoms: HSV causes several forms of primary and recurrent diseases, e.g. Gingivostomatitis, Herpes labialis, Keratoconjunctivitis, Encephalitis. HSV-2 causes several diseases, e.g. Genital Herpes, Neonatal Herpes.

Treatment: Antiviral drugs are used to treat Herpes.

Prevention: Avoid contact with vesicular lesion or ulcer.

S.T.S Connections

Suggest ways to rid human civilization of viruses.

Poliomyelitis

Cause: It is caused by polio virus which is an enterovirus. The virus is small, nonenveloped, have icosahedral nucleocapsid and a single stranded RNA. The genome has a positive polarity i.e. on entering the cell, it functions as the viral RNA.

Transmission: Polio virus is transmitted by the fecel oral route. It replicates in the oropharynx and intestinal tract and spread to blood and central nervous system.

Symptoms: The virus replicates in the motor neuron located in the anterior horn of the spinal cord. Death of these cells results in paralysis of the muscles innervated by those neurons. Non-paralytic poliomyelitis manifests as aseptic meningitis with fever, headache and stiff neck. In paralytic poliomyelitis flaccid paralysis is predominant finding. Painful muscle spasm may also occur. The motor nerve damage is permanent.

Treatment: There is no antiviral therapy. Physiotherapy for the affected muscles is important.

Prevention: Polio can be prevented by the killed (salk vaccine, inactivated vaccine) and the live, attenuated vaccine (sabin vaccine, oral vaccine).

Cotton Leaf Curl Disease

Cotton leaf curl is a serious disease of cotton and several other malvaceous plant species The disease is, at this time, endemic throughout Pakistan and epidemic in Western India. Affected cotton plants exhibit a range of symptoms such as leaf curling, stunted growth and a poor yield of cotton fibre. In addition, affected plants may develop leaf-like outgrowths from the veins on the undersides of leaves.

Fig: 5.12 Cotton Leaf Curl Disease

Cause: The viruses associated with the CLCuD complex on the Indian subcontinent, five of which have been identified. These are all single component begomoviruses (genus Begomovirus family Geminiviridae).

Transmission: This disease is transmitted by the whitefly *Bemisia tabaci*.

Symptoms: The symptoms in cotton usually appear within 2-3 weeks of inoculation by *Bemisia tabaci* and are initially characterized by a deep downward cupping of the youngest leaves. This is followed by either upward or downward curling of the leaf margins, swelling and darkening of the veins as well as the formation of enations (outgrowth) on the veins, which frequently (dependant on variety) develop into cup-shaped, leaf-like structures

Treatment and Prevention: Control of CLCuD is mainly based on insecticide treatments against the insect vector (*Bemisia tabaci*). Roguing, the removal of affected plants, particularly of ratoon cotton from the previous seasons crop, is recommended but appears to have little affect in reducing the incidence of the disease.

Table 5.3 Losses Due to Cotton Leaf Curl Disease, in Punjab, Pakistan

Year	Affected Area (000 ha)			Loss in Production (000 bales)	Loss in Pak Rupees (Million)
	Partial	Complete	Total		
2002-03	357.7	2.05	359.58	265.0	2253
2003-04	489.5	14.12	503.62	514.2	4589
2004-05	1267.4	31.37	1298.77	987.1	9229
2006-07	1686.4	25.21	1711.63	1231.7	14063
2007-08	1432.8	2.5	1435.29	953.5	13778
2008-09	1440.1	40.25	1480.35	1115.7	16079

Source: The Pakistan Cottongrower, 2009, CCRI, Multan. Data 2005-06 not recorded.
Courtesy: Mr. Sardar Mustafa, PARC, Islamabad. Mr. Tariq Mehmood, CCRI, Multan

Table 5.4 Economic Loss From Viral Infections of Bird Flu in Pakistan

Year	Losses in Pak Rs. (Million)
2004-2005	8 Million
2006-2007	24 Million

Source: Pakistan Poultry Association, Pakistan.
Courtesy: Dr. Khalid Naeem and Dr. Afzal, National Agriculture Research Council, Islamabad.

Science, Technology and Society Connections

Interpret how viral infections cause global economic loss.

Skills: Interpreting and Communication.

- Collect and Compare the number of fatalities caused by hepatitis, herpes and polio combined with the total fatalities caused by AIDS.

  National AIDS Control Programme, Ministry of health – Government of Pakistan. www.nacp.gov.pk.

- Give reasons in favour of the statement "prevention is better than cure" and present the arguments in class.

5.6 PRIONS AND VIROIDS

There are four exceptions to the virus like: Defective, pseudovirons, prions and viroids. They are called atypical viruslike agents.

Prions

Structure: Prions are infectious particles that are composed solely of proteins, i.e. they contain no detectable nucleic acid, so they are different from viruses. Further more electron microscopy reveals filaments rather than virus particles. Prions are much **more resistant** to inactivation by ultraviolet light and heat than are viruses. Prions are composed of a single glycoprotein with a molecular weight of 27,000- 30,000. This protein is encoded by a **single cellular gene**.

Diseases Caused by Prions in Man

Prions cause certain slow diseases called "transmissible spongiform encephalopathies, in man e.g. Kuru, Creutzfeldt-Jacob Disease, Fatal Familial Insomni in man. Prions also cause diseases in animals e.g. Scrapie, Visna, Bovine spongiform encephalopathy (mad cow disease).

Viroids

Viroids consist solely of a single molecule of circular RNA without a protein coat or envelope. There is extensive homology between bases in the viriod RNA, leading to large double stranded regions. The RNA is quite small and apparently does not code for any protein. Nevertheless, viriods replicate but the mechanism is unclear. They cause several plant diseases e.g. in potato, coconut, apple, peach, etc., but are not implicated in human diseases.

Exercise

SECTION I : MULTIPLE CHOICE QUESTIONS

Select the correct answer

1. Viruses are considered nonliving because

   A) they do not mutate. B) they do not locomote

   C) they cannot reproduce independently D) have nucleic acid.

2. Which of these are found in all viruses?

   A) envelope, nucleic acid, capsid B) DNA, RNA and proteins

   C) proteins and nucleic acid D) protein, carbohydrate, lipids

3. Which step in the lytic cycle follows attachment of virus and release of DNA into the cell?

   A) production of lysozome B) disintegration of host DNA

   C) assemblage D) DNA replication

4. Which of these is a true statement?

   A) viruses carry with them their own ribosome for protein formation

   B) new viral ribosomes form after viral DNA enters the cell

   C) viruses use the host ribosomes for their own ends

   D) viruses do not need ribosomes for protein formation

5. Which part of an animal virus is not reproduced in multiple copies?

   A) envelope B) protein

   C) capsid D) ribosome

6. RNA retroviruses have a special enzyme that

   A) disintegrates host DNA B) polymerises host DNA

   C) transcribe viral RNA to DNA D) translates host DNA

7. Which of the following illness is caused by a retrovirus?

A) typhoid B) malaria

C) AIDS D) sleeping sickness

8. The HIV primarily infects

A) plasma cells B) helper T cells

C) all white blood cells D) red blood cells

9. Poliomyelitis affects

A) motor neuron B) sensory neuron

C) brain D) muscles

10. HIV attaches to

A) CD4 protein B) nucleoprotein

C) lipoprotein D) glycoprotein

SECTION II : SHORT QUESTIONS

1. What are the components of bacteriophage virus?
2. What do you mean by AIDS, HIV an TMV?
3. Why are viruses called “obligate parasite”?
4. Distinguish between the lytic and lysogenic cycle of becteriophage?
5. What are the uses of bacteriophage in genetic engineering?
6. How are viruses classified on the basis of their hosts?
7. What are the ways to control HIV?
8. How are viruses specific?
9. What is the difference between prions and viroids?

SECTION III : EXTENSIVE QUESTIONS

1. How viruses were discovered? Give the classification of viruses.
2. Describe the structure of bacteriophage, flu virus and HIV?

3. Discuss the parasitic nature of virus?
4. How does a virus survive inside a host cell protected from the immune system?
5. Describe the life cycle of HIV? What are the treatment of AIDS and the control measures against the transmission of HIV? What are the social problems related to AIDS.
6. Write notes on: (a) hepatitis, (b) herpes, (c) poliomyelitis, (d) cotton leaf curl disease.
7. Historically biologists thought that viruses, because of their simple structure, evolved before cellular organisms. Based on what you have learned about viruses, present an argument against this hypothesis.

ANSWER MCQS

1. C 2. C 3. B 4. C 5. C 6.C 7.C 8.B 9.A 10.A

SUPPLEMENTARY READING MATERIAL

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3. Taylor, D.J., Green, N.P.O. and Stout, G.W. Biological science 3rd Ed. Cambridge university press, reprint, 2004.

USEFUL WEBSITES

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2. www.prenhiall.com/~audesirk
3. www.mhhe.com/scienemath/biology/mader