SECTION-2
BIODIVERSITY

CHAPTER-5
ACELLULAR LIFE

Information

David Baltimore, a Nobel Prize-winning biologist, devised the Baltimore classification system, which places viruses into one of seven groups, based on their mode of replication, and genome type.

Science, Technology and Society Connections

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

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.

Teacher's Point

Teacher would guide the students to:

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

Critical Thinking

Why antibiotics do not work against viruses?

Ans: **Antibiotics** are useless against **viral** infections. This is because **viruses** are so simple that they use their host cells to perform their activities for them.

OR (Second Answer)

Most of the antibiotics act on ribosome and stop the process of protein synthesis in bacteria. Virus lacks ribosomes. Therefore, antibiotics do not work against viruses.

Teacher's Point

Teacher would guide the students to:

- 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.

Science Titbits

Since the prophage contains genes, it can confer new properties to the bacteria. When a cell becomes lysogenized, occasionally extra genes carried by the phage get expressed in the cell. These genes can change the properties of the bacterial cell. This process is known as lysogenic conversion or phage conversion. *Clostridium botulinum*, a causative agent of food poisoning, makes several different toxins, 2 of which are actually encoded by prophage genomes.

Q1. Who convinced the majority of biologists that infectious agents do indeed exist?
What do you know about the idea of an infectious agent?

Ans: The idea of an infectious agent that did not use nucleic acids and proteins together was considered impossible, but pioneering work by Nobel Prize-winning biologist **Stanley Prusiner** has convinced the majority of biologists that such agents do indeed exist. Prions and viroids are such agents which are acellular infectious particles like viruses but are even simpler and smaller than viruses.

Teacher's Point

Teacher would guide the students to make a list of the sequence involved in the lytic life cycle of a bacteriophage and life cycle of HIV.

Skills: Interpreting and Recording

- Predict from the given data the incidence and prevalence of AIDS over a period of next five months. HIV FACT SHEET NOVEMBER 2016

Global HIV Statistics:

- 18.2 million people were accessing antiretroviral therapy (June 2016)
- 36.7 million people globally were living with HIV (end 2015)
- 2.1 million people became newly infected with HIV (end 2015)
- 1.1 million people died from AIDS-related illnesses (end 2015)
- 78 million people have become infected with HIV since the start of the epidemic (end 2015)
- 35 million people have died from AIDS-related illnesses since the start of the epidemic (end 2015)

People living with HIV

- In 2015, there were 36.7 million people living with HIV.

New HIV infections

- Worldwide, 2.1 million people became newly infected with HIV in 2015.
- New HIV infections among children have declined by 50% since 2010.
- Every year since 2010, around 1.9 million adults have become newly infected with HIV.

Skills: Interpreting and Recording

- **Make a list of factors responsible for the spread of AIDS.**

1. Having unprotected sex.
2. Other sexually transmitted infections.
3. Transfusion of contaminated blood and blood products.
4. Contaminated syringes and needles.
5. Injecting drugs.
6. Unsafe piercings.
7. Negligence in medical practice.
8. Mother-to-child HIV risk.

HIV/AIDS in Pakistan:

Nearly 100,000 people in Pakistan living with HIV/AIDS, but only 15,370 registered. The number of new HIV infections in Pakistan grew at an average of 17.6 percent per year between 2005 and 2015, making it the highest increase in the world. The highest number of 1,278 Aids patients and HIV carriers were in Sindh, followed by 558 in Punjab, 522 in Islamabad, 468 in the NWFP, 215 in Balochistan and 31 in Azad Kashmir.

Courtesy: The Express Triubne, Islamaabd. 12th May 2016 and The Dawn, Islamabad 28th December 2016.

Science Titbits

Hepatitis F virus (HFV) is a hypothetical virus linked to hepatitis. Several hepatitis F virus candidates emerged in the 1990s; none of these reports have been substantiated.

Another potential viral cause of hepatitis that is probably spread by blood and sexual contact was initially identified as Hepatitis G virus. There is very little evidence that this virus causes hepatitis, as it does not appear to replicate primarily in the liver. It is **now** classified as GB virus C.

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.

Science, Technology and Society Connections

♦ **Suggest ways to rid human civilization of viruses.**

Viruses are responsible for a number of sicknesses that all humans. Unfortunately, there is no cures for viruses. This means it is up to you to get rid of a viral infection. The best way to do this is to strengthen your immune system since it is the only thing capable of getting killing viruses. Having a healthy diet of immune-boosting foods, taking vitamin supplements and practicing several other healthy living tips will create an immune system able to quickly rid the body of viruses.

Science, Technology and Society Connections

♦ **Interpret how viral infections cause global economic loss.**

Plant **virus** diseases may damage leaves, stems, roots, fruits, seed or flowers and may cause **economic losses** by reduction in yield and quality of plant products.

Activity

1. Correlate the social and cultural values of a country with prevalence of AIDS.
2. List the factors responsible for the spread of AIDS.

EXERCISE

MCQs

1. Select the correct answer.

(i) Viruses are considered nonliving because

(A) do not mutate (B) they do not locomote
(C) cannot reproduce independently (D) have nucleic acid

(ii) 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

(iii) 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

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(iv) 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 needs
(D) viruses do not need ribosomes for protein formation

(v) Which part of an animal virus is not reproduced in multiple copies?

(A) envelope (B) protein
(C) capsid (D) ribosome

(vi) 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

(vii) Which of the following illness is caused by a retrovirus?

(A) typhoid (B) malaria
(C) AIDS (D) sleeping sickness

(viii) The HIV primarily infects

(A) plasma cells (B) helper T cells
(C) all white blood cells (D) red blood cells

(ix) Poliomyelitis affects

(A) motor neuron (B) sensory neuron
(C) brain (D) muscles

(x) HIV attaches to

(A) CD4 protein (B) nucleoprotein
(C) lipoprotein (D) glycoprotein

(xi) Hepatitis D is caused by

(A) bacteria (B) virus
(C) prions (D) viroids

Answers

(i) C	(ii) C	(iii) B	(iv) C	(v) B	(vi) C
(vii) C	(viii) B	(ix) A	(x) A	(xi) D	

SHORT QUESTIONS

2. What are the living and nonliving characteristics of viruses?

Ans: Characteristics of viruses:

They show the characteristic of both living and nonliving things.

The living characteristics of viruses are:

(i) Viruses occur in different varieties or strains.

(ii) They have their own genetic material in the form of either DNA or RNA that can undergo mutation.

(iii) They reproduce using the metabolic machinery of the host cell they infect.

(iv) They enter living organism and cause disease i.e., intracellular obligate parasite.

(v) They get destroyed by ultraviolet rays.

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The nonliving characteristics of viruses are:

(i) They lack cellular structure, coenzyme and enzyme system and do not have metabolic activity of their own.

(ii) They can be crystallized and stored in bottles.

(iii) They do not respire. Viruses behave as nonliving, inert infectious particles outside the host.

(iv) They do not have a cellular structure, which is the basis of all life.

3. Give the classification of viruses based on their hosts.

Ans: Classification of Virus:

Virus classification is either based upon host organisms or on other structural characters such as morphology, genome type and mode of action in the host.

The internationally agreed system of virus classification is based on the structure and composition of the virus particle (virion). In some cases, the mode of replication is also important in classification.

Classification of viruses based upon host:

Viruses can be classified on the basis of their hosts e.g., bacteriophage virus, plant viruses and animal viruses.

Bacteriophage virus:

It attacks bacteria. It is a DNA virus with a polyhedral tail.

Plant Viruses:

More than 2,000 types of viral plant diseases are known.

- Most plant viruses discovered till to date including tobacco mosaic virus (TMV), having an RNA genome.
- Many viruses have rod shaped capsid like TMV e.g., potato yellow dwarf virus.

Animal viruses:

Animal viruses occur as parasites in animals.

- Viruses cause foot and mouth disease in livestock.
- Rous sarcoma virus causes cancer in animals.
- In many viral infections viruses attack and destroy certain cells in the human body causing the symptoms and diseases.
- Papovirus causes warts.
- Poxivirus causes small pox.
- Picornovirus causes polio, hepatitis A etc.
- Paramyxovirus causes measles, mumps.

4. What are the parasitic natures of virus?

Ans: Parasitic Nature of Virus:

- Viruses are parasitic in nature. They 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 types of white blood cells, the poliovirus reproduces in spinal nerve cells, and hepatitis viruses infect only liver cells. Human cold viruses infect only the cells lining the upper respiratory tract.

Actually viruses have protein spikes on their surfaces which help them to attach with specific receptors on the host 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.

5. Justify why a virus must have a host cell to parasitize in order to complete its life cycle.

Ans: Viruses must require host cell to complete life cycle:

A virus must have a host cell to parasitize in order to complete its life cycle because viruses are obligate intracellular parasites, which mean they cannot multiply outside a living cell. Viruses infect all sorts of cells, from bacterial cells to human cells.

An isolated virus is unable to reproduce or do anything else except infect an appropriate host cell.

Viruses lack metabolic enzymes, ribosomes, etc., for making proteins. Therefore they need host cell to complete their life cycles.

6. Explain how a virus survives inside a host cell, protected from immune system.

Ans: Survival of viruses inside a host cell:

Host body has a strong defence against viruses but viruses surround the host immune response by:

(i) Blocking complement activation.
(ii) Using complement receptor to enter B lymphocytes.
(iii) Inhibiting interferon induced antiviral response.
(iv) Blocking production of cytokines or response to cytokines.
(v) Suppressing major histocompatibility complex.
(vi) Reducing B-cell activation.
(vii) Changing their own genetic constitution so rapidly that vaccines or antibodies of host against them become ineffective.

These are different ways that how a virus survives inside a host cell, protected from immune system.

7. Determine the method a virus employs to survive/passover unfavourable conditions when it does not have a host to complete the life cycle.

Ans: Viruses can pass unfavourable conditions outside the host:

i. Viruses unlike other "living" organisms do not need food to survive.
ii. They remain dormant or inactive outside the host body. Being tiny, they are not threatened by the other microorganisms. Their only concern would be the pH and temperature, as these would denature the protein.
iii. The virulence of the virus outside the host is maintained for a certain period of time and the time period depends on what virus is or pH and temperature of the medium.
iv. Viruses outside the host are nonliving. It can be said that they go under dormant period as they do not have any metabolic activity outside living host, however, the genome of the virus remains viable for long time (in inactive form) outside the host.

v. Non-enveloped viruses can in fact survive for long periods outside the host (up to several days) whereas enveloped viruses survive for shorter time periods. This is because many enveloped viruses rely on the proteins on the surface of the membrane to attach to the host cell, this envelope is generally sensitive to degradation to sunlight and normal cleaning procedures.

8. Justify the name of virus i.e., "Human Immunodeficiency Virus" by establishing T-helper cells as the basis of immune system.

Ans: Helper T cells regulate immunity by enhancing the response of other immune cells so, the decrease in the number of helper T cells causes deficiency of the human immune system. The virus affects the human immune system, therefore, the virus has been named Human Immunodeficiency Virus (HIV).

9. Reason out the specificity of HIV on its host cells.

Ans: The initial step in the life cycle of HIV is adsorption/attachment which is characterized by the binding of the virion glycoprotein 120 envelope proteins to the CD4 proteins (a receptor) on the surface of T4 cells. 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 single stranded viral RNA in the cytoplasm along with viral enzymes.

The enzyme called **reverse transcriptase** synthesizes a single stranded DNA complementary to virus RNA therefore, called **complementary DNA** (cDNA).

10. What are the symptoms of AIDS.

Ans: Symptoms of AIDS:

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

i. Asymptomatic Carrier:

In **asymptomatic carrier** symptoms that may include are fever, chills, aches (continued pain), swollen lymph glands and an itchy 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.

ii. Aids Related Complex:

The most common symptoms of **AIDS related complex** are swollen lymph glands in the neck, armpit or groin that persist for months.

iii. Full Blown AIDS:

The **full blown AIDS** is the final stage. In it there is severe weight loss and weakness due to persistent diarrhoea and usually one of several opportunistic infections.

Some Other Symptoms:

Other symptoms include night sweats, persistent cough, flu, and persistent diarrhoea, loss of memory, inability to think clearly, loss of judgment and depression.

11. Explain opportunistic diseases that may attack an AIDS victim.

Ans: Opportunistic Diseases:

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), fungal infection, viral infection, gastrointestinal diseases, respiratory diseases, nervous system and eye diseases.



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

12. What are the common control measures against the transmission of HIV?

Ans: Control Measures Against the Transmission of HIV:

AIDS can be controlled by preventing transfer of body fluid (blood, serum, semen, etc.,) from patient to unaffected person.

The following behavior of precautionary measure will prevent AIDS:

(i) Do not use used syringes and needles.

(ii) For blood transfusion, blood must be used after proper screening for HIV.

(iii) Do not share toothbrushes, blades and towels with anyone. Special cares to be taken at barber's shop or hair cutting saloons, beauty salons.

(iv) Surgical instruments must be properly sterilized.

(v) AIDS is primarily a sexually transmitted disease. Refrain from immoral sexual activities and follow Islamic teachings to pass healthy, neat and clean life.

(vi) Mother having HIV should not feed their babies. Shaking hands, hugging, 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.

13. What are the uses of bacteriophage in genetic engineering?

Ans: Uses of Bacteriophages in Genetic Engineering:

Genetic engineering is the field of biotechnology in which alteration in genetic material of an organism is carried out such as transfer of gene from one organism to another. Several biological tools have been used in genetic engineering to accomplish the required task.

The bacteriophages have also been used in number of ways in different approaches of genetic engineering. Some of them are outlined below:

a) Beside bacterial plasmids the phage DNA has also been used as **vector** in genetic engineering techniques such as development of **genomic library** (a collection of bacteria or bacteriophage clones which contains multiple copies of all the genes of an individual's genome)

b) **Phage therapy** is the application of genetically engineered phages that can kill pathogenic bacteria. Phage therapy has advantages over conventional

antibiotic therapy. As phages are fairly narrow in their spectrum of activity, meaning that with phage treatment it is possible to kill bacterial pathogens while avoiding harming of normal bacterial flora, that is, our good bacteria.

c) Bacteriophages have been used for many years as tools for the treatment of bacterial infections but recently a new application in the area of **antibacterial nanomedicines** has been discovered in which bacteriophages can be formulated as targeted drug-delivery vehicles.

14. Describe the structure of prions and name any two diseases caused by them.

Ans: Prions:

Prions, so-called because they are proteinaceous, are infectious particles, smaller than viruses, that contain no nucleic acids (neither DNA nor RNA).

Structure of Prions:

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. This protein is encoded by a **single cellular gene.**

Diseases Caused by Prions:

Fatal neurodegenerative diseases, such as Kuru in humans and in cattle "mad cow disease" (bovine spongiform encephalopathy), were shown to be transmitted by prions.

15. Describe the structure of viroids and name the diseases caused by them.

Ans: Viroids:

Structure of Viroids:

Viroids are plant pathogens that consist of a short stretch (a few hundred nucleobases) of highly complementary, circular, single-stranded RNA without a protein coat or envelope. The RNA is quite small. Viroid RNA does not code for any protein. The replication mechanism involves RNA polymerase II, an enzyme normally associated with synthesis of messenger RNA from DNA, which instead catalyzes "rolling circle" synthesis of new RNA using the viroid's RNA as template. Some viroids are ribozymes, having catalytic properties which allow self-cleavage.

Diseases Caused by Viroids:

The only human disease known to be caused by a viroid is hepatitis D. They cause several plant diseases, e.g., in potato, coconut, apple, peach, etc.

16. Define / Describe / Explain:

virus, virology, virion, capsomers, antiviral therapy, prions, virions.

Ans: Virus:

A **virus** is a small infectious agent that replicates only inside the living cells of other organisms. **Viruses** can infect all types of life forms, from animals and plants to microorganisms, including bacteria and archaea.

Virology:

By 1900, similar disease producing substance had been discovered in both plants and animals. The name filterable viruses were given to these substances. In 1935 **W. M. Stanley** crystallized the infectious particle, now known as tobacco mosaic virus (TMV). Subsequently many other viruses actually have been seen with the help of the electron microscope. The study of virus is called **virology.**

OR

Virology is the scientific discipline concerned with the study of the **biology** of viruses and viral diseases, including the distribution, biochemistry, physiology, molecular **biology**, ecology, evolution and clinical aspects of viruses.

Virion:

Viruses have a very simple structure. A complete viral particle is called **virion.** Primarily, it can be divided into two parts i.e., **core** and **coat.**

Capsomers:

The **capsomere** is a subunit of the capsid, an outer covering of protein that protects the genetic material of a virus. **Capsomeres** self-assemble to form the capsid.

Antiviral Therapy:

Antiretroviral Therapy (ART):

HIV is treated using a combination of medicines to fight HIV infection. This is called **antiretroviral therapy** (ART). ART is not a cure, but it can control the virus so that HIV positive person can live a longer, healthier life and reduce the risk of transmitting HIV to others. ART is a highly effective treatment for HIV infection, preventing progression of the disease in the vast majority of recipients. When ART is accessible and started early in the course of infection, the lifespan of HIV-positive people is typically very close to that of comparable HIV-negative people. But ART can have toxicities, is often costly, and requires strict daily pill taking that can lessen quality of life. Because of the limitations of ART, a cure for HIV infection remains a vital goal for research.

OR

Antiviral therapy is often used by cancer patients to treat viral infections.

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Virions:

Viruses have a very simple structure. A complete viral particle is called **virion.** Primarily, it can be divided into two parts i.e., **core** and **coat.**

OR

A complete virus particle that consists of an RNA or DNA core with a protein coat sometimes with external envelopes and that is the extracellular infective form of a virus.

17. What do you mean by AIDS, HIV, ART, CLCuD and TMV?

Ans: AIDS:

AIDS stands for Acquired Immune Deficiency Syndrome: Acquired **means you** can get infected with it; Immune Deficiency **means** a weakness in the body's system that fights diseases. Syndrome **means** a group of health problems that make up a disease.

HIV:

Human immunodeficiency virus (HIV) is the causative agent of 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.

ART:

HIV is treated using a combination of medicines to fight HIV infection. This is called **antiretroviral therapy** (ART). ART is not a cure, but it can control the virus so that HIV positive person can live a longer, healthier life and reduce the risk of transmitting HIV to others. ART is a highly effective treatment for HIV infection, preventing progression of the disease in the vast majority of recipients. When ART is accessible and started early in the course of infection, the lifespan of HIV-positive people is typically very close to that of comparable HIV-negative people. But ART can have toxicities, is often costly, and requires strict daily pill taking that can lessen quality of life. Because of the limitations of ART, a cure for HIV infection remains a vital goal for research.

CLCuD:

Cotton Leaf Curl Disease:

Cotton leaf curl disease (CLCuD) is a serious disease of cotton.

Cause: The viruses associated with the CLCuD complex on the Indian subcontinent, five of which have been identified as begomoviruses.

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

Symptoms: The symptoms are initially characterized by a deep downward cupping of the youngest leaves. This is followed by development of cup-shaped, leaf-like structures.

Treatment and Prevention:

Control of CLCuD is mainly based on insecticide treatments against the insect vector *(Bemisia tabaci)*.

TMV:

In 1935 **W. M. Stanley** crystallized the infectious particle, now known as tobacco mosaic virus (TMV). Subsequently many other viruses actually have been seen with the help of the electron microscope. The study of virus is called **virology.**

Most plant viruses discovered till to date including tobacco mosaic virus (TMV), having an RNA genome. Many viruses have rod shaped capsid like TMV e.g., potato yellow dwarf virus.

OR

Tobacco mosaic virus (**TMV**) is a positive-sense single stranded RNA virus, genus tobamovirus that infects a wide range of plants, especially tobacco and other members of the family Solanaceae. The infection causes characteristic patterns, such as "mosaic"-like mottling and discoloration on the leaves (hence the name).

18. Distinguish between:

(a) bacteriophage and flu virus

(b) flu virus and HIV

(c) lytic and lysogenic cycle of bacteriophage

(d) prions and viroids?

Ans: (a) bacteriophage and flu virus:

Structure of Bacteriophage:

The bacteriophage or simply phage is the virus that attacks upon bacteria. It is generally a tadpole shaped virus. It consists of head, neck and tail.

Head:

The **head** is icosahedral in shape. The inner core of head consists of a single stranded DNA genome.

Narrow Neck or Collar:

Below the head is narrow **neck** or collar which separate head and tail.

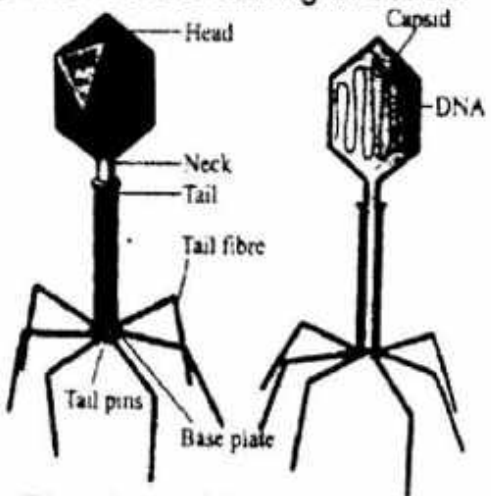
Tail:

The **tail** is a hollow tube made up of proteins through which the nucleic acid passes during infection. The tail is surrounded by a contractile sheath, which contracts during infection of the bacterium.

Basal Plate:

At the end of the tail a **basal plate** is present which possesses about six tail fibres around it and several tail pins or spikes at its lower surface. The tail fibres and tail pins are involved in the binding of the phage to the bacterial cell.

At the bottom of core tube of tail, an enzyme, the **lysozyme** is present which is released upon contraction of tail. It digests the portion of host cell wall so that core tube can be penetrated into the host cell during infection.



Structure of bacteriophage

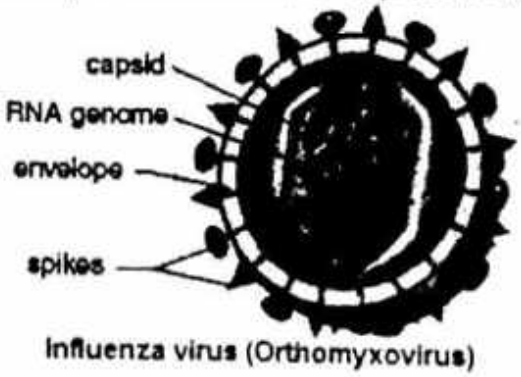
Structure of Influenza or Flu Virus:

Influenza virus exists in three forms called A, B, C.

Composition of Influenza Virus:

Influenza virus is composed of a segmented single-stranded RNA.

A membranous envelope surrounds the capsid having spikes.

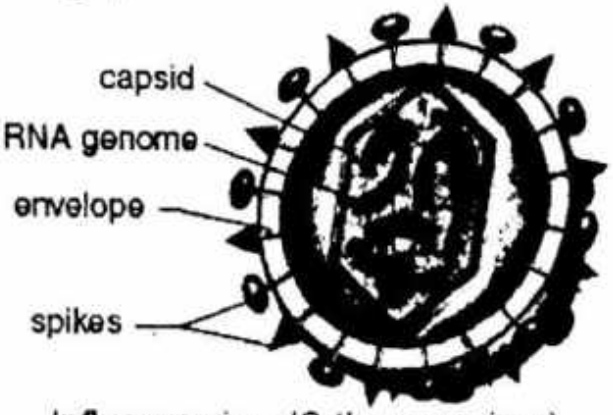


Influenza virus (Orthomyxovirus)

(b) flu virus and HIV:

Ans: Structure of Influenza or Flu Virus:

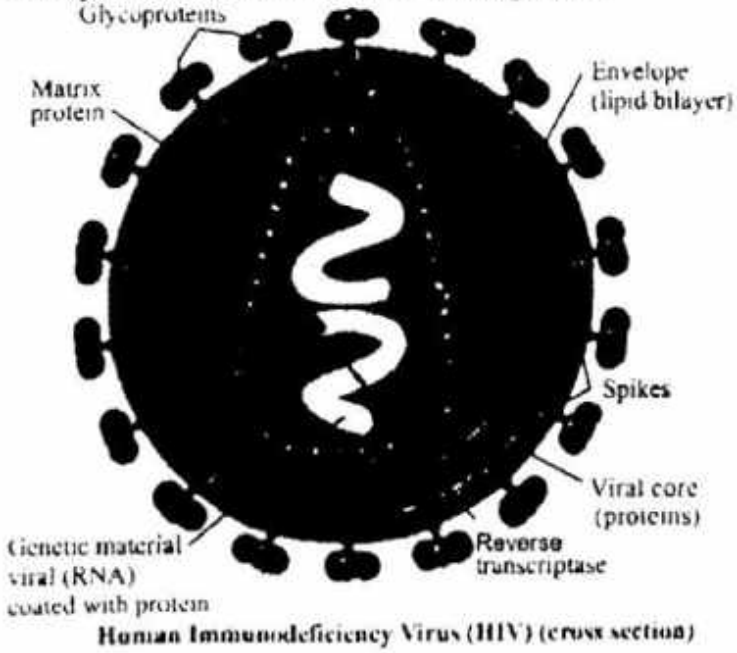
Influenza virus exists in three forms called A, B, C. Influenza virus is composed of a segmented single-stranded RNA. A membranous envelope surrounds the capsid having spikes.



Influenza virus (Orthomyxovirus)

Structure of Human Immunodeficiency Virus:

Human Immunodeficiency Virus (HIV) is a **retrovirus.** It is spherical in shape. The outer covering is a lipoprotein **envelope** which consists of two layers of lipids; different proteins are embedded in the viral envelope, forming **"spikes"** consisting of the outer **glycoprotein (gp) 120** and the **transmembrane gp41.** The lipid membrane is borrowed from the host cell during the budding process (formation of new particles), gp 120 is needed to attach to the host cell, and gp41 is critical for the cell fusion process. Beneath envelope another protein shell is present which is made up of **matrix proteins.** It lies between the envelope and capsid. The HIV capsid is somewhat conical shaped which is composed of capsomers. The viral core contains two single strands of **HIV RNA** and the enzymes needed for HIV replication, such as reverse transcriptase, integrase and protease. The **reverse transcriptase** enzyme is used to convert viral RNA genome into viral DNA genome, integrase enzyme is used to incorporate viral DNA into host DNA while the protease enzyme is used to break large structural proteins into smaller units. These structural proteins are encoded by three out of the nine virus genes.



Human Immunodeficiency Virus (HIV) (cross section)

(c) lytic and lysogenic cycle of bacteriophage:

Lytic phase	Lysogenic phase
1. The viral genome does not integrate with host DNA.	**1.** The viral genome or its complementary DNA gels integrated with the host DNA. It is called prophage or provirus.
2. The host DNA is often hydrolysed in the lytic phase	**2.** The host DNA is not hydrolysed during lysogenic phase
3. The viral genome replicates repeatedly and forms a number of copies in the same host cell.	**3.** The prophage or provirus replicates only once along with the replication of host genome so that a single particle is transferred to a daughter cell.
4. The cellular machinery of the host is completely taken over by the viral genome.	**4.** The cellular machinery of the host is only slightly disturbed.
5. The virus is virulent	**5.** The virus is non virulent or temperate.
6. The host cell undergoes lysis	**6.** The host cell does not get lysed.
7. A number of virus particles are liberated when the host cell become lysed.	**7.** Virus particles are liberated only rarely.

OR (Second Answer)

Lytic Cycle:	Lysogenic Cycle:
1. This type of cycle exhibited by virulent phages (bacteriophages)	**1.** It is exhibited by temperate phages.
2. Here the phage genome becomes integrated with bacterial genome.	**2.** In this case the phage genome does not integrate with bacterial genome, thus a prophage is performed.
3. This cycle is of short duration as the virulent phages replicates and causes immediate lysis of bacterial cell	**3.** This cycle is following longer duration as temperate phage does not replicate immediately after infection.
4. This does not cause the genetic recombination in bacteria.	**4.** This may cause genetic recombination among bacteria.
5. Example: T phage.	**5. Example:** phage.

(d) prions and viroids:

Prions	Viroids
Prions are infectious protein particles.	Viroids are small and naked infectious RNA molecules.
Discovery:	
Prions were discovered by Stanley B. Prusiner.	Viroids were named by T. O. Diener in 1971.

Genetic Material:	
Prions do not contain DNA or RNA.	Viroids contain RNA.
Digestion by Proteinase K and Trypsin:	
Prions can be digested by proteinase K and trypsin.	Viroids cannot be digested by proteinase K and trypsin.
Digestion by Ribonucleases:	
Prions are resistant to ribonucleases.	Viroids can be digested by ribonucleases.
Infections:	
Prions infect animals.	Viroids infect higher plants.
Common Diseases:	
Prions cause diseases such as mad cow disease in cows, scrapie disease in sheep and goats, etc.	Viroids cause diseases such as potato spindle tuber disease, chrysanthemum stunt disease.
Reproduction:	
Prions can self propagate.	Viroids can reproduce only within a host cell.
Size:	
Prions are smaller than viroids.	Viroids are smaller than viruses.

OR (Second Answer)

Prions	Viroids
1. It is an infectious protein particle.	**1.** It is an infectious RNA particle
2. It is formed of only proteins.	**2.** Viroid is formed of only small single stranded circular RNA.
3. RNA or DNA is absent.	**3.** A protein coat is absent.
4. Prions are inactivated by proteinase K and trypsin digestion but resistant to ribonuclease treatment.	**4.** Viroids are inactivated by ribonuciease digestion but resistant to proteinase K and trypsin digestion.
5. Mostly, smaller than viroid.	**5.** Viroid has a smaller size than viruses.
6. Prions infects animals causing neurological degenerative diseases Mad cow disease (Bovine spongiform encephalopathy) in cow and Scrapie disease in sheep and goat.	**6.** Viroid infects only higher plants (Exception: hepatitis D virus in humans is similar to viroid) Common plant diseases include Potato Spindle tuber disease, Chrysanthemum stunt disease.

EXTENSIVE QUESTIONS

19. Trace the history of viruses since their discovery.

Ans: Viruses-Discovery and Structure:

Influenza, bird flu, polio, 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. 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

History and Discovery of Virus:

The word virus is derived from a Latin word "venom" meaning 'poison'. In past, the term virus was associated with infectious diseases which have unknown cause. The first evidence about the existence of virus came when in 1884 **Charles Chamberland,** who worked with **Louis Pasteur,** found that the causative agents of rabies could pass through the porcelain filter (which has pore sizes of 0.1 - 1 micron i.e., 100 - 1000 nm). However such filters could be used to completely remove all bacteria or other cells known at the time from a liquid suspension.

Tobacco Mosaic Disease:

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 porcelain filter 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. In 1935 **W. M. Stanley** crystallized the infectious particle, now known as tobacco mosaic virus (TMV). Subsequently many other viruses actually have been seen with the help of the electron microscope. The study of virus is called **virology.**

20. Give the classification of viruses based upon capsid and genomes.

Ans: Classification of Virus:

Virus classification is either based upon host organisms or on other structural characters such as morphology, genome type and mode of action in the host.

The internationally agreed system of virus classification is based on the structure and composition of the virus particle (virion). In some cases, the mode of replication is also important in classification.

Classification of viruses based upon of structure:

(i) On the bases of capsid:

Although diverse in size and shape viruses have common features, most of which appear in the following four types:

(a) Viruses having helical capsid with over all shape of a rigid rod e.g., tobacco mosaic virus.

(b) Viruses having a polyhedral capsid with a glycoprotein spike at each vertex e.g., Adenoviruses.

(c) Viruses having an outer envelope studded with glycoprotein spikes e.g., Influenza viruses.

(d) Viruses having a complex capsid consisting of a polyhedral head and a tail apparatus, e.g., Bacteriophage.

(ii) **On the bases of genomes:**

The genomes of viruses may consists of:

(a) Double-stranded (dsDNA) e.g. Poxivirus (smallpox virus, cowpox virus).

(b) Single -stranded DNA (ssDNA) e.g., Parovirus (mild rash).

(c) Double-stranded RNA (dsRNA) e.g., Reovirus (diarrhea).

(d) Single-stranded RNA (ssRNA); serves a mRNA e.g., Togavirus (Rubella virus).

(e) ssRNA; template for mRNA synthesis e.g., Orthomyxovirus (Influenza virus).

(f) ssRNA; template for DNA synthesis., Retrovirus (HIV).

21. Describe the general structure of a virus.

Ans: General Structure of a Virus:

Viruses have a very simple structure.

Virion:

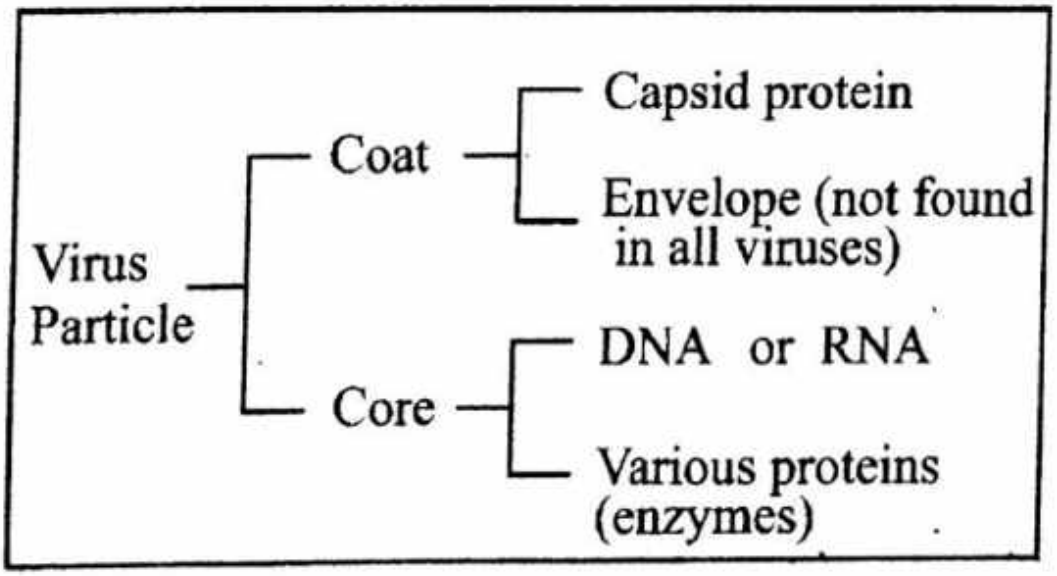
A complete viral particle is called **virion.** Primarily, it can be divided into two parts i.e., **core** and **coat.**

Core:

The core is inner part of virion which consists of viral genome and various proteins (enzymes).

Genome:

Genome is the genetic material, which is either DNA or RNA, which may be single stranded or double stranded. **Core proteins** include one or more enzymes that facilitate the virus in its mode of action within host body. For example; all single stranded RNA viruses have the enzyme transcriptase (RNA dependent RNA polymerase) to convert single stranded RNA genome into double stranded RNA genome. Retroviruses and hepatitis B virus contain the enzyme reverse transcriptase to convert single stranded RNA genome into double stranded DNA genome.



Coat:

The **coat** is the outer covering of viral particle which consists of capsid and envelope.

Capsid:

The **capsid** is the protective coat of protein surrounding the core. Capsid is composed of identical repeating subunits called **capsomers.** The number of capsomers is specific to a particular kind of virus. For example: Herpes virus has 162 capsomers in its capsid while adenovirus that causes common cold contains 252 capsomers in its capsid. There are two forms of symmetry in virus capsid. When the capsomers are arranged in 20 triangles, it is called **icosahedral** (polyhedral or spherical). When the capsomers are arranged in a hollow coil that appears rod shaped, it is called **helical.**

Envelope:

A few viruses have an additional lipoprotein **envelope** around the capsid which is derived from the cell surface membrane of the host and also contain virally encoded proteins. The viral envelope is often covered with **glycoprotein spikes** that help them to recognize the host cell.

22. Describe the structure of bacteriophage with diagram.

Ans: Structure of Model Viruses:

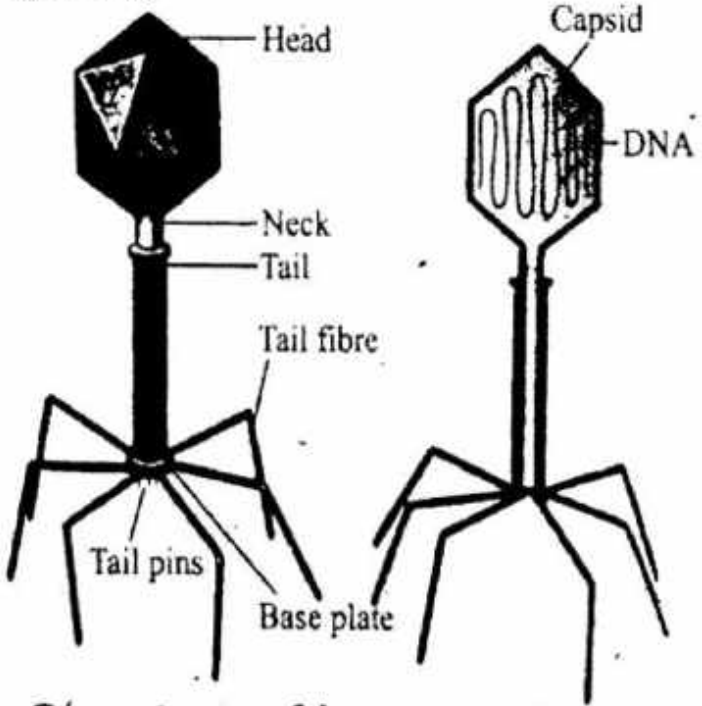
The structure of bacteriophage, flu virus and HIV has been described here to explain the structure of model viruses.

Structure of Bacteriophage:

The bacteriophage or simply phage is the virus that attacks upon bacteria. It is generally a tadpole shaped virus. It consists of head, neck and tail.

Head:

The **head** is icosahedral in shape. The inner core of head consists of a single stranded DNA genome.



Structure of bacteriophage

Narrow Neck or Collar:

Below the head is narrow **neck** or collar which separate head and tail

Tail:

The **tail** is a hollow tube made up of proteins through which the nucleic acid passes during infection. The tail is surrounded by a contractile sheath, which contracts during infection of the bacterium.

Basal Plate:

At the end of the tail a **basal plate** is present which possesses about six tail fibres around it and several tail pins or spikes at its lower surface. The tail fibres and tail pins are involved in the binding of the phage to the bacterial cell.

At the bottom of core tube of tail, an enzyme, the **lysozyme** is present which is released upon contraction of tail. It digests the portion of host cell wall so that core tube can be penetrated into the host cell during infection.

23. Describe the structure of flu virus with diagram.

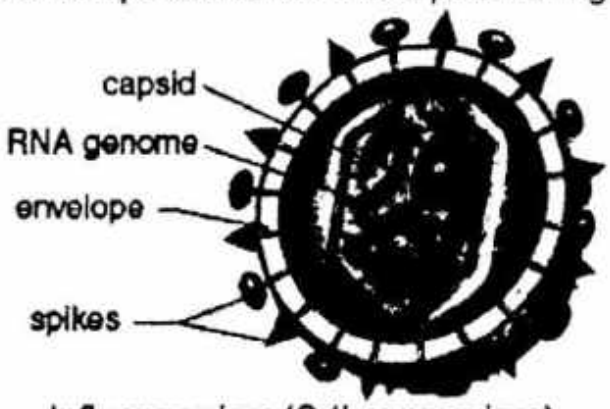
Ans: Structure of Influenza or Flu Virus:

Influenza virus exists in three forms called A, B, C.

Composition of Influenza Virus:

Influenza virus is composed of a segmented single-stranded RNA.

A membranous envelope surrounds the capsid having spikes.



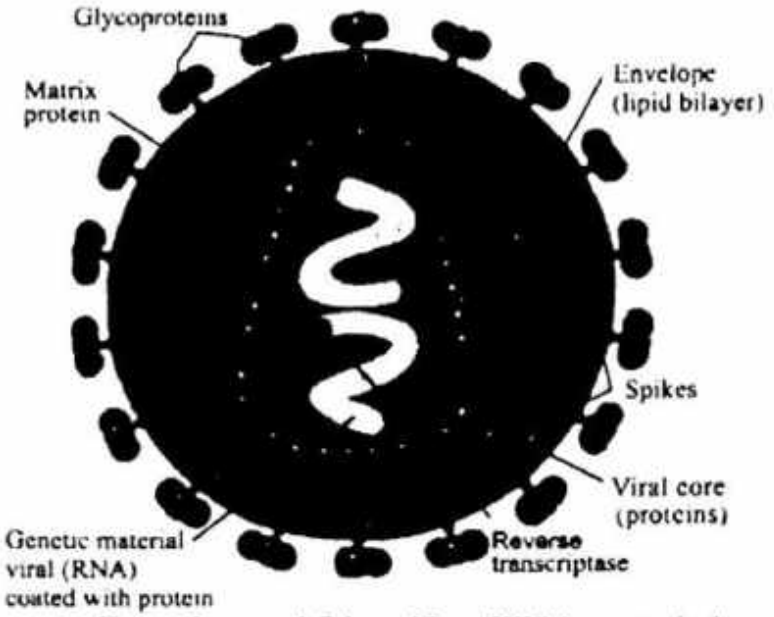
Influenza virus (Orthomyxovirus)

24. Describe the structure of human immunodeficiency virus with diagram.

Ans: Structure of Human Immunodeficiency Virus:

Human Immunodeficiency Virus (HIV) is a **retrovirus.** It is spherical in shape.

The outer covering is a lipoprotein **envelope** which consists of two layers of lipids; different proteins are embedded in the viral envelope, forming **"spikes"** consisting of the outer **glycoprotein (gp) 120** and the **transmembrane gp41.** The lipid membrane is borrowed from the host cell during the budding process (formation of new particles). gp 120 is needed to attach to the host cell, and gp41 is critical for the cell fusion process. Beneath envelope another protein shell is present which is made up of **matrix proteins.** It lies between the envelope and capsid. The HIV capsid is somewhat conical shaped which is composed of capsomers. The viral core contains two single strands of **HIV RNA** and the enzymes needed for HIV replication, such as reverse transcriptase, integrase and protease. The **reverse transcriptase** enzyme is used to convert viral RNA genome into viral DNA genome, integrase enzyme is used to incorporate viral DNA into host DNA while the protease enzyme is used to break large structural proteins into smaller units. These structural proteins are encoded by three out of the nine virus genes.



Human Immunodeficiency Virus (HIV) (cross section)

25. Describe the Lytic and Lysogenic life cycles of a virus.

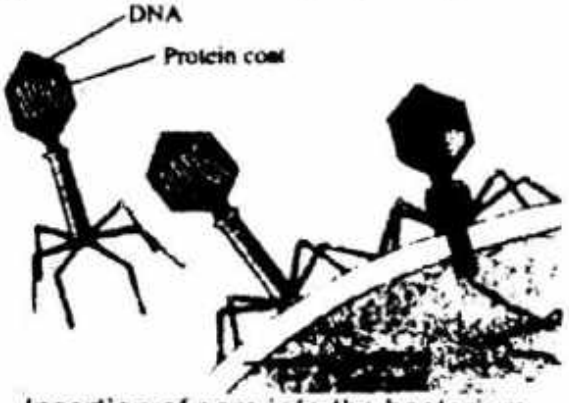
Ans: Life Cycle of a Bacteriophage:

Bacteriophages or phages show two types life cycles i.e., **Lytic cycle** and **Lysogenic cycle.**

Steps of Life Cycle of Bacteriophage:

The life cycle of bacteriophage comprises two main steps i.e., infection process and replication within the host cells.

The initial steps in the infection process such as adsorption, penetration and genome injection are quite similar in both cycles but mode of replication is much different in lytic cycle or lysogenic cycle.



Insertion of core into the bacterium

Infection Process:

The common steps of infection process of bacteriophages to their host are as under:

Adsorption:

The first step in the infection process is the adsorption of the phage to the bacterial cell. This step is mediated by the tail fibres and tail pins/spikes. Phages attach to specific receptors on the bacterial cell.

Penetration:

The binding of the phage to the bacterium results in the contraction of the sheath and release of lysozyme that digest the portion of bacterial envelope; as a result the hollow core tube is pushed through the bacterial envelope. This insertion of core tube is called **penetration.**

Genome injection:

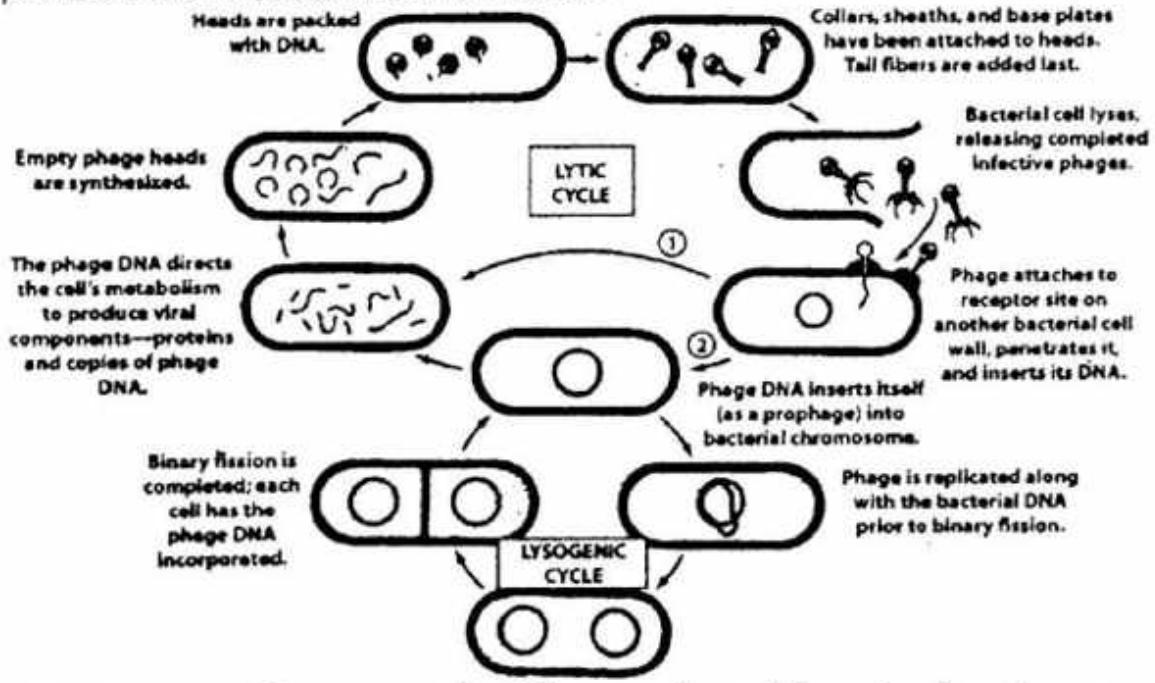
The penetration of core results into the injection of viral DNA in the bacterial cytoplasm whereas, the remainder of the phage remains on the outside of the bacterium.

Replication of Bacteriophage in Lytic Cycle:

Lytic or Virulent Phage:

The bacteriophage that performs lytic cycle is called **lytic** or **virulent phage** because it immediately causes lysis (breakdown) of its host cell after its own multiplication. It develops **Master-Slave relationship** with the host cell because host genomic DNA is immediately disintegrated by the virally encoded DNA digesting enzyme (DNAase). Since viral DNA is already undergone certain chemical modification therefore, such enzymes do not affect it. The disintegration of host DNA enables the viral DNA to takes over the control of the whole metabolic machinery of its host. In lytic cycle the subsequent steps are **synthesis of phage components, assembly, maturation, lysis** and **release.**

Soon after the disintegration of host DNA phage specified mRNAs and proteins are began to produce. Structural proteins (head, tail) that comprise the phage as well as the proteins needed for lysis of the bacterial cell are separately synthesized. Nucleic acid is then packaged inside the head and then tail is added to the head. The assembly of phage components into mature infective phage particle is known as maturation. Within 20 to 25 minutes, approximately 200 phage particles are produced. In lysis and release phase the bacteria begin to lyse due to the accumulation of the phage lysis protein i.e., lysozyme and intracellular phage particles are released into the medium.



Lytic and lysogenic life cycle of bacteriophage

Replication of Bacteriophage in Lysogenic Cycle:

Lysogenic or Temperate Phages:

The bacteriophages that perform lysogenic cycle are called **lysogenic** or **temperate phages.** These phages can either multiply via the lytic cycle or enter a dormant state in the cell. Such phages develop **Host-Guest relationship** because in this case the phage DNA actually integrates into the host chromosome and is replicated along with the host chromosome and passed on to the daughter cells. This integrated state of phage DNA is termed **prophage.** This process is known as **lysogeny** and the bacteria harboring prophage are called **lysogenic bacteria.**

Induction:

The lysogenic state of a bacterium can get terminated anytime when it exposed to adverse conditions. This process is called **induction.**

Conditions that favour the termination of the lysogenic state include:

Desiccation, exposure to UV or ionizing radiation, exposure to mutagenic chemicals, etc. The separated phage DNA then initiates lytic cycle resulting in cell lysis and releases of phages.

Such phages are then capable of infecting new susceptible cells and render them lysogenic.

26. Describe the usage of bacteriophage in genetic engineering.

Ans: Usage of Bacteriophages in Genetic Engineering:

Genetic engineering is the field of biotechnology in which alteration in genetic material of an organism is carried out such as transfer of gene from one organism to another. Several biological tools have been used in genetic engineering to accomplish the required task.

The bacteriophages have also been used in number of ways in different approaches of genetic engineering. Some of them are outlined below:

a) Beside bacterial plasmids the phage DNA has also been used as **vector** in genetic engineering techniques such as development of **genomic library** (a collection of bacteria or bacteriophage clones which contains multiple copies of all the genes of an individual's genome)

b) **Phage therapy** is the application of genetically engineered phages that can kill pathogenic bacteria. Phage therapy has advantages over conventional antibiotic therapy. As phages are fairly narrow in their spectrum of activity, meaning that with phage treatment it is possible to kill bacterial pathogens while avoiding harming of normal bacterial flora, that is, our good bacteria.

c) Bacteriophages have been used for many years as tools for the treatment of bacterial infections but recently a new application in the area of **antibacterial nanomedicines** has been discovered in which bacteriophages can be formulated as targeted drug-delivery vehicles.

27. Explain the life cycle of HIV.

Ans: Life Cycle of Human Immunodeficiency:

Human immunodeficiency virus (HIV) is the causative agent of 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.

Life Cycle of HIV:

The primary hosts of HIV are helper T lymphocytes (CD4 or T4 cells). In addition macrophages and certain brain cells may also be affected.

Following steps are involved in the life cycle of HIV.

(1) The initial step in the life cycle of HIV is adsorption/attachment which is characterized by the binding of the virion glycoprotein 120 envelope proteins to the CD4 proteins (a receptor) on the surface of T4 cells.

(2) 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 single stranded viral RNA in the cytoplasm along with viral enzymes.

(3) The enzyme called **reverse transcriptase** synthesizes a single stranded DNA complementary to virus RNA therefore, called **complementary DNA** (cDNA)

(4) After reverse transcription the viral genomic RNA is disintegrated by the ribonuclease (RNAase) enzyme.

(5) The single stranded cDNA is replicated to form double stranded cDNA.

(6) The double stranded cDNA then integrates into the host cell DNA. Integration is mediated by a virus encoded enzyme integrase.

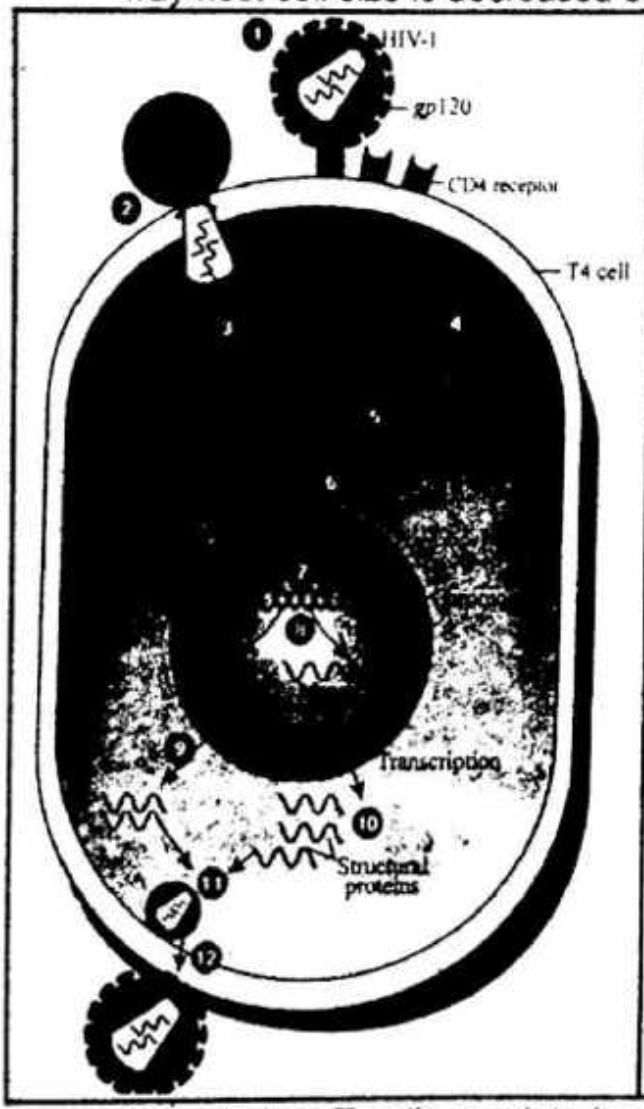
(7) The integrated DNA is now called provirus.

(8 & 9) Viral mRNA is transcribed from the proviral DNA by the host cell RNA polymerase. During transcription not only viral mRNAs for different protein are formed but viral genomic RNA is also produced.

(10) The viral mRNAs are **translated** by host ribosomes into several large proteins, which are then cleaved by the virus-encoded protease to form the virion structural proteins.

(11) The viral components are assembled and nature virions are produced.

(12) Finally, the mature virions are gradually **released by budding off** from the host cell and enclosing a portion of host cell membrane around them. In this way host cell size is decreased enough that it becomes non-functional.



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.

Since, helper T cells regulate immunity by enhancing the response of other immune cells so, the decrease in the number of helper T cells causes deficiency of

the human immune system. The virus affects the human immune system, therefore, the virus has been named Human Immunodeficiency Virus (HIV).

28. Describe the treatments available for AIDS.

Ans: Treatment of AIDS:

The aim of HIV treatment is to reduce the viral load (it is the quantity of virus at which it is detected in an organism) to an undetectable level as long as possible and to reduce transmission by using antiviral drugs. 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 and wishes of the patient.

Antiretroviral Therapy (ART):

HIV is treated using a combination of medicines to fight HIV infection. This is called **antiretroviral therapy** (ART). ART is not a cure, but it can control the virus so that HIV positive person can live a longer, healthier life and reduce the risk of transmitting HIV to others. ART is a highly effective treatment for HIV infection, preventing progression of the disease in the vast majority of recipients. When ART is accessible and started early in the course of infection, the lifespan of HIV-positive people is typically very close to that of comparable HIV-negative people. But ART can have toxicities, is often costly, and requires strict daily pill taking that can lessen quality of life. Because of the limitations of ART, a cure for HIV infection remains a vital goal for research.

29. Describe the causative agent, symptoms, transmission, treatment and prevention of the following diseases:

(a) Hepatitis **(b) Herpes**

(c) Polio **(d) Cotton leaf curl disease**

Ans: (a) Hepatitis:

Hepatitis is generally characterized as inflammation of liver including other symptoms.

Cause:

It is generally caused by viral infection or rarely due to toxicity of drugs and certain other causes. It may present in acute (recent infection, relatively rapid onset) or chronic (slowly progressing) forms.

The most common causes of viral hepatitis are the five unrelated hepatotropic (that replicate in liver cells) viruses i.e., Hepatitis A, Hepatitis B, Hepatitis C, Hepatitis D, and Hepatitis E.

i. Hepatitis "A":

Cause:

Hepatitis A (also called infectious hepatitis) is caused by HAV (Picornavirus).

Transmission:

HAV is transmitted by the fecal-oral route.

Symptoms:

The typical symptoms are fever, anorexia, nausea, vomiting and jaundice. Dark urine, pale feces are also seen. Treatment No antiviral therapy is available

Prevention:

Active immunization with a vaccine containing inactivated HAV is available. Observation of proper hygiene

ii. Hepatitis "B":

Cause:

Hepatitis B (also called serum hepatitis) is caused by HBV (Hepadnavirus).

Symptoms:

It is similar lot hepatitis A

Transmission:

The three main modes of transmission are via Mood, sexual contact and prenatally from mother to newborn.

Treatment: Alpha interferon is effective against HBV.

Prevention: Vaccine is highly effective in preventing.

iii. Hepatitis "C":

Cause: Hepatitis C is caused by Hepatitis C virus (Flavivirus).

Transmission: It is only transmitted by blood.

Symptoms: Symptoms are just lice hepatitis B.

Treatment:

A combination of alpha interferon and ribavirin is the treatment choice for chronic hepatitis C.

Prevention:

No. Vaccine is available. Blood transfusion should be screened as preventive measure.

iv. Hepatitis "D":

Cause:

The only human disease known to be caused by a viroid is hepatitis D.

Transmission:

The hepatitis D viroid can only enter a human liver cell if it is enclosed in a capsid that contains a binding protein. It obtains this from the hepatitis B virus. The viroid then enters the blood stream and can be transmitted via blood or serum transfusions.

Symptoms: As in hepatitis B but more severe.

Treatment and Prevention: Same as HBV.

v. Hepatitis "E":

Cause: It is caused by HEV.

Transmission: Like HAV, it is also transmitted by the fecal-oral route.

Treatment and Prevention:

There is no antiviral treatment and vaccine.

Observation of proper hygiene.

(b) Herpes:

Herpes Simplex:

Herpes simplex is a superficial viral infection characterized by one or more painful, fluid-filled sores or blisters (an elevation of the skin) appear on the skin or epithelium of outer openings of the body.

Tingling, itching, or burning may be felt on the skin before the blisters appear. Blisters break open and often ooze fluid and form a crust, before healing. The sores can last from 7 to 10 days. Where the sores appear often varies with type.

Types of Herpes:

There are two primary types of herpes i.e., oral herpes and genital herpes.

i. Oral Herpes:

Cause:

It is caused by herpes simplex virus type-1.

Transmission:

HSV Type-1, is transmitted primarily through oral secretions (saliva) or physical contact with sores on the skin. It can also be spread by sharing objects such as toothbrushes or eating utensils. .

Symptoms:

Most blisters appear on the lips or around the mouth. Sometimes blisters form on the face or on the tongue.

Treatment: Antiviral drugs are used to treat herpes.

Prevention: Avoid contact with affected area of the patient.

ii. Genital Herpes:

Cause: It is caused by herpes simplex virus type-2.

Transmission:

In general, a person can only get HSV type 2 infection during sexual contact with someone who has a genital HSV-2 infection.

Symptoms:

In genital herpes the sores typically occur on the penis, vagina, buttocks, or anus.

Treatment: Antiviral drugs are used to treat Herpes.

Prevention: Avoid contact with affected area of the patient.

(c) Polio:

Poliomyelitis

Cause: It is caused by polio virus which is also an enterovirus.

Transmission: Polio virus is transmitted by the fecal oral route.

Symptoms:

It replicates in the oropharynx and intestinal tract and spread to blood and central nervous system where virus replicates in the motor. Death of these cells results in paralysis of the muscles innervated by neuron located in the spinal cord. 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 (weakened) vaccine (sabin vaccine, oral vaccine).

(d) Cotton Leaf Curl Disease:

Cotton leaf curl disease (CLCuD) is a serious disease of cotton.

Cause:

The viruses associated with the CLCuD complex on the Indian subcontinent, five of which have been identified as begomoviruses.

Transmission:

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

Symptoms:

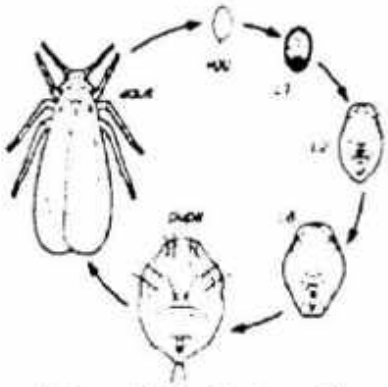
The symptoms are initially characterized by a deep downward cupping of the youngest leaves. This is followed by development of cup-shaped, leaf-like structures.

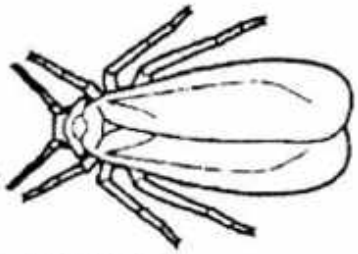
Treatment and Prevention:

Control of CLCuD is mainly based on insecticide treatments against the insect vector *(Bemisia tabaci)*.



Cotton leaf curl disease





Bemisia tabaci

Table: Losses due to cotton leaf curl disease, in Punjab, Pakistan

Year	Affected Area (000 ha)			Loss in Production (000 balse)	Loss in Pak Rupees (million)
	Partial	Complete	Total		
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
2009-10	1693.5	43.39	1956.62	1840.1	44160
2010-11	1341.8	28.33	1370.12	1164.90	48457
2011-12	569.6	0.00	569.60	482.20	11815

Production loss in bales calculated on the survey reports conducted by the PWQC, Punjab. Economic loss estimated on the basis of annual average lint prices at Multan Market Committee Courtesy: Mr. Tariq Mehmood, Director, CCRI, Multan.