VIRUSES

- These are simple acellular ultramicroscopic obligate parasites made of nucleic acids and protein.
- Absence of metabolic system, motility, fail to respond to external stimuli, absence of protoplasm and fail to grow outside the host are the **non-living characters** of Viruses.
- Ability to maintain genetic continuity, undergoing mutations, able to reproduce in the host, presence of protein and nucleic acids are the **living characters** of Viruses.
- Genetic engineering is mainly based on the discoveries made in Virology.
- They are described as connecting links of living and non – living organisms.

History

- **Edward Jenner** discovered vaccine for small pox without knowing the nature of the causal agent.
- **Louis Pasteur** developed Rabies vaccine.
- **Iwanowski** discovered virus. He demonstrated the causal agent of Mosaic disease in tobacco as organisms smaller than bacteria.
- **Beijerinck** described Virus as Contagium Vivum Fluidum or Living infectious Fluid.
- **W. M. Stanley** crystallised TMV.
- **Pierie** and **Bawden** established the chemical nature of viruses as Nucleoproteins.
- **Gierer** and **Schramm** proved the real nature of nucleic acid as infectious agent and genetic material.
- **Fraenkel** – **Conrat** confirmed the genetic material of TMV as RNA.
- Ultracentrifugation, X – ray crystallography and Electron microscopy techniques are used in the discovery of Viruses.

Types of Viruses

- Viruses are host specific and obligate intracellular parasites.
- **Phytophages** are parasitic in plants. They have RNA as genetic material some have DNA. e.g. Cauliflower Mosaic Virus and Dahlia Mosaic Virus.
- **Zoophages** are parasitic on animals. They have DNA as genetic material. RNA is seen in Polio virus, Influenza virus and AIDS virus.
- **Bacteriophages** are parasitic in Bacteria. They usually have DNA. Some have RNA. e.g. f_2 bacteriophage and ϕ 6 bacteriophage.
- **Mycophages** are parasitic on Fungi and have Double stranded RNA as genetic material.
- **Zymophages** are parasitic in Yeasts and have dsDNA
- **Cyanophages** are parasitic in Blue Green Algae and have dsDNA.

Structure of Viruses

- Viruses not only show variation in their external morphology but also in their internal chemical structure.

Size:

- A particle of virus is known as Virion.
- The usual size of virus ranges from **10 – 300** nm.
- The smallest virus is **Bacteriophage** f_2 and the largest is **Vaccinia virus**.
- Vaccinia virus is viewed under compound microscope.
- Most of the viruses are clearly seen under Scanning and Transmission Electron Microscopes.

Shape:

- Shape is determined under **low power** of Electron microscope.
- **TMV** is rod shaped, **Vaccinia virus** is rectangular, **Adenovirus** is Polyhedral, **Polio virus** is spherical, **Bacteriophage** is tadpole shaped and **Rhabdo virus** is Bullet shaped.

Symmetry:

- It is dependent on the mode of arrangement of **capsomers** in the Capsid. It is of three types.
- In helical symmetry the capsomers arranged systematically in the form of helix that resembles a staircase around the core of nucleic acid. e.g. TMV
- In cubical symmetry the capsid is **polyhedral** in shape and the capsomers are arranged in icosahedron symmetry. In icosahedron there are **20 equilateral** triangular faces. e. g. **Adenovirus**
- Complex symmetry or Binal symmetry shows both helical and icosahedron symmetries.
  e.g. **Bacteriophages**.

Chemical Structure:

- Chemically viruses are **Nucleocapsids**.
- Viral protein coat is called as **Capsid**. It protects the nucleic acid and also helps in its transfer between host cells.
- The units of capsid are called as **Capsomers** or **Protomers**.
- The nucleic acid is either **DNA** or **RNA**.

- Most of the plant viruses have RNA. Some have DNA e.g. **Cauliflower Mosaic Virus** and **Dahlia Mosaic Virus**.
- Most of the animal viruses have DNA. Some have RNA e.g. **Polio virus, Influenza virus, Oncoviruses** and AIDS virus.
- Single stranded DNA is present in **ϕ × 174, M 13** bacteriophage.
- Double stranded RNA is present in Wound Tumour Virus, **Maize rough dwarf virus**, **Rice dwarf virus**, **Reovirus, Blue tongue virus, Bacteriophage ϕ6.**
- Infectious nucleic acids are known as **Viroids**. They do not have capsid. They cause disease in plants e.g. Potato spindle tuber virus and Citrus exocortosis virus.
- Infectious proteins are called as **Prions**. They cause disease in animals e.g. Scrapie disease in sheep and Mad cow disease in Cows.

Structure of Tobacco Mosaic Virus (TMV)

- It is the most extensively studied plant virus that represents the structure of a typical plant virus.
- It was first crystallised by **Stanley**.
- Electron microscopic, biochemical and X-ray crystallographic studies helped for the study of TMV.
- **Franklin Conrat** and **Williams** described the structure of TMV.
- It is a rod shaped virus with helical symmetry.
- It is **300 nm** in length and **18 to 19 nm** in diameter. Molecular weight is **39 × 10^6** daltons.
- Its capsid has **2130** helically arranged capsomers around the central hole of 4 nm.
- Each capsomer has a polypeptide chain made of **158** amino acids.
- A linear spirally coiled single stranded RNA with **6,500** nucleotides is present interior to capsid.
- TMV is transmitted through the cell sap of infected to host and enters into a new host through wounds.
- The mechanical means such as rubbing, transplanting and handling, wind, water and vectors are also involved in its transmission.

Structure of Bacteriophage

- Viruses that attack bacteria are called as **Bacteriophages**.
- They were discovered by **Twort** and studied in detail by **Felix d' Herelle**.
- They are tadpole shaped with a large head and a tail. Among them T-even phages (**T_2, T_4 etc**.) are most common.
- T-even phages consist of two main parts known as **head and tail**.
- Head is **65 × 95** nm in size. It is hexagonal in cross section and capped by hexagonal pyramid.
- Head has several capsomers with each capsomer having **80,000 daltons** molecular weight.
- Head protein is **semipermeable membrane** and encloses a folded double stranded DNA. It is 1000 times longer than the Phage itself.
- The DNA of T-even phages contains **5 – hydroxy methyl cytosine** in place of cytosine.
- Core of tail is **95 nm** length and **8 nm** in diameter. It is extended from head to the tail plate at the base.
- Surrounding the core is the tail sheath, composed of about 144 sub-units.
- The subunits are arranged in 24 rings each containing 6 subunits.
- A ring like **Collar** is present around the tail core between tail sheath and head. Its function is not known.
- Tail is sealed by a hexagonal base plate or end plate.
- Each corner of **base plate** has a **tail pin** and **jointed tail fibre**. Hence there are a total of six tail fibres and six tail pins.
- **Each fibre** has two parts known as proximal half and distal half. These are useful in recognising the specific binding sites on the Bacterial cell wall at the time of viral replication.

Replication of Viruses

- It is best studied in **Bacteriophages**. Viral replication is also referred as viral multiplication.
- All bacteriophages exist as Vegetative phages for some time in the bacterial cell.
- Those bacteriophages in which the DNA of bacteriophage is incorporated into the bacterial DNA are called as **Temperate Phages**. Its DNA is called as **Prophage**.
- Bacteriophages whose DNA can not be integrated with the DNA of host are called as **Lytic phages** or **Virulent phages**.
- The multiplication process of virulent phages is called as Lytic cycle and that of temperate phages as Lysogenic cycle.

1. The Lytic or Growth cycle

- **Delbruck's** one-step growth experiments helped us to understand the viral growth cycle.
- Since there is lysis of bacterial cell at the end of virulent phages replication, it is known as lytic cycle.
- It is shown by T-even phages. It has four phases known as Adsorption, Penetration, Latent period and Lysis.

i. Adsorption

- It is attachment of viral particle with its tail fibres to the host cell.
- In this collisions occur between bacterial cells and viral particles.
- At specific sites of bacterial cells the viruses adher with the help of tail fibres.

ii. Penetration

- The enzyme lysozyme of viral tail dissolves the bacterial cell wall and establishes a passage.
- Viral tail sheath shows contraction and the viral nucleic acid is incorporated into the host cell. This is known as **penetration**.
- The protein coat of the virus remains outside the bacterial cell. It is known as **Ghost**.
- The host DNA is degraded and the cell is forced to synthesize viral constituents by following the orders from viral DNA.

iii. Latent period

- It has 2 sub-stages known as **Eclipse period** and **Maturation period**.
- The first half of latent period is known as **Eclipse period**. In this the virions are not detectable and the genome is concealed. Host cell does not contain the complete infective virions.
- The second half of this period in which new phages are formed is called as **maturation period**.
- During this, the viral proteins are synthesized first and later the viral DNA.
- Different protein parts of virus such as tail, tail plate, tail fibres, tail pins, head and collar are synthesised separately. These and the viral DNA are assembled to form Viral particles.

iv. Lysis

- It is the physiological breakage of bacterial cell wall due to the action of lysozyme to liberate the viral particles.
- The average number of viral particles required for the breakage of bacterial cell wall is called as **Burst size**.

2. Lysogenic cycle

- It is shown by temperate phages such as λ **Coliphages.** These phages infect the bacterial cells and introduce the DNA like in lytic phages.
- The DNA is integrated into the bacterial DNA and replicated along with bacterial DNA in successive generations of Bacteria.
- The viral DNA does not destroy the bacterial DNA.

Transduction

- Sometimes during viral reproduction errors occur. In such cases, the bacterial DNA pieces are incorporated into the viral capsids.
- Phages with bacterial and Viral DNA are released and infect the fresh bacteria.
- The bacterial DNA carried by the viruses is placed in the new bacterium.
- This DNA brought by the virus is integrated with fresh bacterial DNA.
- In this way DNA of bacterium is transferred to another bacterium by bacteriophages. Such phenomenon is known as **transduction**.
- It is seen in both lytic and lysogenic cycle.

Only 2 or 3 in one million phages take part in transduction

Viral diseases of Plants

- Viruses affect the whole plant. Hence viral plant diseases are called as **systemic** diseases.
- Usually **leaves** show the characteristic symptoms. The overall effect on plant is reduction in growth, vigour and yield of the plant. Some of the viral diseases of plants are as follows.

i. **Chlorosis**: it is yellowing or whitening of entire leaf due to degradation of chlorophyll.
e.g. **Rice yellowing**.

ii. **Mosaic**: it is yellowing or whitening of leaf as isolated patches in the lamina. e.g. **Tobacco Mosaic disease**.

iii. **Vein clearing**: The tissues of the veins become yellow coloured and the remaining region remains as green. e.g. **Bhendi vein clearing.**

iv. **Vein banding**: The leaf tissues except at the veins become yellow coloured.
e.g. **Citrus vein banding**.

v. **Ring spots**: Chlorophyll of lamina is degraded in the form of circular spots.
e.g. **Tomato spotted wilt**.

vi. **Dwarfing or Stunting**: It is reduction in the growth of plant parts. e.g. **Rice stunting**

vii. **Malformation**: It is abnormal growth of plant or plant parts. e.g. **Swollen shoot of Coco**

viii. **Floral Breaking**: It is loss of colour at some places and formation of dark colours at some other places. e.g. **Tulip Mosaic Break**

Transmission of Viral diseases

- This varies according to the **host** and **virus** types. Very few viruses are transmitted freely through air, water and contact. Majority of them transmitted by the following methods.

i. **Vegetative parts**: it is transmission of viruses through buds, stem cuttings and some by grafting methods in crops like potato, sugarcane, banana, rose etc.

ii. **Mechanical transmission**: In this the sap of viral infected plants is transmitted through physical contact, agricultural implements and hands of labourers. e.g. **Potato virus**

iii. **Seed transmission**: About more than 50 plant viruses are transmitted through seeds. e.g. **Bean mosaic**, **Lettuce mosaic** etc.

iv. **Pollen grains**: Pollen grains of infected plant have viruses and these pollen grains when deposited on the stigmas of uninfected plant, transmit the virus. e.g. **Cherry ring spot**.

v. **Insects**: Majority of plant viruses are transmitted through insects. These insects are called as vectors. The vectors are usually **Mosquitoes**, **Aphids**, **Thrips**, **White flies** etc. e.g. Rice tungro, Potato leaf roll, Papaya mosaic

Nematodes: Soil borne viral diseases are transmitted through nematodes such as *Xephenema* and *Longidorus.*

vii. **Fungi**: Some fungi transmit soil borne viruses. e.g. Zoospores of *Olphidium brassicae* transmit **T**obacco **N**ecrosis **V**irus.

vii. **Phanerogamic parasites**: Among these plants, *Cuscuta* is known to transmit the virus through its haustoria.

viii. **Body fluids**: Some animal viruses are transmitted through body fluids. AIDS caused by HIV is transmitted through blood, semen etc.

Control of Viral diseases

The following methods are followed to control viral diseases.

i. **Exclusion of the source of infection**: This is preventing the entry of viral inoculum into the new area from its existing area by strict enforcement of quarantine laws.

ii. **Isolation of the source of infection**: It is destroying the viral infected plants or their parts soon after their identification in the field by burning. Wild plants that serve as hosts are also eradicated by this method.

iii. **Immunization**: It is making the host resistant to diseases by vaccination. It is applicable to only vertebrate diseases such as Polio.

iv. **Eradication of Vector**: Since many viruses transmitted through insect vectors, their eradication by using Insecticides is effective in controlling viral diseases.

v. **Chemotherapy**: Chemicals with virus inhibiting properties such as **Cytovirin – 2, Thiouracil, 2,4 – D, Zinc sulphate** and **Malachite Green** are used to control viral diseases.

vi. **Breeding of disease resistant varieties**: It is the most effective method to control viral diseases. In resistant varieties, the host system is immune to the virus infection.