STRUCTURE OF VIRIONS WITH SPECIAL REFERENCE TO TMV & T_4 PHAGES

The intact virus that are infectious particle is called the virion. Each virion consists of a nucleic acid core (DNA or RNA) surrounded by a protein coat (capsid) to form the nucleocapsid. The capsid is made up of a number of subunits called capsomeres. The nucleocapsid may be naked or may be surrounded by a loose membranous envelope. Enveloped virus particles are called lipoviruses.

Viruses occur in following three shapes :-

a) **Icosahedral** : It is a regular polyhedron with 20 triangular faces and 12 corners, and so some viruses or virions resemble an icosahedron. Such viruses may have naked capsids (e.g. Poliovirus) or the capsids may be covered by envelopes (e.g. herpes simplex virus).

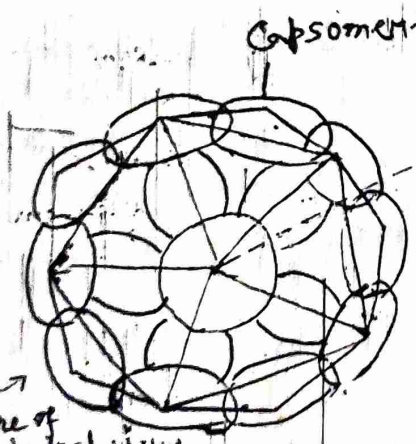


Fig. : Structure of a icosahedral virus

b) **Helical** : This resembles a long rod. The capsid is a hollow cylinder with a helical structure. Helical capsids also may be naked (e.g. TMV) or surrounded by an envelope (e.g. the influenza virus).

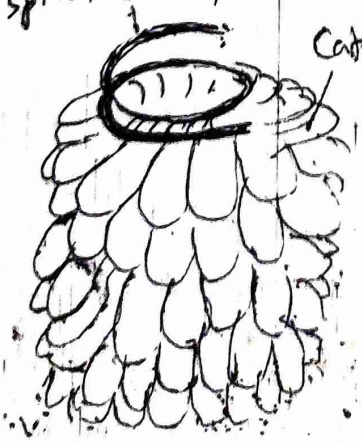
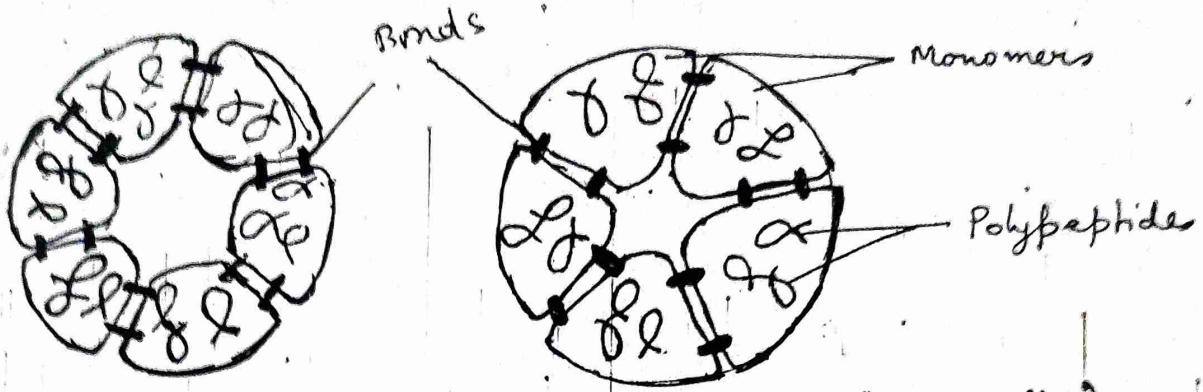


Fig. : Structure of a helical virus (TMV)

c) **Complex** : Some viruses are complicated in structure with an admixture of the helical and icosahedron in shape. Complex viruses are divided into two groups those without identifiable capsid (e.g. the vaccinia

THE CAPSID:

The capsomeres present in the capsid are similar or occasionally dissimilar. The electron micrographs have revealed that the capsomeres are spherical or grape-like in shape. Each capsomere is composed of few monomers. Each monomer is



made up of one or more polypeptide chains. Capsomeres are of two types – pentameres and hexameres. Pentameres consists of 5 monomers and hexamere consists of 6 monomers. The monomers are held together by bonds. The capsomeres are also held together by bonds, but these bonds were found to be weaker than the bonds between the monomers.

THE ENVELOPE:

The envelope is 10–18 nm thick. It is made up of lipoproteins. Sometimes the envelope is covered with projections, called spikes.

In addition to nuklic acid, protein and lipid, certain complex viruses contain carbohydrates, traces of metals, vitamins, enzymes (transcriptases) and co-enzymes.

TOBACCO MOSAIC VIRUS (TMV):

1 turn = 10 Å

300 nm = 3000 Å

TMV is a rod-shaped (rigid rod) helical virus about 300 nm long and 15-18 nm in diam., weighing 39×10^6 daltons. The virus consists of a protein tube with a lumen of ~~40 Å diam~~ ~~4 nm~~ 20 Å diam. enclosing a RNA. The tube is made up of ~~a number of~~ 2130 identical protein subunits (capsomeres) arranged in a helical manner. Each subunit has a molecular weight of 17,500 daltons. It is made up of a single polypeptide chain consisting of 158 amino acid residues arranged in definite sequence.

Fig: Diagrammatic representation of ~~TMV~~ tobacco mosaic virus

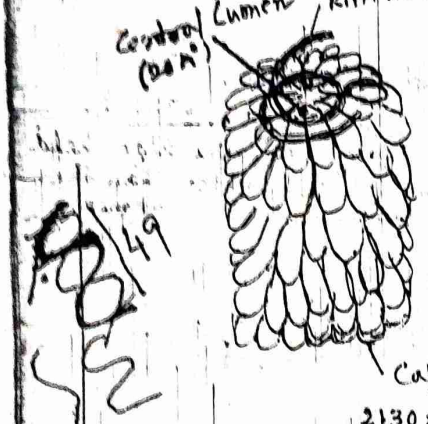


Fig: A part of tobacco mosaic virus showing protein subunits tagged on RNA helix.

The RNA is a single-stranded molecule coiled into a helix 80 Å in diameter. It follows the pitch of the protein helix. Each turn of the RNA helix contains about 49 nucleotides; and has a pitch of 23 Å. There are 49 protein subunits associated with three turns of RNA helix, i.e. 16⅓ protein subunits per turn of the helix. Thus, each protein subunit is associated with three nucleotide residues of RNA. The total nucleotides in RNA is 6400. The molecular weight of RNA ~~of TMV-RNA~~ is 2.06×10^6 daltons.

However, the RNA molecule is not located in the central lumen of protein tube. Rather it is deeply embedded amongst the successive protein subunit rings. It has been observed that the nucleotide of the TMV virus begins with the insertion of a hairpin loop of RNA is to the central lumen of the protein coat. Then the loop intercalates between the rings of subunits where the RNA strand becomes trapped. The helical structure of virus [illegible] of RNA and protein subunits are also [illegible].

6400 / 49 | 6400 | 130

T4 Bacterio-Phage

The T4 bacteriophage, which infects E. coli bacterium, is tadpole shaped, with head and tail regions. The tail regions consist of four sub-structures — the head-tail connector, tail sheath, tail base plate, and tail fibres. Structurally, the bacteriophage shows a combination of icosahedral symmetry and helical symmetry (binal symmetry).

The head :- The head capsid has the form of a prolate icosahedron. (The str. has been described as an elongated, by pyramidal, hexagonal prism, etc.) It consists of two ten-faceted equatorial bands with a pyramidal vertex at either end. It is about 95 nm long and 65 nm wide. The head contains DNA, associated cations, several peptides, and three internal proteins. The head capsid is made up of about 2000 similar subunits of protein (capsomeres).

The DNA is linear, double-stranded, terminally redundant & circularly permuted. It is packed inside the head like a ball of yarn. It is about 500 μm long and has a molecular weight of 120×10^6 daltons. It contains 5-hydroxy methyl cytosine (HMC) instead of cytosine.

Head tail Connector :- It has a collar with attached whiskers. The tail fibers are kept folded around the tail, their mid points being held by the whiskers.

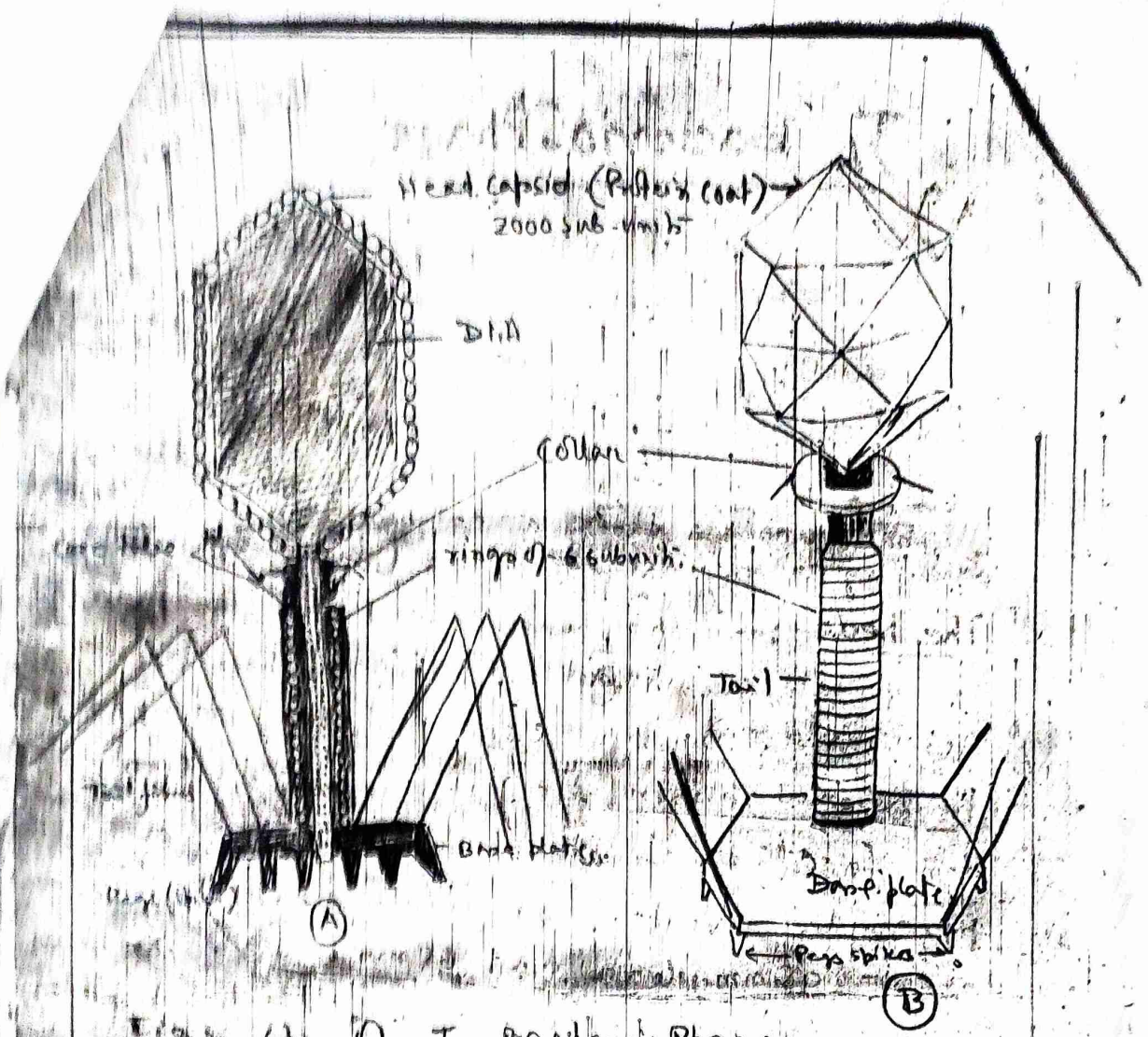


Fig:- Structure of T4 Bacteriophage.

(B) **The Tail** :- The tail consist of an inner core or tube of about 8nm diameter, through which DNA passes out, surrounded by a contractile protein tail sheath. The tail is about 80 nm. long and 18 nm. in diameter. The tail sheath consists of 144 subunits arranged in 24 rings of 6 subunits each. It is connected to the collar at upper end and to the base plate at the lower end. The inner core or tube possesses an axial hole of 2.5nm diameter.

(C) **The base plate** :- The baseplate is hexagonal and has a tail pin or spike at each

In ssRNA viruses, the RNA strand may be "plus" or "infections" (e.g. Picornaviruses, togaviruses, retroviruses) or "minus" & non-infections (e.g. rhabdoviruses, paramyxoviruses, etc.). Plus ssRNA directly acts as mRNA and translates protein on the ribosomes. Hence it is infectious. Minus ssRNA first transcribes a complementary mRNA strand which has opposite polarity. This mRNA then translates protein. The minus strand is, therefore, noninfectious.

Usually the viral nucleic acids contain normal nucleotides similar to the nucleotides of host cells (i.e. A, G, T/U & C). But some nucleic acids of some viruses contain modified nucleotides that are not normal components of host cells. Unusual nucleotides found phage DNA include 5-hydroxymethylcytosine, which replaces cytosine in T-even phages; 5-hydroxymethyluracil which replaces thymine in SP8 phage; 2-amino-purine, which replaces Adenine in S2L phage, etc.