RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Plant Virology **MSPP-102**

Lecture 1

Composition and structure of viruses

Morphology

Plant viruses come in different shapes and sizes. Nearly half of them are elongate (rigid rods or flexuous threads), and almost as many are spherical (isometric or polyhedral), with the remaining being cylindrical bacillus-like rods.

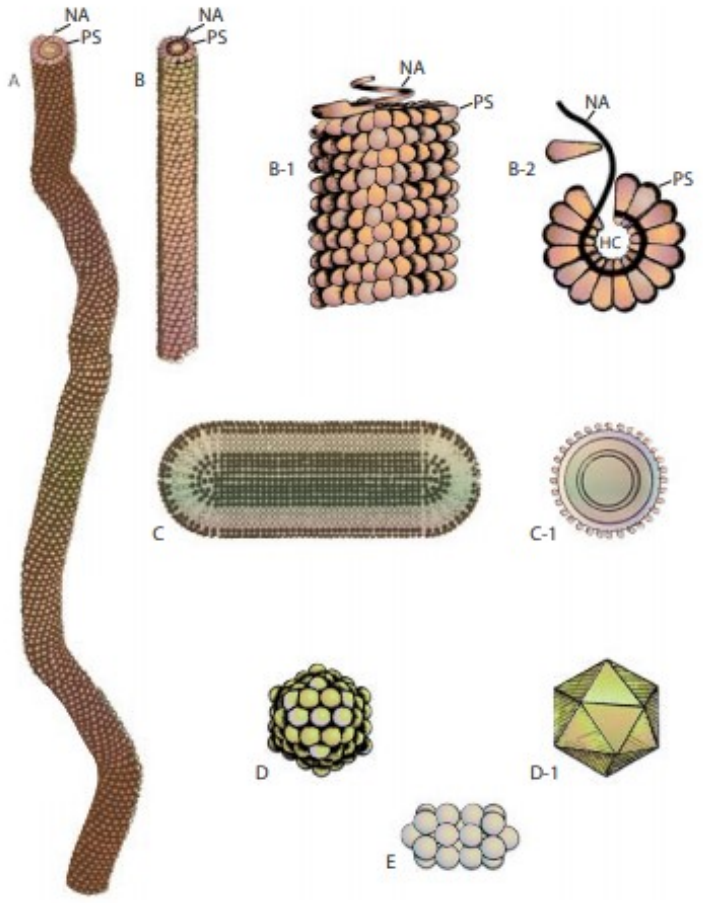


Figure: Relative shapes, sizes, and structures of some representative plant viruses. (A) Flexuous thread-like virus. (B) Rigid rod-shaped virus. (B-1) Side arrangement of protein subunits (PS) and nucleic acid (NA) in viruses A and B. (B-2) Cross-section view of the same viruses. HC, hollow core. (C) Short, bacillus-like virus. (C-1) Cross-section view of such a virus. (D)

Isometric polyhedral virus. (D-1) Icosahedron representing the 20-sided symmetry of the protein subunits of the isometric virus. (E) Geminivirus consisting of twin particles.

- Some elongated viruses are rigid rods about 15 by 300 nanometers, but most appear as long, thin, flexible threads that are usually 10 to 13 nanometers wide and range in length from 480 to 2,000 nanometers.
- Rhabdoviruses are short, bacilluslike, cylindrical rods, approximately three to five times as long as they are wide (52–75 by 300– 380nm).
- Most spherical viruses are actually polyhedral, ranging in diameter from about 17 nanometers (tobacco necrosis satellite virus) to 60 nanometers (wound tumor virus).
- Tomato spotted wilt virus is surrounded by a membrane and has a flexible, spherical shape about 100 nanometers in diameter. Many plant viruses have split genomes, i.e., they consist of two or more distinct nucleic acid strands encapsidated in different-sized particles made of the same protein subunits. Thus, some, like tobacco rattle virus, consist of two rods, a long one (195 by 25nm) and a shorter one (43 by 25nm), whereas others, like alfalfa mosaic virus, consist of four components of different sizes.
- Also, many isometric viruses have two or three different components of the same size but containing nucleic acid strands of different lengths. In multicomponent viruses, all of the nucleic acid strand components must be present in the plant for the virus to multiply and perform in its usual manner.
- The surface of viruses consists of a definite number of protein subunits, which are arranged spirally in the elongated viruses and packed on the sides of the polyhedral particles of the spherical viruses
- In cross section, the elongated viruses appear as hollow tubes with the protein subunits forming the outer coat and the nucleic acid, also arranged spirally, embedded between the inner ends of two successive spirals of the protein subunits. In spherical viruses the visible shell.

Composition and Structure

Chemical composition of plant viruses

Protein(Capsid)

Capsomere

Nucleic acids

RNA	DNA
+ve strand RNA	
-ve strand RNAλ	
ssRNA	ssDNA
dsRNA	dsDNA

Each plant virus consists of at least a nucleic acid and a protein. Some viruses consist of more than one size of nucleic acid and proteins, and some of them contain enzymes or membrane lipids.

The nucleic acid makes up 5 to 40% of the virus, protein making up the remaining 60 to 95%.

The lower nucleic acid percentages are found in the elongated viruses, whereas the spherical viruses contain higher percentages of nucleic acid.

The total mass of the nucleoprotein of different virus particles varies from 4.6 to 73 million daltons. The weight of the nucleic acid alone, however, ranges only between 1 and 3 million ($1–3 \times 10^6$) daltons per virus particle for most viruses, although some have up to 6×10^6 daltons and the 12 component wound tumor virus nucleic acid is approximately 16×10^6 daltons. All viral nucleic acid sizes are quite small when compared to 0.5×10^9 daltons for mollicutes and 1.5×10^9 daltons for bacteria.

A/a composition of capsid proteins of some viruses

1. Alanine CMV: 17; PVY: 16 TMV: 14; PVX: 76	**6. Glutamine** CMV: 20; PVY: 23 TMV: 16; PVX: 33	**11. Leucine** CMV: 26; PVY: 10 TMV: 12; PVX: 19	**16. Serine** CMV: 32; PVY: 10 TMV: 16; PVX: 31
2. Arginine CMV: 24; PVY: 11 TMV: 11; PVX: 18	**7. Glutamic acid**	**12. Lysine** CMV: 18; PVY: 13 TMV: 2; PVX: 22	**17. Tryptophane** CMV: 1 ; PVY: 2 TMV: 3; PVX: 9
3. Asparatic acid CMV: 30; PVY: 22 TMV: 18; PVX: 42	**8. Glycine** CMV: 16; PVY: 13 TMV: 6 ; PVX: 23	**13. Methionine** CMV: 8; PVY: 8 TMV: 0 ; PVX: 15	**18. Tyrosine** CMV: 11; PVY: 6 TMV: 4; PVX: 4
4. Asparagines	**9. histidine** CMV: 4; PVY: 4 TMV: - ; PVX: 4	**14. Phenylalanine** CMV: 7 ; PVY: 5 TMV: 8; PVX: 22	**19. Threonine** CMV: 17; PVY: 13 TMV: 16; PVX: 58
5. Cystein **CMV: 0; PVY: 1** **TMV: 1; PVX: 5**	**10. Isoleucine** CMV: 16; PVY: 12 TMV: 9 ; PVX: 21	**15. Proline** CMV: 18; PVY: 11 TMV: 8 ; PVX: 34	**20. Valine** CMV: 22; PVY: 13 TMV: 14; PVX: 27
Total CMV: 287	PVY: 203	TMV: 158	PVX: 463

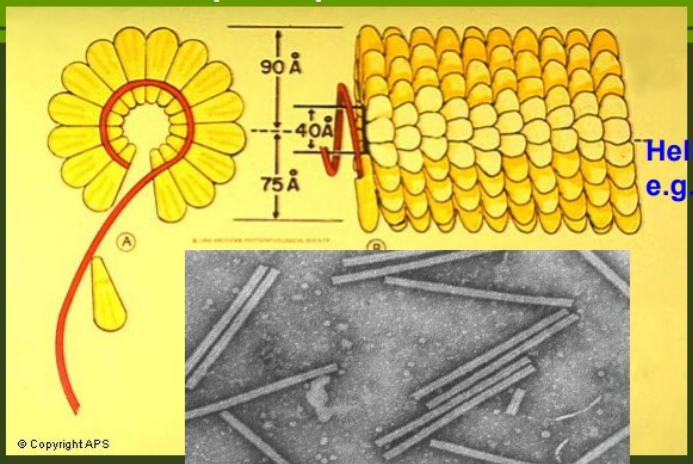
%age of protein & n/a in some viruses

%age of protein & n/a in some viruses		
Virus	**n/a (%)**	**Protein (%)**
TMV	5	95
PVX	6	94
PVY	5	95
CpMV	31-33	67-69
CMV	18	82
TRSV	40	60

TMV architecture

- **Negatively stained particles revealed that :**
  - One end of the rod can be seen as concave
  - The other end is convex
  - 3'end of the RNA is at the convex end & 5' at concave end (Wilson wt al. 1976; Butler et al., 1977)
  - A central canal with a radius of ~2nm becomes filled with stain in –vely stained preparations
- **Short Rods:** of variable length & <300nm, causes problem of end to end aggregation etc.

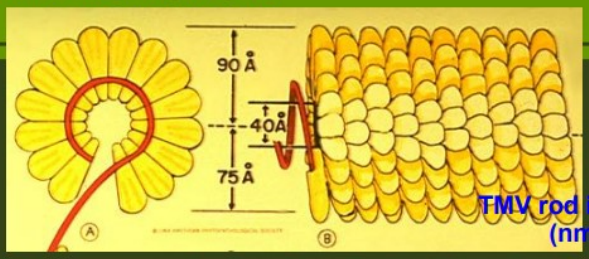
Rod shaped particles



Helix (rod)
e.g., TMV

TMV rod is 18 nanometers (nm) X 300 nm

PARTICLE STRUCTURE



TMV rod is 18 nanometers (nm) X 300 nm

- Tobacco mosaic virus is typical, well-studied example
- Each particle contains only a single molecule of RNA (6395 nt) and 2130 copies of the coat protein subunit (158 aa; 17.3 kDa)
  - 3 nt/subunit
  - 16.33 subunits/turn
  - 49 subunits/3 turns
- TMV protein subunits + nucleic acid will self-assemble *in vitro* in an energy-independent fashion
- Self-assembly also occurs in the absence of RNA