

## Tobacco Mosaic Virus (TMV)

**Tobacco mosaic virus** (TMV) is a single stranded [RNA virus](#) that infects plants, especially [tobacco](#) and other members of the family [Solanaceae](#). It can infect well over 350 different species of plants. The [infection](#) causes characteristic patterns, such as "[mosaic](#)"-like [mottling](#) and discoloration on the [leaves](#) (hence the name). TMV was the first [virus](#) to ever be discovered.

[W. M. Stanley](#) in 1935 who also showed that TMV remains active even after crystallization. For his work, he was awarded 1/3 of the [Nobel Prize in Chemistry](#) in 1946,

**Structure:** TMV is made up of a piece of nucleic acid (ribonucleic acid; RNA) and a surrounding protein coat. The complete virus is a submicroscopic, rigid, rod-shaped particle. Once inside the plant cell, the protein coat falls away and nucleic acid portion directs the plant cell to produce more virus nucleic acid and virus protein, disrupting the normal activity of the cell. Its [capsid](#) is made from **2130 molecules of coat protein** and **one molecule of genomic single strand RNA 6400 bases long**. The **protein monomer** consists of **158 amino acids** which are assembled into **four main alpha-helices**, which are joined by a prominent loop proximal to the axis of the virion. Virions are ~300 nm in length and ~18 nm in diameter. There are three **RNA nucleotides per protein monomer**. TMV can multiply only inside a living cell but it can survive in a dormant state in dead tissue, retaining its ability to infect growing plants for years after the infected plant part died.

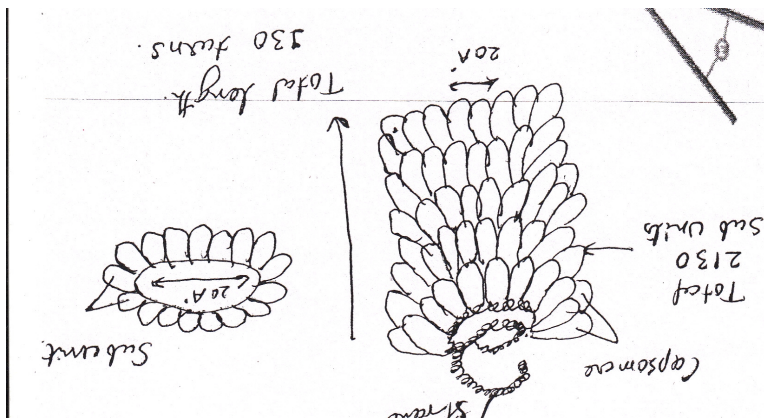
**Mechanical Transmission:** The mostly TMV spreads from plant to plant through workers' hands, clothing or on tools. Vegetative propagation of infected plant carries TMV and other virus diseases. The virus particles are found in all parts of the plant except the few cells at the tips of the growing points. Infected stock plants should be discarded immediately.

**Symptoms** vary with the species of plant infected and the environmental conditions. In some cases environmental conditions bring out symptoms while other conditions mask or hide symptoms. Symptoms associated with TMV infections:

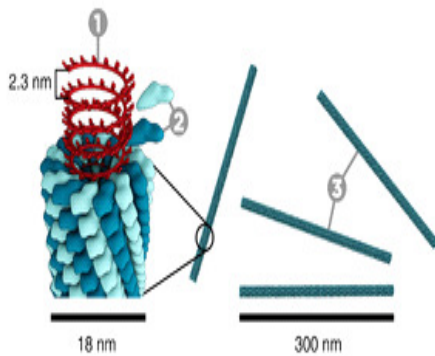
- stunting
- mosaic pattern of light and dark green (or yellow and green) on the leaves
- malformation of leaves or growing points
- yellow streaking of leaves (especially monocots)

- yellow spotting on leaves
- distinct yellowing only of veins

Some of the above symptoms can also be caused by high temperature, insect feeding, growth regulators, herbicides, mineral deficiencies, and mineral excesses. TMV diseases cannot be diagnosed on the basis of symptoms alone.



## Structure



Schematic model of TMV: 1. nucleic acid ([RNA](#)), 2. capsomer (protomer), 3. [capsid](#)

Tobacco mosaic virus has a rod-like appearance. Its [capsid](#) is made from 2130 [molecules](#) of coat protein (see image to the left) and one molecule of genomic single strand RNA 6400 bases long. The coat protein self-assembles into the rod like helical structure (16.3 proteins per helix turn) around the RNA which forms a hairpin loop structure (see the [electron micrograph](#) above). The protein monomer consists of 158 [amino acids](#) which are assembled into four main alpha-helices, which are joined by a prominent loop proximal to the axis of the virion. Virions are ~300 nm in length and ~18 nm in diameter. Negatively stained electron microphotographs show a distinct inner channel of ~4 nm. The RNA is

located at a radius of ~6 nm and is protected from the action of cellular enzymes by the coat protein. There are three RNA nucleotides per protein monomer.<sup>[13]</sup> X-ray [fiber diffraction](#) structure of the intact virus was studied based on an [electron density](#) map at 3.6 Å resolution.

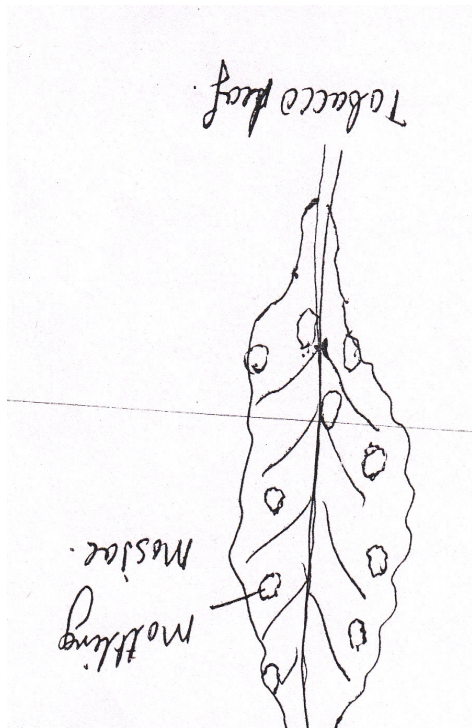
### Physicochemical properties

TMV is a thermostable virus. On a dried leaf, it can withstand up to 120 degrees Fahrenheit (50 °C) for 30 minutes. TMV has an [index of refraction](#) of about 1.57.

### Multiplication and Infection

The replication of virus RNA is an essential part of the TMV reproduction or multiplication. Most of the plants contain RNA dependent RNA Polymerases which helps in replication of viral RNA. Four TMV – specific proteins are known to be made. TMV viral RNA directly serve as mRNA in the production of messenger in complex. After the coat protein and RNA genome have been synthesized they automatically assemble into complete TMV virion. The protomere come together to form disks composed of two layers of protomere arranged in a helical spiral. After its multiplication, it enters the neighboring cells through [plasmodesmata](#). For its smooth entry, TMV produces a 30 kDa [movement protein](#) called P30 which enlarge the plasmodesmata. TMV most likely moves from cell-to-cell as a complex of the RNA, P30, and replicase proteins.

It can also spread through [phloem](#) for longer distance movement within the plant. Moreover, TMV can be transmitted from one plant to another by direct contact. Although TMV does not have defined transmission vectors, the virus can be easily transmitted from the infected hosts to the healthy plants, by human handling.





Tobacco mosaic virus symptoms on tobacco



Tobacco mosaic virus symptoms on orchid

Consumption of tobacco products infected with the tobacco mosaic virus has not been found to have any effect on humans.

### **Treatment and Managing TMV**

**No chemicals can cure a virus-infected plant.**

- Purchase virus-free plants.
- Remove all weeds since these may harbor TMV.
- Remove all crop debris from benches and the greenhouse structure.
- Set aside plants with the above symptoms and obtain a diagnosis.
- Discard infected plants.
- Disinfect tools by placing them in disinfectant for at least 10 min. Rinse thoroughly with tap water. Disinfect door handles and other greenhouse structures that may have become contaminated by wiping thoroughly with one of these materials.
- Propagate plants via seed rather than vegetative propagation.
- Thoroughly wash hands after handling tobacco products or TMV-infected plants.
- Do not keep tobacco products in the pockets of clothing worn into the greenhouse.

Launder greenhouse work clothes regularly.

### **Investigational uses**

TMV has ability to incorporate metal coatings (nickel and cobalt) into its shell due this property TMV can be incorporated into battery electrodes. Addition of TMV to a battery electrode increases the battery's capacity by up to six times compared to a normal electrode.

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