Nature and Properties of Viruses

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Viruses

- Viruses are simple, acellular entities consisting of one or more molecules of either DNA or RNA enclosed in a coat of protein (and sometimes, in addition, substances such as lipids and carbohydrates).
- They can reproduce only within living cells and are obligately intracellular parasites.

Discovery of Viruses

- The scientific study of viruses and the infections they cause – began in the closing years of the 19th century.
- Although Louis Pasteur and Edward Jenner developed the first vaccines to protect against viral infections, they did not know that viruses existed.
- The first evidence of the existence of viruses came from experiments with filters that had pores small enough to retain bacteria.
- In 1892, Dmitri Ivanovsky used one of these filters to show that sap from a diseased tobacco plant remained infectious to healthy tobacco plants despite having been filtered.
- Martinus Beijerinck called the filtered, infectious substance a "virus" and this discovery is considered to be the beginning of virology.
- The subsequent discovery and partial characterization of bacteriophages by Frederick Twort and Félix d'Herelle further catalyzed the field, and by the early 20th century many viruses had been discovered.
- In 1926, Thomas Milton Rivers defined viruses as obligate parasites.
- Viruses were demonstrated to be particles, rather than a fluid, by Wendell Meredith Stanley, and the invention of the electron microscope in 1931 allowed their complex structures to be visualised.

General Properties of Viruses

- **Viruses are a unique group of infectious agents whose distinctiveness** resides in their simple, acellular organization and pattern of reproduction.
- A complete virus particle or **virion consists** of one or more molecules of DNA or RNA enclosed in a coat of protein, and sometimes also in other layers.
- These additional layers may be very complex and contain carbohydrates, lipids, and additional proteins.
- Viruses can exist in two phases:
  - extracellular and
  - intracellular.
- Virions, the extracellular phase, possess few if any enzymes and cannot reproduce independent of living cells.
- In the intracellular phase, viruses exist primarily as replicating nucleic acids that induce host metabolism to synthesize virion components; eventually complete virus particles or virions are released.

...General Properties of Viruses

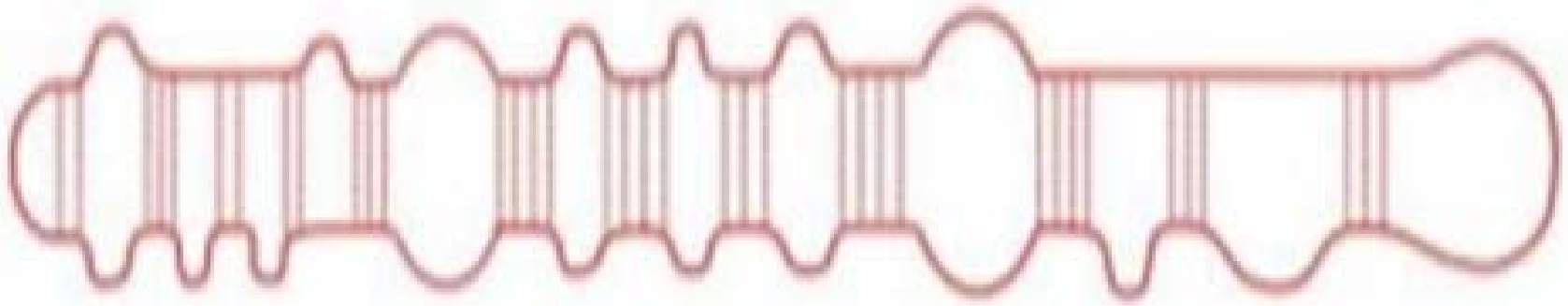
- In summary, viruses differ from living cells in at least three ways:
  - (1) their simple, acellular organization;
  - (2) the presence of either DNA or RNA, but not both, in almost all virions (human cytomegalovirus has a DNA genome and four mRNAs); and
  - (3) their inability to reproduce independent of cells and carry out cell division as procaryotes and eucaryotes do.
- Although bacteria such as chlamydia and rickettsia *are obligately intracellular* parasites like viruses, they do not meet the first two criteria.

…General Properties of Viruses

- Viruses are cultured by inoculating living hosts or cell cultures with a virion preparation.
- Purification depends mainly on their large size relative to cell components, high protein content, and great stability.
- The virus concentration may be determined from the virion count or from the number of infectious units.
- All viruses have a nucleocapsid composed of a nucleic acid surrounded by a protein capsid that may be icosahedral, helical, or complex in structure.
- Capsids are constructed of protomers that self-assemble through noncovalent bonds.
- A membranous envelope often lies outside the nucleocapsid.
- More variety is found in the genomes of viruses than in those of procaryotes and eucaryotes; they may be either single-stranded or double-stranded DNA or RNA.
- The nucleic acid strands can be linear, closed circle, or able to assume either shape.
- Viruses are classified on the basis of their nucleic acid's characteristics, capsid symmetry, the presence or absence of an envelope, their host, the diseases caused by animal and plant viruses, and other properties.

What are Viroids?

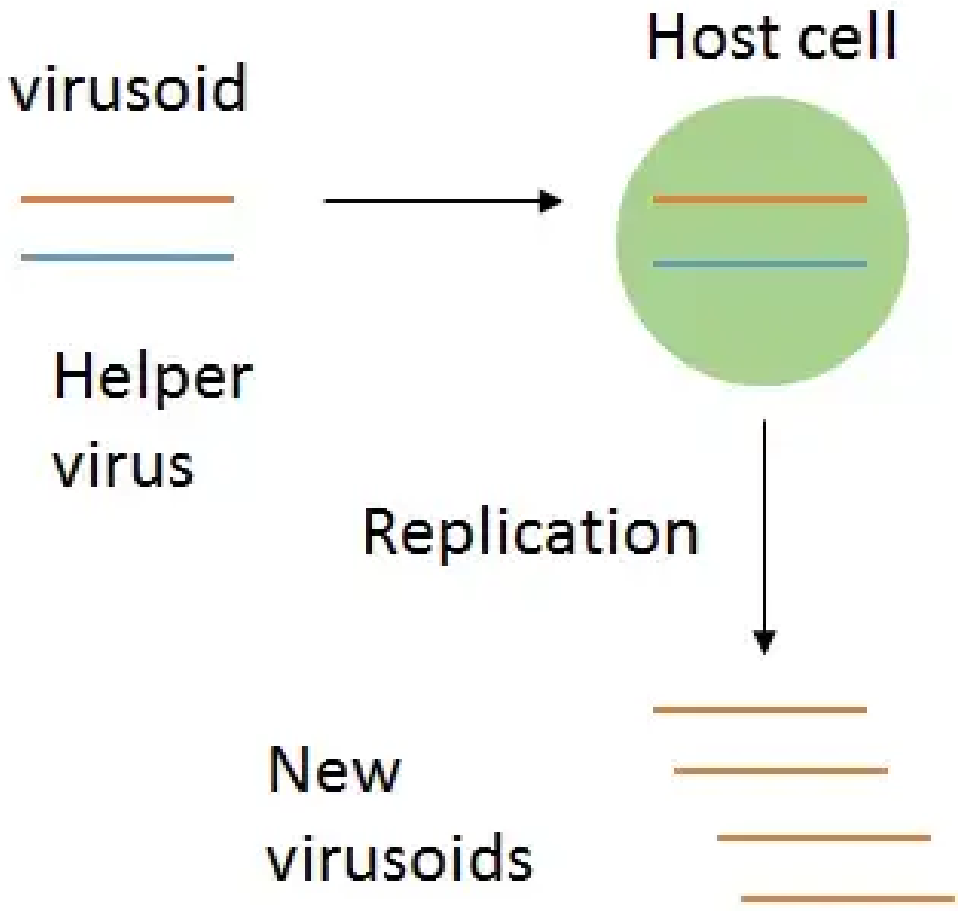
- Viroids are infectious pathogens that affect only plants, therefore are also called plant pathogens.
- Structurally, viroids are smaller than viruses and possess circular strands of ribonucleic acids (RNAs) (only 250–400 bases long) with no protein coating.
- Although the viroid encodes no protein enzymes, the viroid RNA itself acts as a **ribozyme**; that is, the RNA catalyzes an enzymatic reaction.
- These entities hijack the cellular machinery present in plant cells to replicate new copies of themselves.
- Viroids replicate by a rolling circle mechanism.
- The viroids own ribozyme activity is used for self-cleavage of the multimeric RNA generated during replication.
- Host enzymes provide all other functions.
- It primarily affects all forms of higher plants.
- Some of the plants that are affected by these pathogens are potatoes, tomatoes, cucumbers, chrysanthemums, coconut palms, avocados, etc.
- Viroids were first discovered by T.O. Diener in the year 1971.
- It was first examined in the potato spindle tuber viroid caused a huge loss to the potato industry.



Structure of a viroid – circular single-stranded RNA with some pairing between complementary bases and loops where no such pairing occurs

Virusoids

- A second type of pathogenic RNA that can infect commercially important agricultural crops are the **virusoids**.
- RNA replication of **virusoids** is similar to that of viroids but, unlike viroids, virusoids require that the cell also be infected with a specific “helper” virus.
- There are currently only five described types of virusoids and their associated **helper viruses**.
- The helper viruses are all from the family of **Sobemoviruses**. An example of a helper virus is the subterranean clover mottle virus, which has an associated virusoid packaged inside the viral capsid.
- Once the helper virus enters the host cell, the virusoids are released and can be found free in plant cell cytoplasm, where they possess ribozyme activity.
- The helper virus undergoes typical viral replication independent of the activity of the virusoid.
- The virusoid genomes are small, only 220 to 388 nucleotides long.
- A virusoid genome does not code for any proteins, but instead serves only to replicate virusoid RNA.


virusoid
Host cell
Helper
virus
Replication
New
virusoids

What are the Similarities Between Viroid and Virusoid?

- Viroids and virusoids are circular single-stranded RNA molecules that are infectious.
- They are unable to self-replicate.
- They do not possess protein capsids.
- Moreover, they do not code for proteins.
- Both viroid and virusoid are smaller than viruses.
- Furthermore, both are non-living disease agents.
- Both viroid and virusoid can infect commercially important agricultural crops.
- **What is the Difference Between Viroid and Virusoid?**
- The key difference between viroid and virusoid is that viroid does not require a helper virus to establish an infection while virusoid requires a helper virus to establish an infection in the host.

Satellite viruses

- Satellite viruses (SVs) are subviral pathogens that are entirely dependent upon the replication machinery of their helper viruses.
- All satellite viruses encode their own capsid proteins.
- They are incapable of completing the infection cycle without the assistance of a helper virus.
- Satellite viruses have been described in animals, protists and plants.
- There are only four known plant SVs: satellite tobacco necrosis virus, satellite tobacco mosaic virus, satellite panicum mosaic virus, and satellite maize white line mosaic virus.
- To be classified as a satellite virus:
- 1) The virus must be dependent upon a helper virus to replicate,
- 2) the helper virus must not be dependant on the satellite virus for replication, and
- 3) there must be no significant homology between the genomes of the satellite and helper viruses.

Prions

- At one time, scientists believed that any infectious particle must contain DNA or RNA.
- Then, in 1982, Stanley **Prusiner**, a medical doctor studying scrapie (a fatal, degenerative disease in sheep) discovered that the disease was caused by proteinaceous infectious particles, or **prions**.
- Because proteins are acellular and do not contain DNA or RNA, Prusiner's findings were originally met with resistance and skepticism; however, his research was eventually validated, and he received the Nobel Prize in Physiology or Medicine in 1997.
- A prion is a misfolded rogue form of a normal protein (PrPc) found in the cell.
- This rogue prion protein (PrPsc), which may be caused by a genetic mutation or occur spontaneously, can be infectious, stimulating other endogenous normal proteins to become misfolded, forming plaques.
- Today, prions are known to cause various forms of **transmissible spongiform encephalopathy (TSE)** in human and animals.

…Prions

- TSE is a rare degenerative disorder that affects the brain and nervous system.
- The accumulation of rogue proteins causes the brain tissue to become sponge-like, killing brain cells and forming holes in the tissue, leading to brain damage, loss of motor coordination, and dementia.
- Infected individuals are mentally impaired and become unable to move or speak.
- There is no cure, and the disease progresses rapidly, eventually leading to death within a few months or years.
- TSEs in humans include **kuru**, **fatal familial insomnia**, **Gerstmann-Straussler-Scheinker disease**, and **Creutzfeldt-Jakob disease** .
- TSEs in animals include **mad cow disease**, **scrapie** (in sheep and goats), and **chronic wasting disease** (in elk and deer).
- TSEs can be transmitted between animals and from animals to humans by eating contaminated meat or animal feed.
- Transmission between humans can occur through heredity (as is often the case with GSS and CJD) or by contact with contaminated tissue, as might occur during a blood transfusion or organ transplant.
- There is no evidence for transmission via casual contact with an infected person.

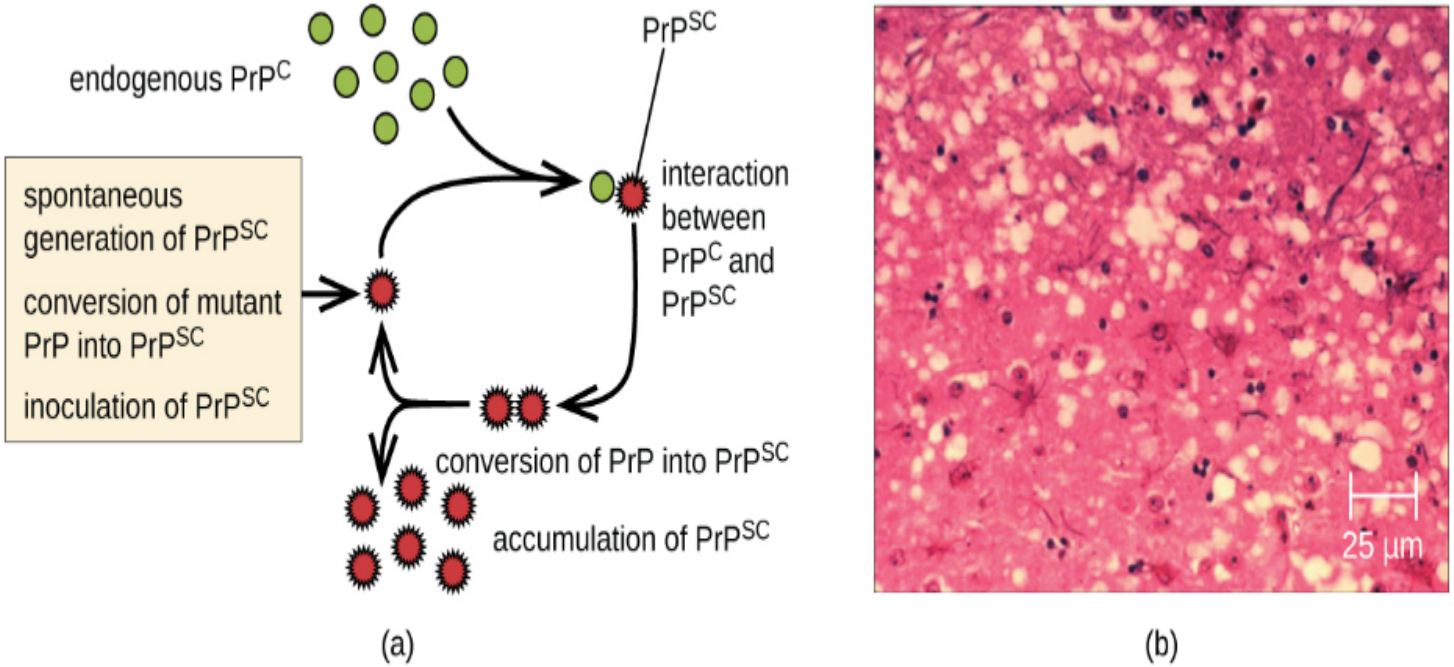


Figure 6.4.2: Endogenous normal prion protein (PrPc) is converted into the disease-causing form (PrPsc) when it encounters this variant form of the protein. PrPsc may arise spontaneously in brain tissue, especially if a mutant form of the protein is present, or it may originate from misfolded prions consumed in food that eventually find their way into brain tissue. (credit b: modification of work by USDA)