Chapter 5 Viruses

Section 1 General Properties of Viruses

1 General properties

（1）They are very small in size. They can pass bacteria filter, and can be seen only by electron microscope；

（2）They have no cell structure. They are made of only protein and nucleic acid, therefore called “molecular life;

（3）They have only DNA or RNA;

（4）They have no system for enzyme or protein synthesis.

（5）They are non-living macromolecule out the host. The replication of nucleic acid and synthesis of protein can only be carried out in host cell.

（6）They are sensitive to interferon but not to antibiotics.

2 Two stages of virus

In the extracellular phase, viruses exist in the state of virion. The virion posses few if any enzymes and can not reproduce independently 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.

Section 2 Size, structure and classes of virus

1 Size of virus

Virus particle (virion)

Virus particles (virions) vary widely in size.

Viruses are smaller than cells, ranging in size from 0.02 to 0.3 μm (20 to 300 nm).

A common unit of measure for viruses is the nanometer, which is 1000 times smaller than 1 um.

Smallpox virus, one of the largest viruses, is about 200-300 nm in diameter (a bit smaller than the size of the smallest bacteria，such as the mycoplasmas);

Poliovirus, one of the smallest, is only 28 nm in diameter (about the size of a ribosome).

2 Structure of virus

1) General structure

All viruses consist of an RNA or DNA core genome, surrounded by a protein coat capsid.

The combined viral genome and capsid is called nucleocapsid.

In some viruses, the capsid is covered by an envelope.

Depending on the virus, envelopes may or may not be covered by spike.

2) Nucleic acid of virus

The nucleic acid of viruses can be composed of either DNA or RNA, and some use both as their genomic material at different stages in their life cycle.

However , only one type of nucleic acid is found in the virion of any particular type of virus.

This can be single-stranded (ss) or double-stranded (ds).

In most case, animal viruses have dsDNA or ssRNA, plant viruses have ssRNA, bacterial viruses have dsDNA, and fungal viruses have dsRNA.

3 Capsid of virus

Each capsid is composed of protein subunits called capsomeres.

Arrangement of capsomeres result in different shapes:

Spiral arrangement ---rod, tobacco mosaic virus;

Stereo arrangement ---icosahedron，adenovirus；

Complex arrangement (both spiral arrangement and stereo arrangement)---tadpole, bacteriophage.

4 Envelope and spike

Envelope usually consists of some combination of lipids, proteins, and carbohydrates.

Spike project from the surface of the envelope, which consists of carbohydrateprotein complexes.

5 Classes of virus

Based on the composition, virus can be divided into two groups: euvirus and subvirus.

Euvirus has both nucleic acid and protein. Subvirus has either nucleic or protein.

Subvirus includes : viroid, virusoid and prion.

Viroids are small, circular, single-stranded RNA molecules that are the smallest known pathogens. The extracellular form of the viroid is naked RNA-there is no capsid of any kind. Viroids are plant pathogens. For example, Potato spindle tuber disease, PSTD is caused by viroid.

Virusoids are a kind of defective viroids which are included in the particle of a real virus, which are also called viroid-like, or satellite. The real virus is called helper virus. For example, hepatitis D virus-HDV is the virusoid of hepatitis B virus-HBV.

Prions have a distinct extracellular form, which is entirely protein. It apparently does not contain any nucleic acid. The word “prion” represents “protein infection”. For example, mad cow disease is caused by bovine spongiform encephalitis, BSE.

Section 3 Bacteriophage

1 Types of bacteriophage

Type A has a head and a long, contractile tail.

Type B has a head and a long, noncontractible tail.

Type C has a head a very short tail.

Type D has a spherical head with a large capsomere on the each corner.

Type E has a spherical head.

Type F has a filament.

Type A, type B and type C have dsDNA. Type D and type F have ss DNA. Type E has ss RNA.

2 Virulent phage and temperate phage

Virulent phage multiplys in large quantity in host cell and destroys the host eventually.

Temperate phage lives peacefully with the host with its nucleic acid replicating in accordance to it host’s.

Lysogeny is the property of temperate phage, which lives peacefully with its host.

Prophage is temperate phage that integrates into the host’s nucleic acid.
Lysogen, lysogenic cell is the host cell that contains prophage.
Immunity of lysogen is the immunity obtained by the host cells that have been infected by temperate.
Recovery of lysogen is the phenomenon that a lysogenic cell losts its prophage in any way.

Section 4 Multiplication of phage

1 Process of multiplication
The multiplication cycle of bacteriophages, like that of all viruses, can be divided into several distinct stages.

Attachment stage--- phages contact host cells randomly and then are attached to them permanently.

Penetration stage---nucleic acid of viruses is injected in the host cells, while capsid is left outside.

Replication stage---nucleic acids are replicated, capsid and other components of the virus are manufactured separately.

Maturity stage---nucleic acids, capsids and other components are assembled to form a mature virus.

Release stage---host cells are destroyed and mature virus are released.
The whole process is called lytic cycle. The lytic cycle of E.coli T takes about 15-25min.
The total number of phages from one host is called burst size. Burst size of T2 is 150 (9～447），T4 100，f2 10000.

2 One-step growth curve

1) Concept

Plaque is the clear dot on the lawn of bacteria which are infected by virus.

Titer(titre) is the number of infectious virus in 1 ml , it is also called plaque-forming unit or infective centre.

2) One-step growth curve

There are 3 phases in one-step growth curve.

(1) Latent phase: In this phase, the number of virion does not increase. It can be divided in to two phases,

Eclipse phase.

Intracellular accumulation phase.

(2) Rise phase: In this phase, the number of virion increases rapidly.

(3) Plateau: In this phase, the number of virion does not increase.

Section 5 Other virus

1 Plant virus
Most plant viruses are rod-shaped or filamentous without envelope, they are not specific to host.
Their multiplication is similar to that of phage, yet there are still some differences:

1) Penetration into a susceptible plant cell only occurs through abrasions or insect bites.

2) Uncoating of the viral nucleic acid happens within the plant cell.

Symptom of disease:

- Mosaic, red-colored or yellow-colored leaves.
- Dwarf, deformed plant.
- Lesion on leaves.

2 Animal Virus

Their multiplication is similar to that of phage.

Animal Viruses cause human diseases, such as AIDS(aquired immune deficiency syndrome, by human immunodeficiency virus, HIV), heptitis and so on.

3 Insect virus

Insect viruses, in most case, exist in insect cell in the form of polyhedron.

Polyhedron is a kind of crystal which consists of protein and insect virus. There are 3 kinds of polydedrons.

Nuclear polyhedosis virus（NPV）multiplys in nucleus of insect cell and has rod-like inclusion of protein.

Cytoplasmic polyhedosis virus（CPV）multiplys in cytoplasm of insect cell and has ball-like inclusion of protein.

Granulosis virus(GV) is inclusion of protein in which there is only one virus.

Insect virus can be used in biocontrol againt insect.