CHAPTER TWELVE

General properties of viruses

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DEFINITION OF VIRUS

- Are entities whose genomes are elements of nucleic acid that replicate inside living cells, using the cellular machinery and causing the synthesis of specialized elements that can transfer viral genome to other cells.

GENERAL PROPERTIES OF VIRUSES

1. Smallest infectious agents
2. Consist either of RNA or DNA but never both.
3. Obligate intracellular parasites
4. Fail to grow on artificial media
5. Nucleic acid is encased in a protein shell
6. Entire infectious unit is also called as virion
7. Not inactivated by antibiotics
8. Divide by replication
9. Limited host range (mostly)

CLASSIFICATION OF VIRUSES

- Viruses may fall into 4 broad groups:
  - Human and animal viruses
  - Plant viruses
  - Insect viruses
  - Bacterial viruses

CLASSIFICATION OF VIRUSES

- Human viruses can be broadly classified on basis of 2 criteria:-
- Clinical criteria which include
  - Respiratory viruses
  - Enteric viruses
- On basis of epidemiological features

  eg: arboviruses

CLASSIFICATION OF VIRUSES

- The other classification is based on:

1. Kind of nucleic acid
2. Strategy of viral replication
3. Morphology of virion
4. Presence of envelope

- These are called physicochemical classification

PRIONS

- Are pathogens composed of proteins without any detectable nucleic acid.
- Believed to be the causative agents of chronic degenerative neurological disorders.

MORPHOLOGY

- The viruses are composed of nucleic acid and protein.
- The **Genome** consists of single nucleic acid which stores all vital information required by the virus for its multiplication.
- Genome is surrounded by a shell or coat made of protein called **capsid.**

MORPHOLOGY

- The genome and capsid are collectively known as **nucleocapsid.**
- Most of the viruses have additional covering of lipid around their nucleocapsid called viral **envelope**.
- The complete virus particle called **virion** (virion = mean virus is infectious and structurally intact)

CAPSIDS

- Are aggregates of repeating subunits called **capsomers** which are arranged in defined patterns
- **Capsomers:** may be made up of a few molecules of protein or one protein molecule.
- Capsid has 2 functions:

1. To protect the genome from external harmful factors
2. To introduce the viral genome into host cell

- Similar functions are also performed by lipid envelope for the virus.

ENVELOPE

- Is present in almost all viruses except some families (8 families)
- Is bilayer lipid membrane, the lipid is derived from cytoplasmic membrane of the host cell.

SIZE OF VIRUSES

- Viruses vary in diameter from 20 to 300nm.
- The poxviruses are the largest in size, measure around 330 x 230 x 100nm.
- Paramyxoviruses and herpes viruses vary in their diameter from 120-300nm. Where as influenza and adenoviruses have diameter of 60-120nm.
- The smallest viruses are picorna which measure 20-40nm.
- Fig 13.1 (shows the shapes and size of viruses)

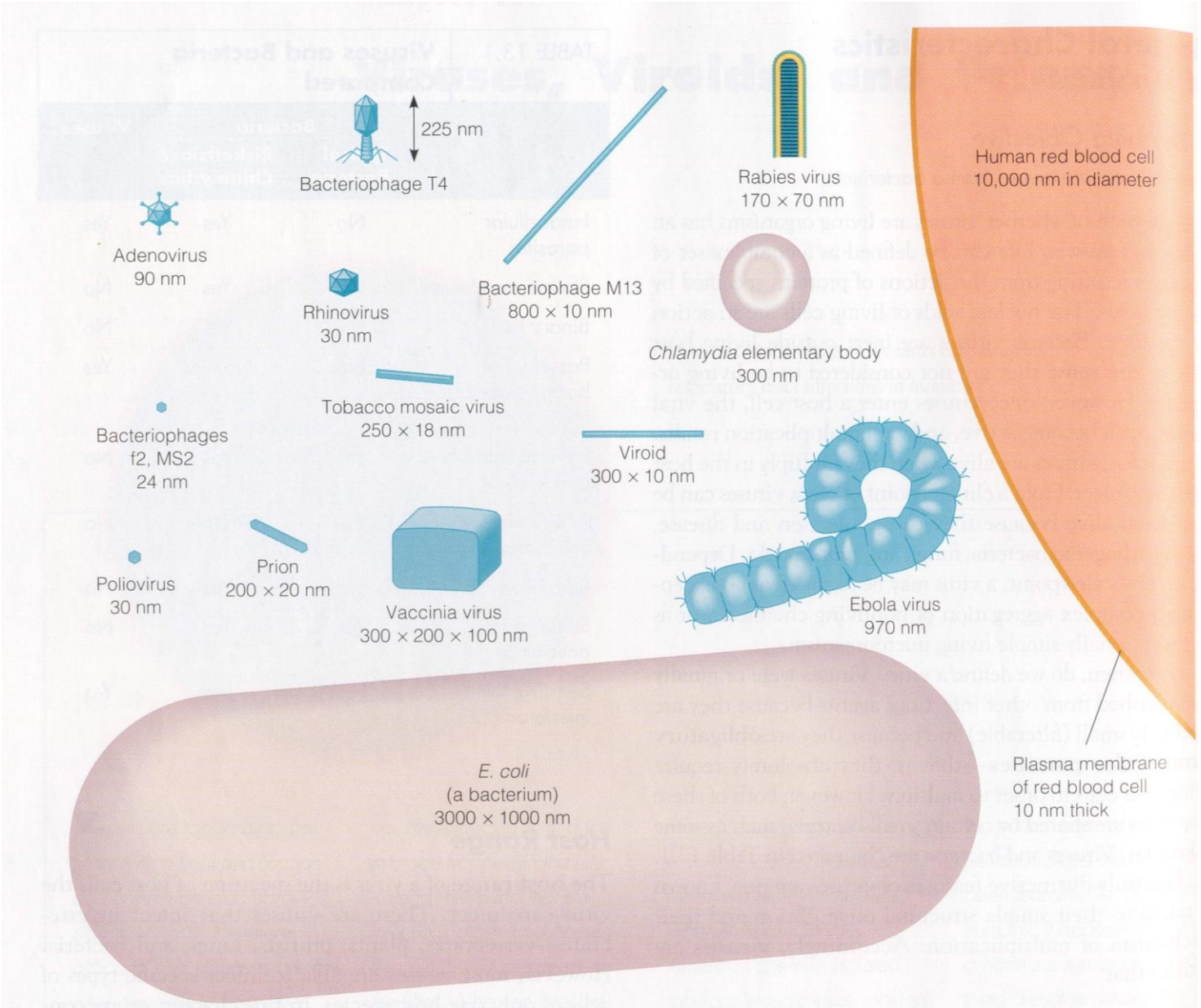
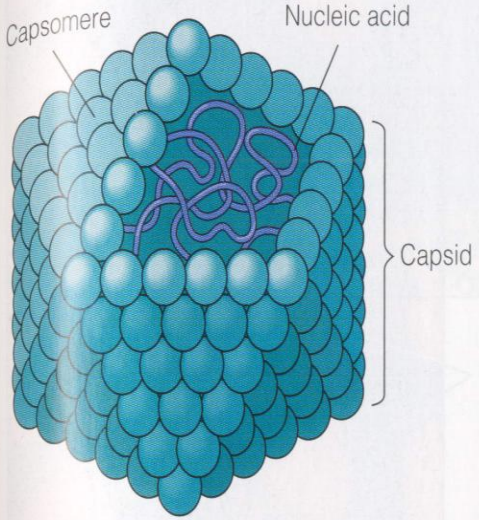


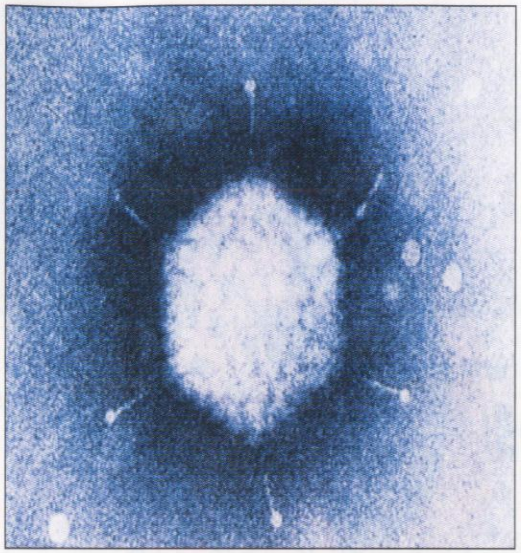
FIGURE 13.1 **Virus sizes.** The sizes of several viruses (teal blue) and bacteria (pink) are compared with a human red blood cell, shown to the right of the microbes. Dimensions are given in nanometers (nm) and are either diameters or length by width.

TABLE 13.1 **Viruses and Bacteria Compared**

	Bacteria		Viruses
	Typical Bacteria	Rickettsias/ Chlamydias	
Intracellular parasite	No	Yes	Yes
Plasma membrane	Yes	Yes	No
Binary fission	Yes	Yes	No
Pass through bacteriological filters	No	No/Yes	Yes
Possess both DNA and RNA	Yes	Yes	No
ATP-generating metabolism	Yes	Yes/No	No
Ribosomes	Yes	Yes	No
Sensitive to antibiotics	Yes	Yes	No
Sensitive to interferon	No	No	Yes



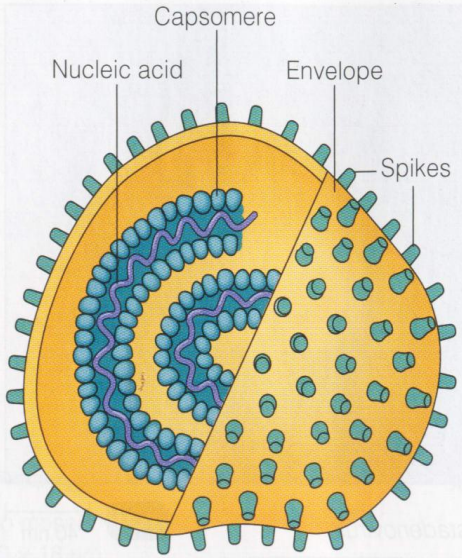
(a) A polyhedral virus



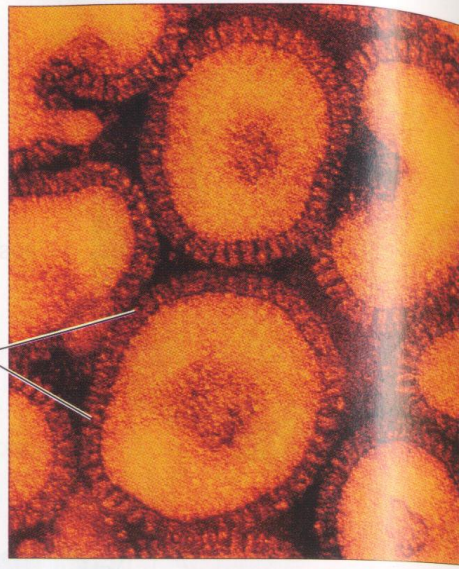
(b) *Mastadenovirus*

FIGURE 13.2 **Morphology of a nonenveloped polyhedral virus. (a)** A diagram of a polyhedral (icosahedral) virus. **(b)** A micrograph of the adenovirus *Mastadenovirus*. Individual capsomeres in the protein coat are visible.

- A viral capsid is composed of capsomeres that often form an icosahedron.



(a) An enveloped helical virus



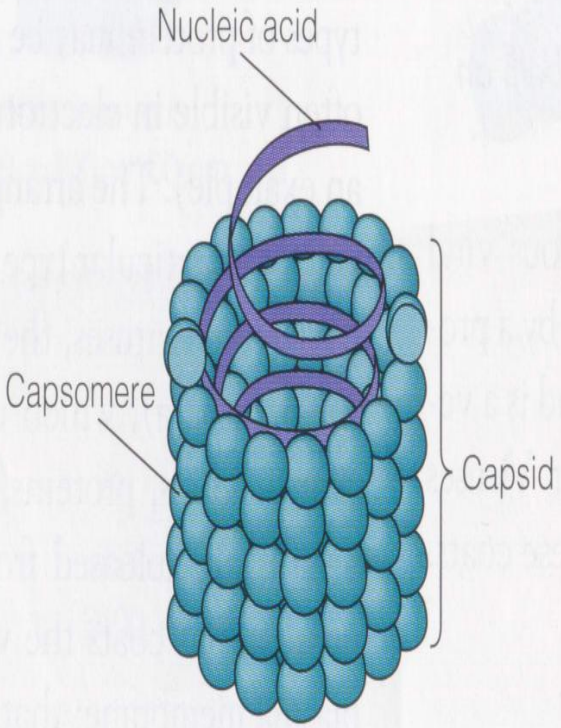
(b) *Influenzavirus*

FIGURE 13.3 **Morphology of an enveloped helical virus. (a)** A diagram of an enveloped helical virus. **(b)** A micrograph of *Influenzavirus* A2. Notice the halo of spikes projecting from the outer surface of each envelope (see Chapter 24).

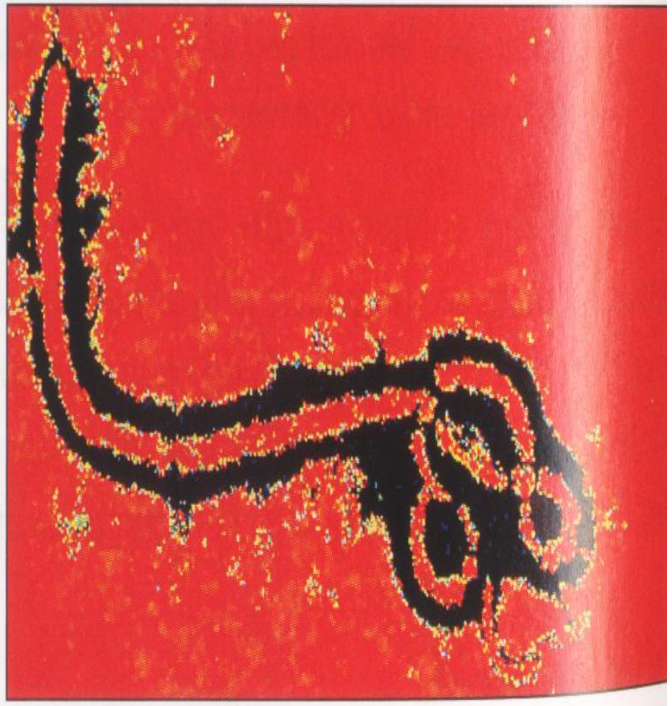
- What is the nucleic acid in a virus?

FIGURE 13.4 **Morphology of a helical virus. (a)** A diagram of a portion of a helical virus. Several rows of capsomeres have been removed to reveal the nucleic acid. **(b)** A micrograph of Ebola virus, a filovirus showing helical rods.

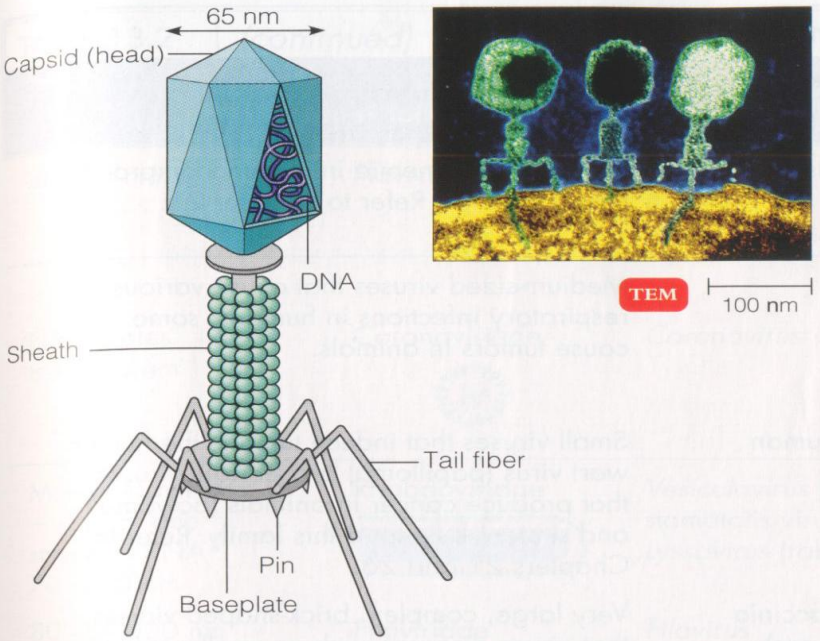
- Helical viruses look like long or coiled threads.



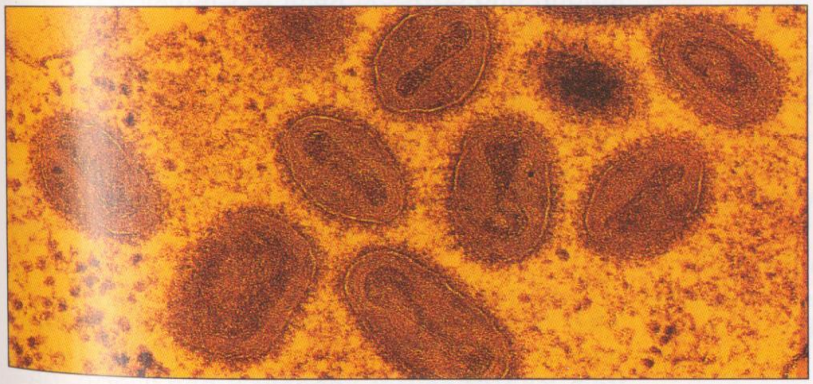
(a) A helical virus



(b) Ebola virus



(a) A T-even bacteriophage



(b) *Orthopoxvirus*

FIGURE 13.5 **Morphology of complex viruses. (a)** A diagram and micrograph of a T-even bacteriophage. **(b)** A micrograph of variola virus, a species in the genus *Orthopoxvirus*, which causes smallpox.

■ What is the chemical composition of a capsid?

VIRAL NUCLEIC ACIDS

- Some viruses possess DNA others RNA.
- Some are double stranded, others are single stranded, some are linear others are circular.
- Some have plus (+) polarity others have minus (-) polarity.

VIRAL PROTEIN

- The molecular weight and number of proteins in viruses is variable.
- Molecular weight ranges between 10,000 - 150,000 Daltons, and the number of protein species from 3 to 100.
- Viral envelope may possess glycoproteins as well as matrix proteins which present on the inner surface of the envelope, provide extra strength to the envelope.

VIRAL PROTEIN

- In addition, there are 2 types of viral proteins **haemagglutinins** and **enzymes**, they perform specialized functions.
- The coat proteins called **structural proteins**.
- The enzymes and haemagglutinins know as **non-structural proteins**.

PRESERVATION OF VIRAL INFECTIVITY

- Viruses are more sensitive to environmental changes, than other organisms.
- Temperature, pH, and lipid solvents affect viruses and their infectivity.
- **Temperature:** Viruses survive for seconds at 60ºC, mints at 37ºC, hours at 20ºC and days at 40ºC and years at -70ºC. (Liquid nitrogen -196ºC)
- Enveloped viruses are more heat labile than non-enveloped.

PRESERVATION OF VIRAL INFECTIVITY

- **PH:** Viruses prefer physiological pH, any alteration in these results in deterioration of infectivity of virus.
- **Lipid solvents:** Ether or Chloroform, detergents and any lipid solvent on coming in contact with viruses, especially those having envelops, destroy them.

REPLICATION OF VIRUSES

- Viruses are obligatory intracellular parasites.
- Do not possess machinery which helps them in synthesizing their nucleic acids or proteins, the genetic information for which is present in the genome of the virus.
- Virus use host machinery to undertake these processes. (Fig 13-15 replication of viruses)

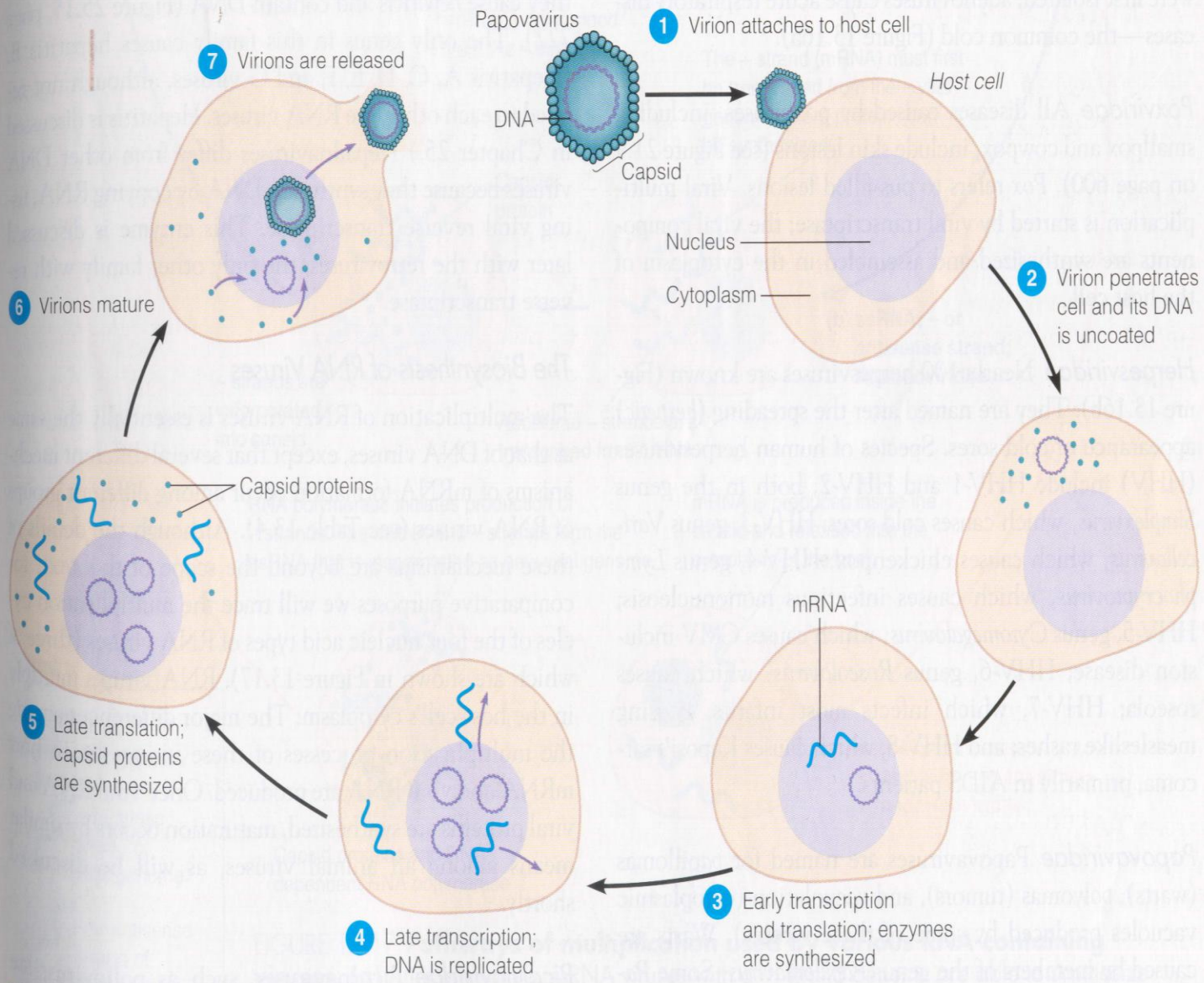


FIGURE 13.15 **Multiplication of *Papovavirus*, a DNA-containing virus.**

■ Why is mRNA made?

ATTACHMENT OF VIRUS TO HOST CELLS

- First event of viral infection, its attachment to cell surface this process is called as **binding** or **adsorption** (it require receptors on surface of host cell)

PENETRATION

- Occur by any of the following methods:

A. **Translocation:** whole non envelope virus enters the cell of host by moving across the cell membrane.

B. **Endocytosis:** engulfment of virus by the invagination of a section of plasma membrane.

C. **Fusion:** envelope fused with membrane of endosome and direct fusions of viral envelope with the surface membrane of the cell may also take place.

UNCOATING

- Partial uncoating of the virion occurs immediately after entering into host cell.
- Some parts of the genome are expressed and start directing the synthesis of early protein and early mRNA.
- Gradually complete uncoating occurs, because of the interaction of virion with host components and enzymes

TRANSCRIPTION

- ssRNA viruses with (+) polarity can directly bind to ribosomes to synthesize proteins
- RNA viruses with (-) polarity make use of RNA dependent RNA polymerase.
- DNA viruses use host DNA dependent-DNA polymerase to perform this function

TRANSLATION

- Viral mRNA use ribosome of host cell to synthesize proteins in the same way as host mRNA dose.
- Two types of proteins are synthesized depending on the time of their appearance:
  - Early proteins
  - Late proteins

GENOME REPLICATION

- Viruses reproduce their own nucleic acid which directs:
- Its replication
- Synthesis of their own specific proteins

ASSEMBLY

- May take place in host cell, in the cytoplasm, or in cell nucleus.
- Envelope is acquired by budding through cell membrane

RELEASE

- Virion is released by 3 mechanisms:

A. Cell lysis.

B. Cell degeneration.

C. Budding.

- The duration of viral replication in case of DNA viruses varies from 5 to 15 hours and in RNA viruses varies from 3-10 hours

RELEASE

- Viral infection in host cells is not always productive sometimes either:
- Viral coded proteins are not synthesized or
- Assembly is defective, this is known as **abortive infection**
- Certain viruses fail to replicate in host cell, this is known as **defective viruses**, can replicate in presence of a helper virus.

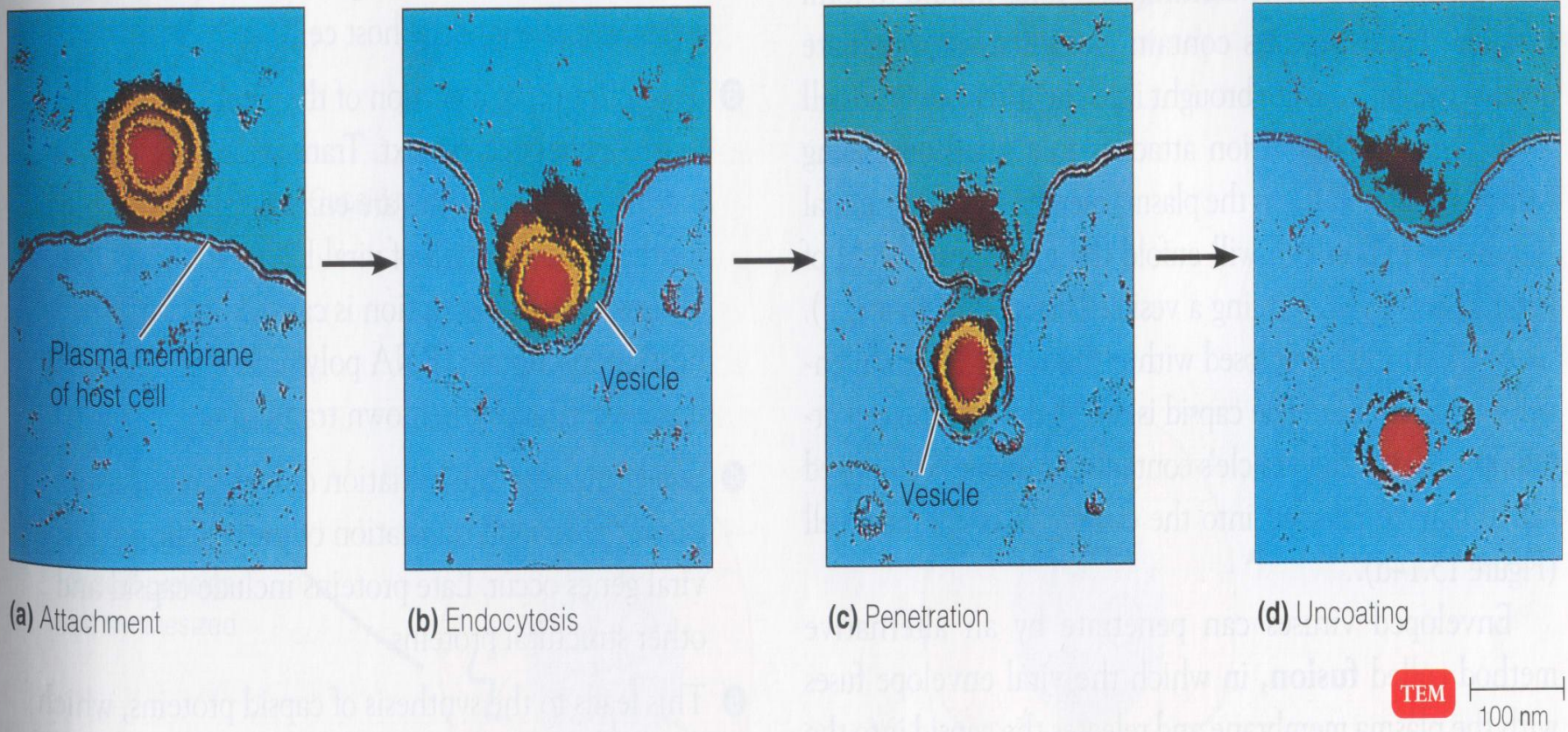


FIGURE 13.14 **The entry of herpes simplex virus *(Simplexvirus)* into an animal cell.** **(a)** Attachment of the viral envelope to the plasma membrane. **(b)** The cell's plasma membrane folds inward, forming a vesicle around the virus; this results in loss of the envelope. **(c)** The nonenveloped capsid penetrates the cytoplasm of the cell from the vesicle. **(d)** The nucleic acid core is uncoated by digestion of the capsid.

■ Viruses enter animal cells by endocytosis.

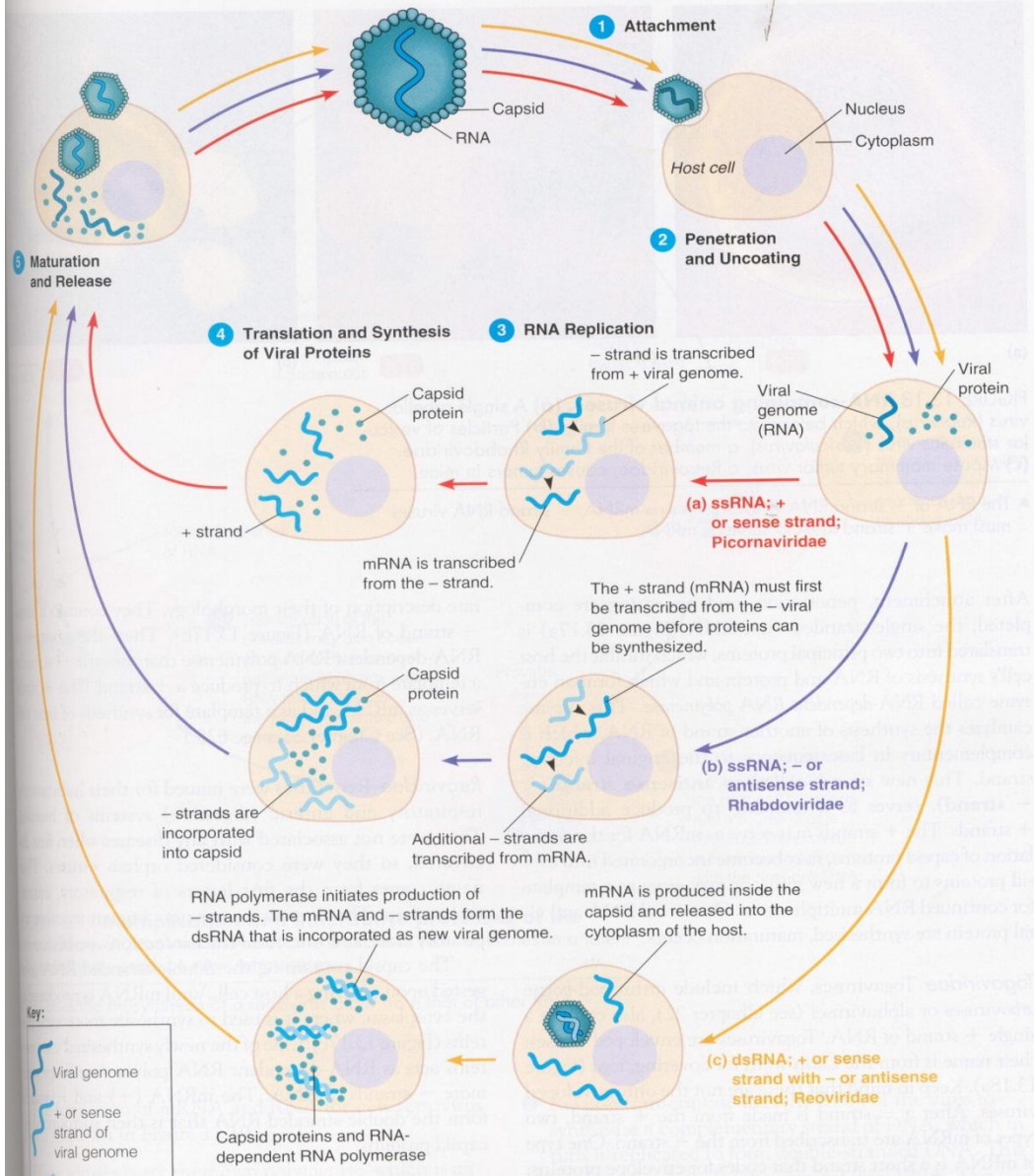
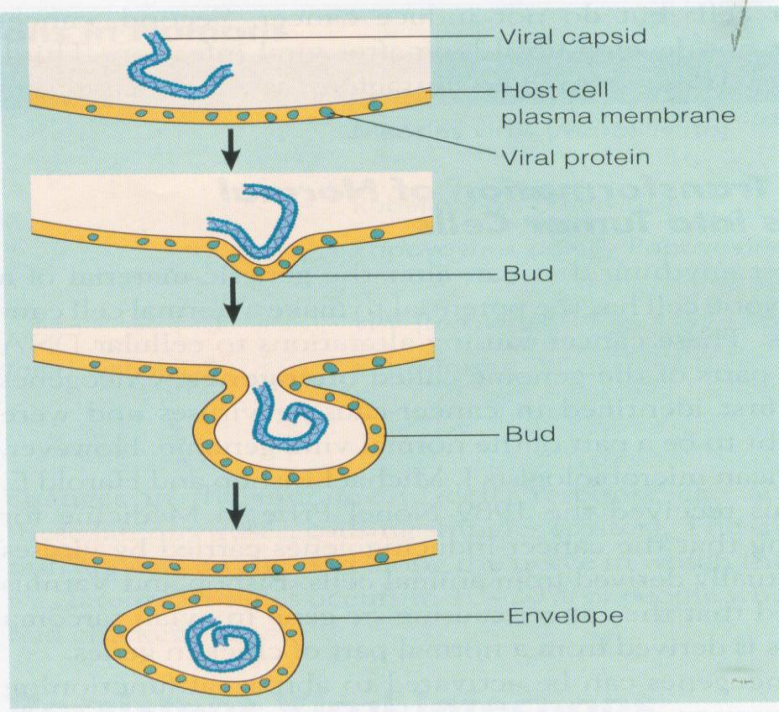
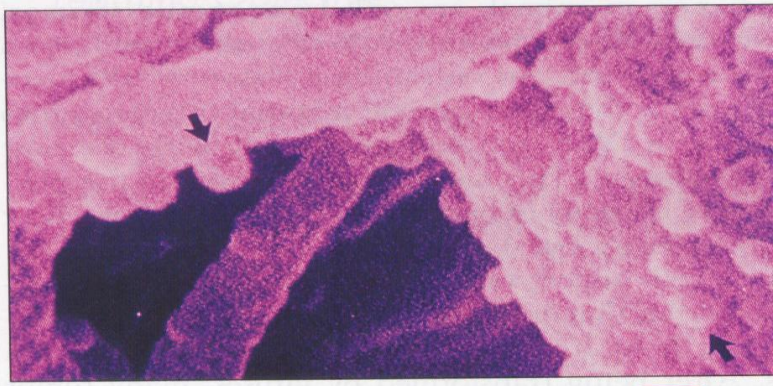


FIGURE 13.17 **Pathways of multiplication used by various RNA-containing viruses. (a)** After uncoating, ssRNA viruses with a + strand genome are able to synthesize proteins directly from their + strand. Using the + strand as a template, they transcribe – strands to produce additional + strands to serve as mRNA and be incorporated into capsid proteins as the viral genome. **(b)** The ssRNA viruses with a – strand genome must transcribe a + strand to serve as mRNA before they begin synthesizing proteins. The mRNA transcribes additional – strands for incorporation into capsid protein. Both ssRNA and **(c)** dsRNA must use mRNA (+ strand) to code for proteins, including capsid proteins.



(a) Release by budding



(b) *Alphavirus*

FIGURE 13.20 **Budding of an enveloped virus.** **(a)** A diagram of the budding process. **(b)** The small "bumps" (at arrow) seen on this freeze-fractured plas membrane are Sindbis virus (*Alphavirus*) particles ca in the act of budding out from an infected cell.

CULTIVATION OF VIRUSES

- Viruses are obligate intracellular parasites; they require living cell system for their cultivation.
- Three kinds of systems have been used:

1. Laboratory animals
2. Embryonated eggs
3. Cell lines (Tissue cultures)

DETECTION OF VIRAL GROWTH IN CELL CULTURE

- Can be detected by the following techniques:

1. Cytopathic effect (CPE)
2. Haemagglutination and haemadsorption
3. Immunofluorescence
4. Interference
5. Transformation.

CYTOPATHIC EFFECT (CPE)

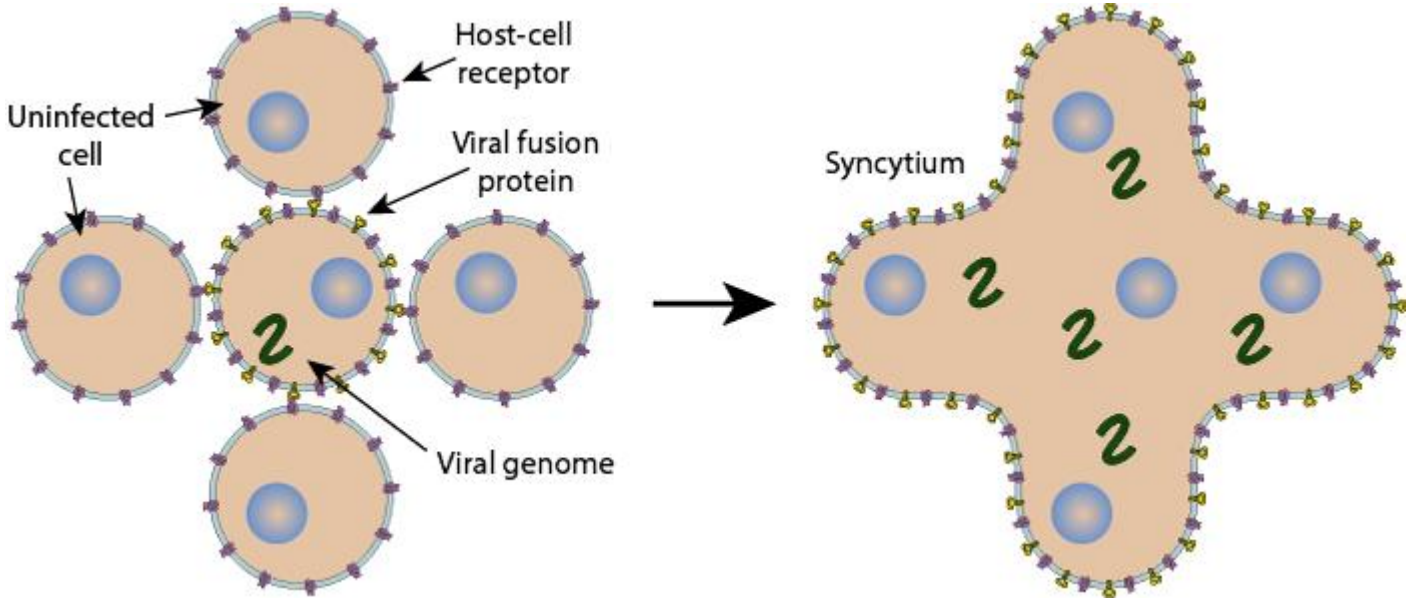
- Many viruses kill the cells in which they grow.
- Some make changes in morphology of host cells.
- Some do not produce CPE.

CYTOPATHIC EFFECT (CPE)

- CPE can be seen under the microscope in stained and unstained cells; these changes include:

1. Rounding of cells
2. Syncytium formation (fusion of an infected cells with neighboring cells leading to the formation of multi-nucleate enlarged cells).
3. Rounding and aggregation like grape-clusters
4. Production of inclusion bodies which are intracytoplasmic or intranuclear aggregates of viral replication can be seen only after staining

Syncytium


Host-cell
receptor
Uninfected
cell
Viral fusion
protein
Viral genome
Syncytium

Hemadsorption

- Some viruses code for red cell agglutinins that are incorporated in the host cell membrane during infection.
- When erythrocytes are added to the infected cell layer, they adhere to the surface of the infected cells.

Immunofluorescence

- Cells from virus infected cultures can be staining with fluorescent-conjugated antiserum and examined under UV light for detection of viral antigen.
- Most sensitive and specific method for detection of viruses in tissue culture.

Interference

- The growth of the non cytopathogenic virus in cell culture can be detected by subsequent challenge with a known cytopathogenic virus.
- The growth of the first virus will inhibit the infection with the second virus by interference.

Transformation

- Oncogenic viruses induce cell transformation, so that growth of cells appears in the piled up fashion due to the formation of micro tumors.

ASSAY OF VIRAL INFECTIVITY

- Measurement of viral infectivity is important for scientific work. Various techniques are now available and used according to the facilities available. Some of these are:

I. Traditional methods

- Plaque assay
- Endpoint dilution assay
- Protein assays
- Transmission Electron Microscopy (TEM)

ASSAY OF VIRAL INFECTIVITY

II. Modern methods

- Tunable Resistive Pulse Sensing (TRPS).
- Flow cytometry.
- Quantitative Polymerase Chain Reaction (qPCR).
- Enzyme-Linked Immunosorbent Assay (ELISA).

Thank You