INTRODUCTION TO VIROLOGY

GENERAL PROPERTIES AND CLASSIFICATION

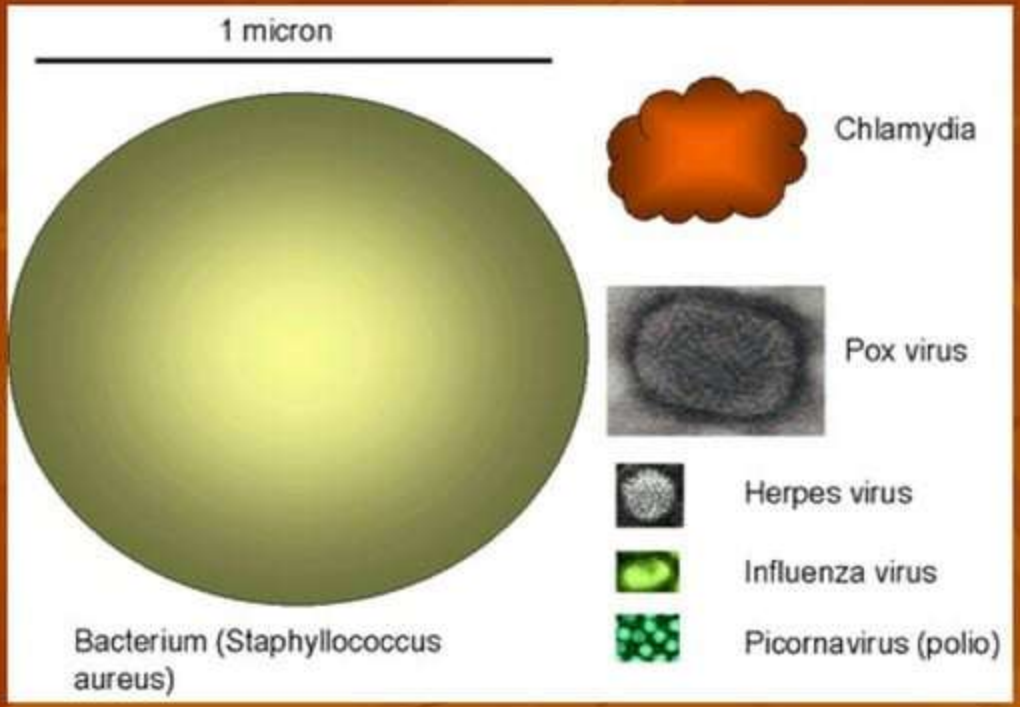
Dr. Farouk
Assistant Professor of Medical Virology
drfarouk_08@live.com

GENERAL PROPERTIES OF VIRUSES

- EducationalObjectives

General:

- 1. To familiarize you with the structural components of the virus, which can act as antigens during the infection process.
- 2. To emphasize the unique nature of viral nucleic acid and its role in the infection process.
- 3. To familiarize you with the morphological types of virus in order that this information can be used in making a diagnosis.
- 4. To develop an understanding of the virus replication cycle in order to appreciate how the physician can interrupt this cycle.


1 micron
Chlamydia
Pox virus
Herpes virus
Influenza virus
Picornavirus (polio)
Bacterium (Staphyllococcus aureus)

General properties and classification of viruses

Three main properties distinguish viruses from other microorganism.

1- Small size.
   - Virus 10 - 300 nm.
   - Bacteria 1000 nm.
   - Erythrocyte 7500 nm.

2- Genome.
   - DNA
   or
   - RNA

3- Metabolically inert. They are totally dependent upon a living cell.

	Growth on artificial media	Division by binary fission	Whether they have both DNA and RNA	Whether they have ribosomes	Whether they have muramic acid	Their sensitivity to antibiotics
Bacteria	Yes	Yes	Yes	Yes	Yes	Yes
Mycoplasma	Yes	Yes	Yes	Yes	No	Yes
Rickettsia	No	Yes	Yes	Yes	Yes	Yes
Chlamydia	No	Yes	Yes	Yes	No	Yes
Viruses	No	No	No	No *	No	No

Structure of viruses.

The structure which make up a virus particle are known as:

- Virion - the intact virus particle.
- Capsid - the protein coat.
- Capsomeres - the protein structure units of which the capsid is composed.
- Nucleic acid - Carrying genetic information.
- Envelope - the particles of many viruses are surrounded by a lipoprotein envelope containing viral antigens.

Factors which affect host range include:

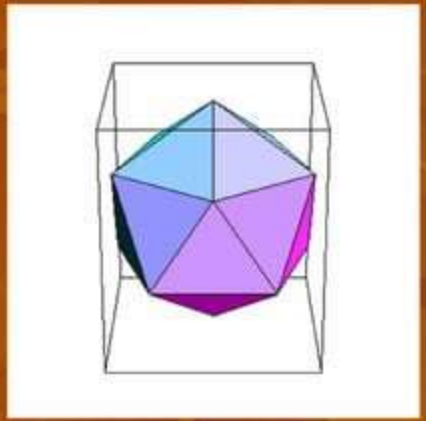
i) Whether the virus can get into the .host cell

ii) If the virus can enter the cell, is the appropriate cellular machinery available for the virus to replicate?

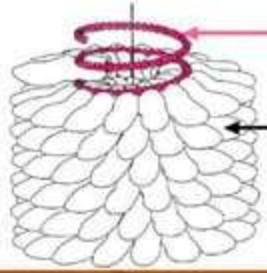
iii) If the virus can replicate, can infectious virus get out of the cell and spread the infection?

FIVE BASIC STRUCTURAL FORMS OF VIRUSES IN NATURE

- **Naked icosahedral** e.g. poliovirus, adenovirus, hepatitis A virus
- **Naked helical e.g. tobacco mosaic virus, so far no human viruses with this structure known**
- **Enveloped icosahedral e.g. herpes virus, yellow fever virus, rubella virus**
- **Enveloped helical e.g. rabies virus, influenza virus, parainfluenza virus, mumps virus, measles virus**
- **Complex e.g. poxvirus**

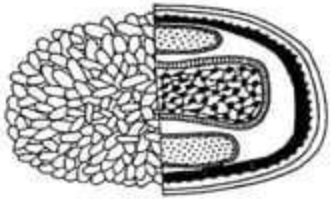


TOBACCO MOSAIC VIRUS



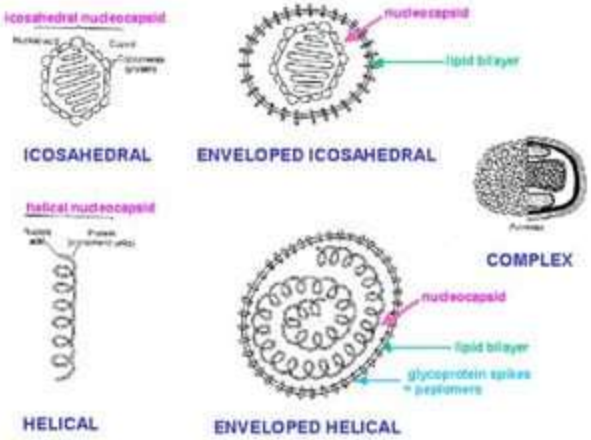
adapted From:
Klug and Caspar Adv. Virus Res. 7:225

COMPLEX SYMMETRY



POXVIRUS FAMILY

5 BASIC TYPES OF VIRAL SYMMETRY



Adapted from Schaeter et al., Mechanisms of Microbial Disease

INTERNATIONAL CLASSIFICATION OF VIRUSES

Primary characteristics used in classification

Viruses are classified according to the nature of their genome and their structure

VIRAL CLASSIFICATION

Nucleic acid:

- RNA or DNA
- Single-stranded or double-stranded
- Non-segmented or segmented
- linear or circular
- If genome is single stranded RNA, can it function as mRNA?
- Whether genome is diploid (it is in retroviruses)

Virion structure:

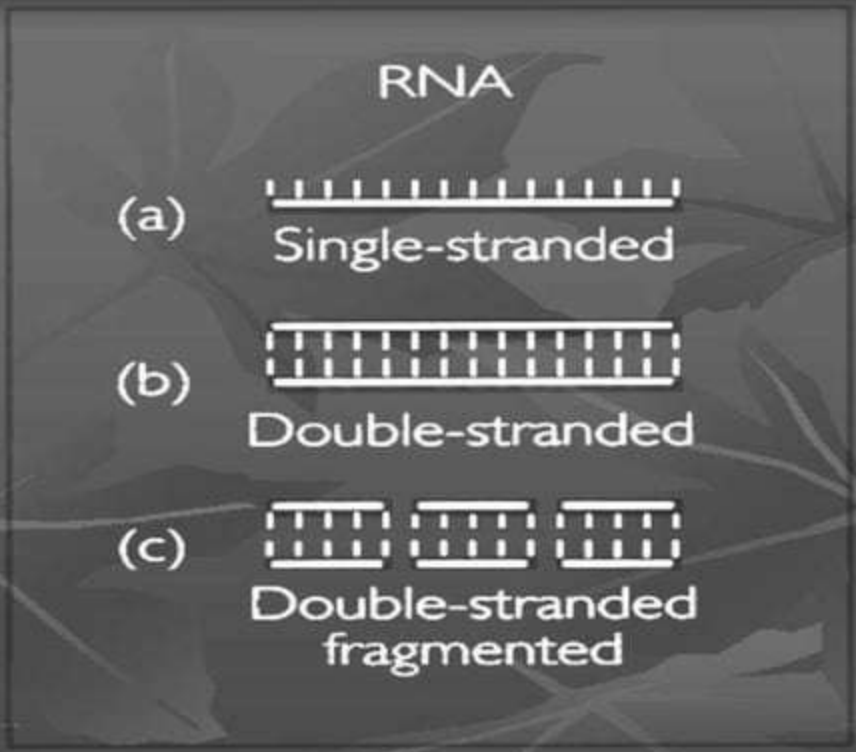
- Symmetry (icosahedral, helical, complex)
- Enveloped or not
- Number of capsomers

- **Virus particles (nucleocapsids) show three types of symmetry:**
  - Cubic (Icosahedral) (e.g. polio virus)
  - Helical (e.g. Influenza virus)
  - Complex (e.g pox viruses)
- **Viral nucleic acids (genomes) structure:**
  * The molecule may be
  - Double stranded, as in higher life forms.

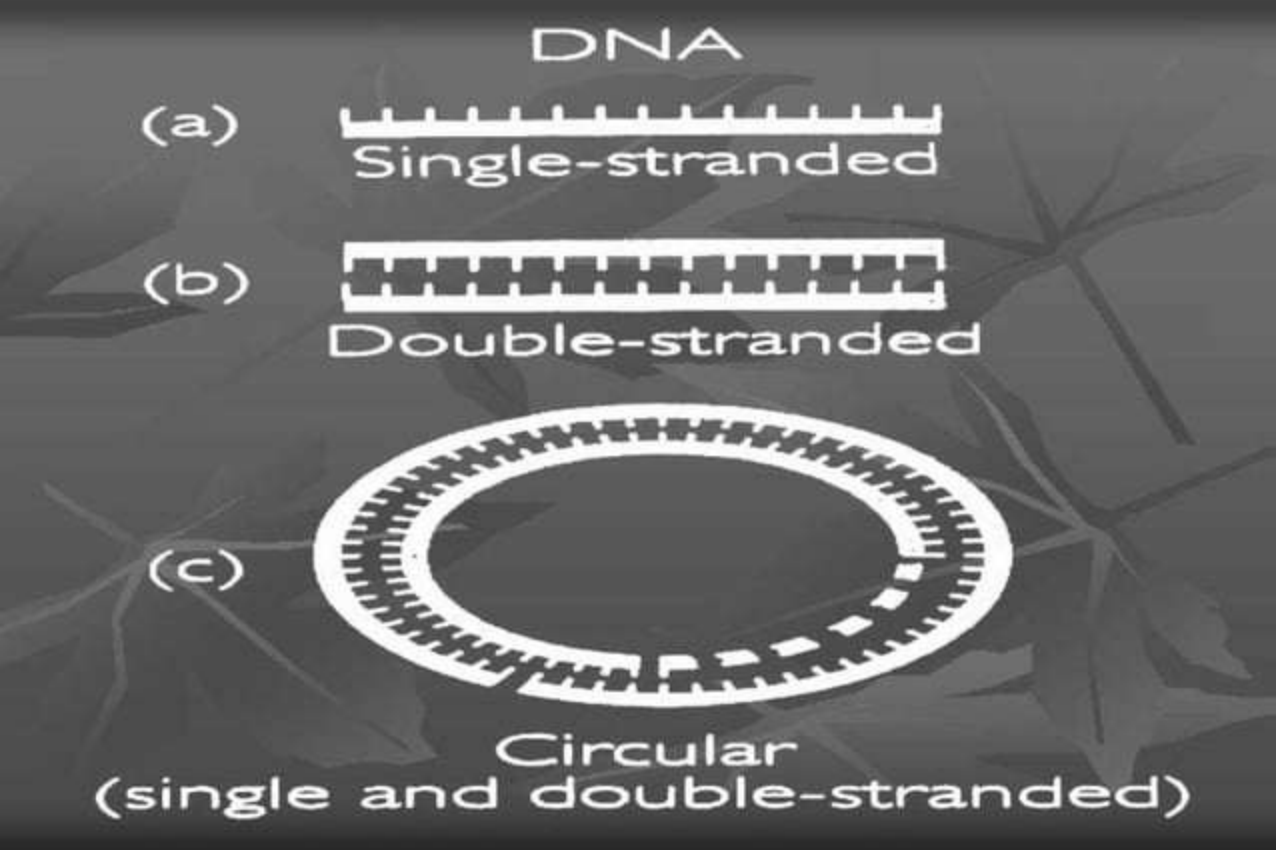
or

  - Single stranded.
  * they may be:
  - Linear
  - Circular
  - Continuous
  - Segmented

- In RNA viruses whose gemone consists of single stranded nucleic acid, the latter is either positive-stranded (can act directly as messenger RNA (mRNA)) or negative-stranded (must be transcribed by a virus-associated RNA transcriptase enzyme to mirror-image positive stranded copy, which is then used as mRNA).



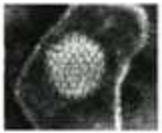
RNA virus genomes.


DNA
(a)
Single-stranded
(b)
Double-stranded
(c)
Circular
(single and double-stranded)

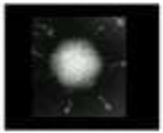
Chemical composition of viruses.

- Viral protein, the structural proteins of viruses have several important functions:
- Facilitate transfer of the viral nucleic acid from one host cell to another;
- Protect the viral genome against inactivation by nucleases.
- Participate in the attachment.
- Provide the structural symmetry of the viral particle;
-Enzymes (which are proteins) are essential for replicative cycle;
-Determine the antigenic characteristics of the virus.
- Viral nucleic acid, encode the genetic information.
- Viral lipids, lipids-containing viruses are sensitive to treatment with ether and other organic solvents, indicating that disruption or loss of lipid result in loss infectivily Non-lipid-containing viruses are generally resistant to ether.
- Viral carbohydrates, viral envelopes contain glycoproteins.
-That attach the viral particle to a target cell.
-The glycoprotein are also important viral antigen.

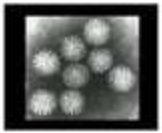
Poxviridae



Herpesviridae

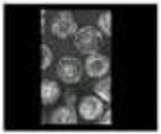


Adenoviridae

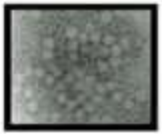


Papovaviridae

human papilloma



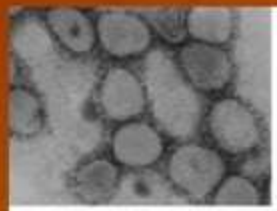
Hepadnaviridae



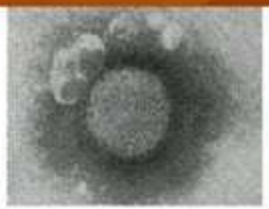
Parvoviridae

DNA Viruses

100 nanometers

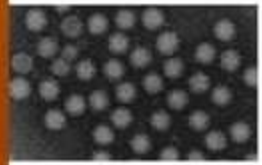


Coronaviridae (NS+)



Arenaviridae (S, ambi)

Picornaviridae (NS+)

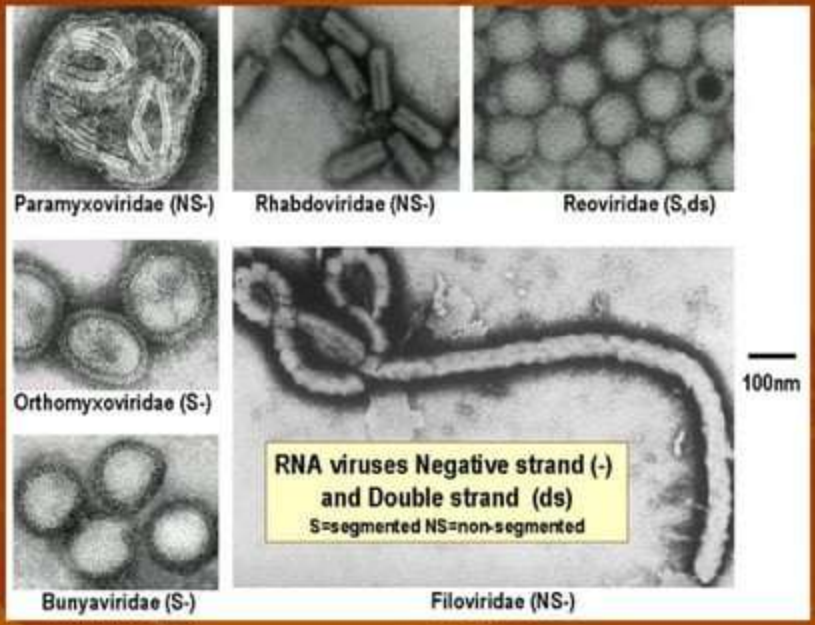


Calciviridae (NS+)

RNA viruses Positive strand (+)

S=segmented NS=non-segmented
Ambi: part + and part -

100nm

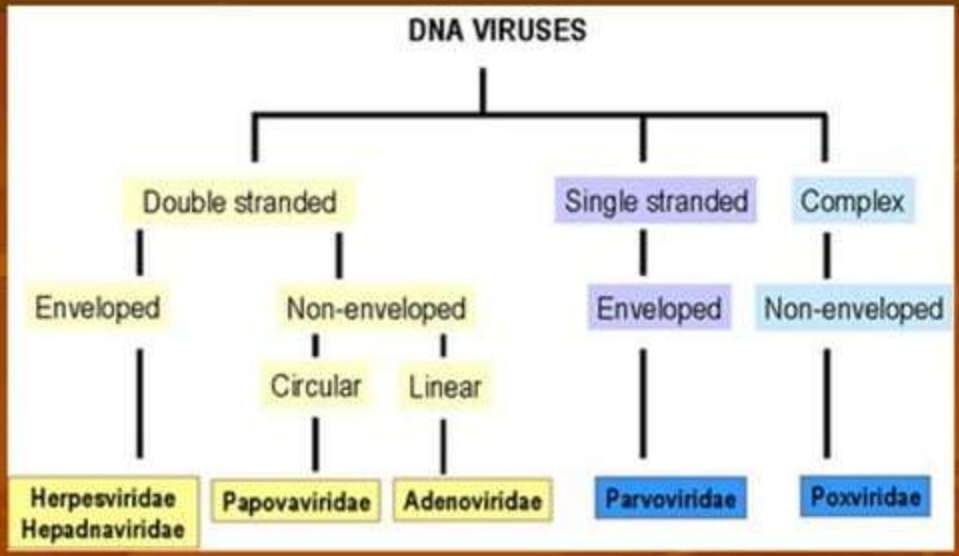

Paramyxoviridae (NS-)
Rhabdoviridae (NS-)
Reoviridae (S,ds)
Orthomyxoviridae (S-)
Bunyaviridae (S-)
RNA viruses Negative strand (-)
and Double strand (ds)
S=segmented NS=non-segmented
Filoviridae (NS-)
100nm

- The main criteria which used for the classification of viruses are:
  - Type of nucleic acid;
  - Number of strands of nucleic acid and their physical construction;
  - Polarity of the viral genome (+ or - stranded) ;
  - The symmetry of the nucleocapsid;
  - The presence or absence of a lipid envelope.

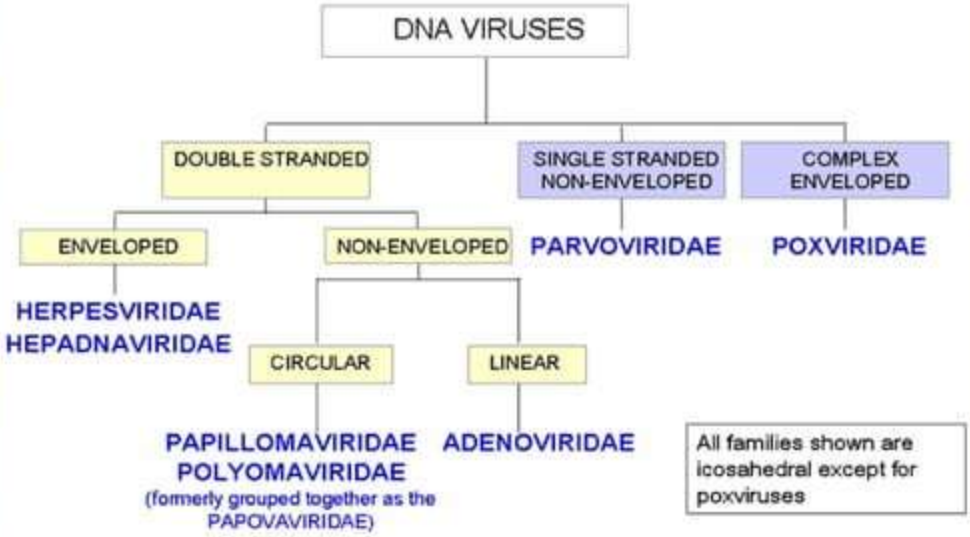
On these criteria, viruses are now grouped into families, subfamilies and genera. Further subdivision based on the degree of antigenic similarity.

For example:

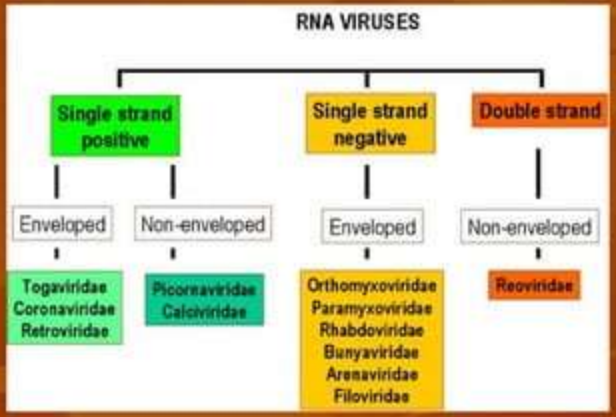
- Family : Parvoviridae
  Subfamily : Parvovirinae
  Genus : Parvovirus
- Family : Herpesviridae
  Subfamily : Alphaherpesvirinae
  Genus : Herpes Simplex viruses
  Genus : Varicella-zoster virus
  Subfamily : Beta herpes virinae
  Genus : Cytomegalo virus
  Genus : Human herpesvirus 6
  Subfamily : Gammaherpes virinae
  Genus : Epstein-Bar virus

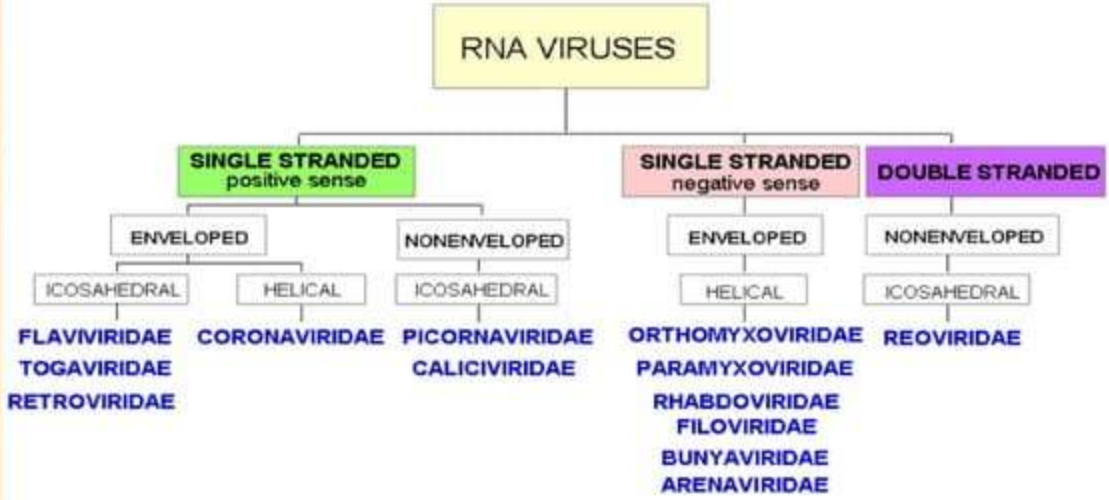


Families of DNA viruses. All families shown are icosahedral except poxviruses



Modified from Volk et al., Essentials of Medical Microbiology, 4th Ed. 1991


RNA VIRUSES
Single strand positive
Single strand negative
Double strand
Enveloped
Non-enveloped
Enveloped
Non-enveloped
Togaviridae
Coronaviridae
Retroviridae
Picornaviridae
Caliciviridae
Orthomyxoviridae
Paramyxoviridae
Rhabdoviridae
Bunyaviridae
Arenaviridae
Filoviridae
Reoviridae



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Summary

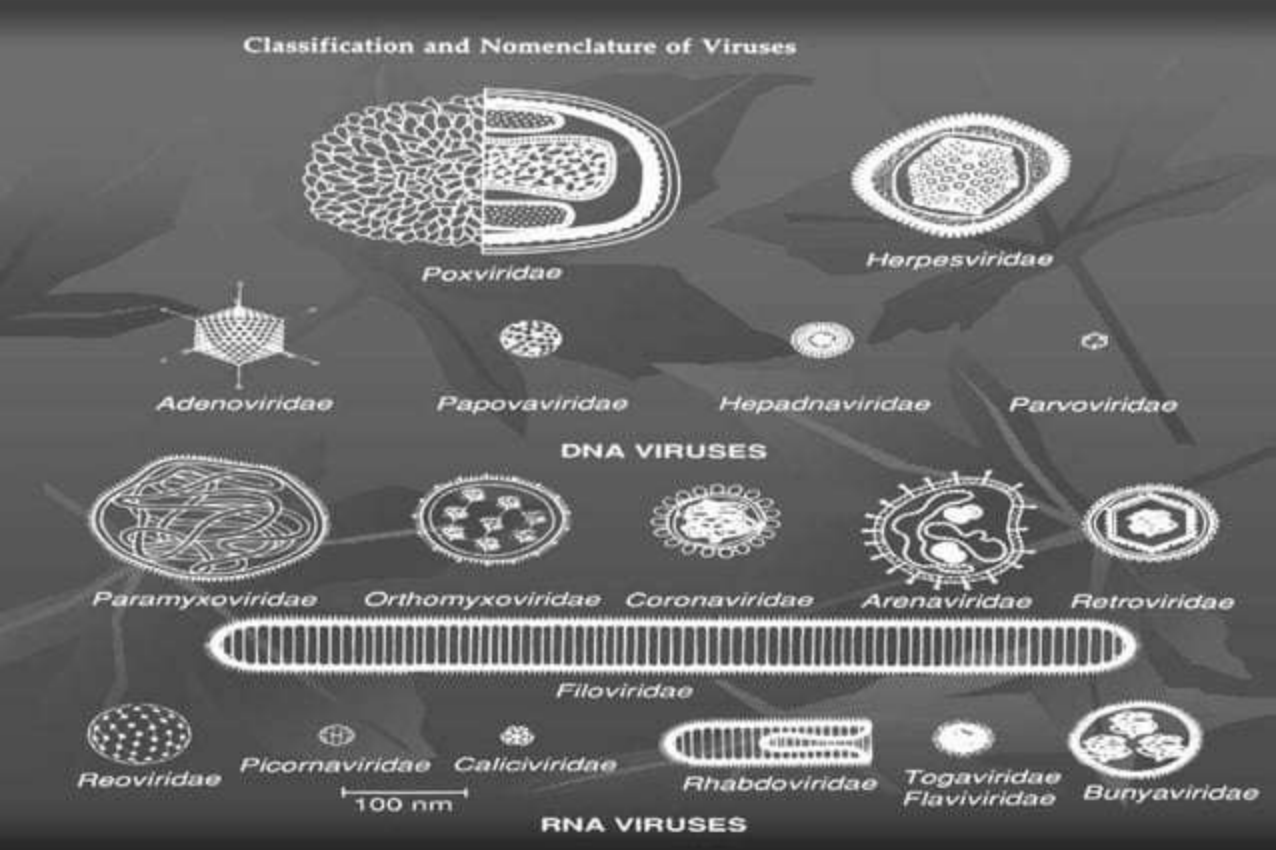
- 1. Viruses contain either DNA or RNA as their genetic material, but not both. This nucleic acid usually has unique chemical and/or physical features which makes it distinguishable from human nucleic acid.
- 2. Viral nucleic acid is enclosed in a capsid made up of protein subunits called protomeres.
- 3. Some species of viruses have a membrane, the envelope, surrounding the capsid; other species do not have an envelope, i.e., they are naked. Enveloped viruses have glyco-protein spikes arising from their envelope. These spikes have enzymatic, absorptive, hemagglutinating and/or antigenic activity.
- 4. The morphology of a virus is determined by the arrangement of the protomeres. When protomeres aggregate into units of five or six (capsomeres) and then condense to form a geometric figure having 20 equal triangular faces and 12 apices, the virus is said to have icosahedral (cubic) morphology. When protomeres aggregate to form a capped tube, they are said to have helical morphology. Any other arrangement of the protomeres results in a complex morphology.

.)Summary (Cont

- 5. All viruses undergo a replication cycle in their human host cell consisting of adsorption, penetration, uncoating, nucleic acid replication, maturation and release stages.
- 6. During the viral replication cycle, an accumulation of mature viruses, incomplete viruses and viral parts occurs within the cell. This accumulation is the inclusion body. The size, shape, location and chemical properties of the inclusion body are used by the pathologist to diagnose viral infectious disease.
- 7. A virally-infected cell generally presents three signals that it is infected. The first is the production of double-stranded RNA, which induces interferon; the second is the expression of viral protein on the surface of the plasma membrane, thus causing activation of cytotoxic T-cells, natural killer cells and sometimes induction of antibody synthesis. The third is the formation of an inclusion body either within the cytoplasm or the nucleus or very rarely within both the cytoplasm and nucleus.

.)Summary (Cont

- 8. In general, all DNA-containing viruses replicate in the host cell nucleus. The exceptions to the rule are the poxviruses.
- 9. In general, all RNA-containing viruses replicate in the host cell cytoplasm. The exceptions to the rule are the retroviruses and the orthomyxoviruses.


Classification and Nomenclature of Viruses
Poxviridae
Herpesviridae
Adenoviridae
Papovaviridae
Hepadnaviridae
Parvoviridae
DNA VIRUSES
Paramyxoviridae
Orthomyxoviridae
Coronaviridae
Arenaviridae
Retroviridae
Filoviridae
Reoviridae
Picornaviridae
Caliciviridae
Rhabdoviridae
Togaviridae
Flaviviridae
Bunyaviridae
100 nm
RNA VIRUSES