

# INTRODUCTION TO VIROLOGY

GENERAL PROPERTIES AND  
CLASSIFICATION

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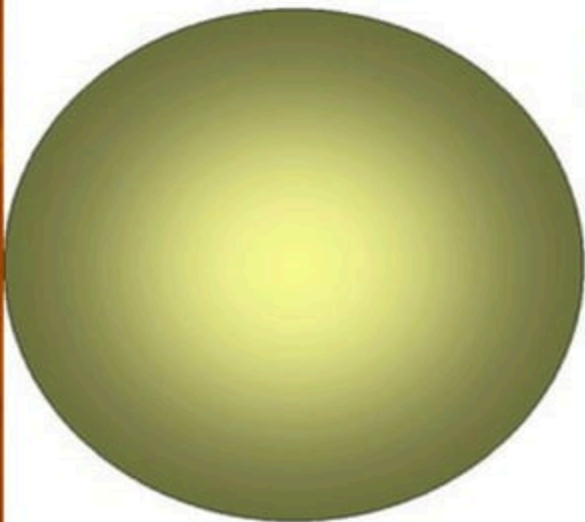
# GENERAL PROPERTIES OF VIRUSES

- Educational Objectives

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



Bacterium (Staphylococcus aureus)



Chlamydia



Pox virus



Herpes virus



Influenza virus



Picornavirus (polio)

## 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
<b>Bacteria</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Mycoplasma</b>	Yes	Yes	Yes	Yes	No	Yes
<b>Rickettsia</b>	No	Yes	Yes	Yes	Yes	Yes
<b>Chlamydia</b>	No	Yes	Yes	Yes	No	Yes
<b>Viruses</b>	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.



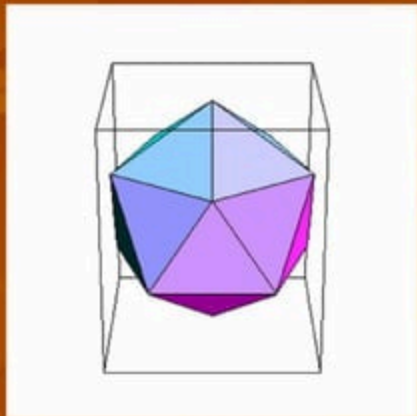
## **Factors which affect host range include:**

- 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?

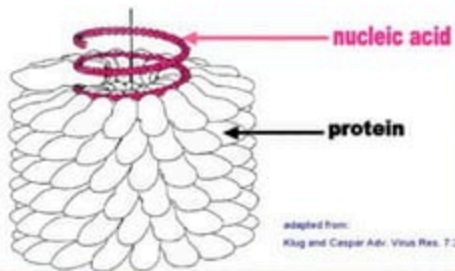
## **FIVE BASIC STRUCTURAL FORMS OF VIRUSES IN NATURE**

- **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

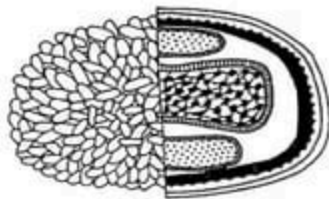




## TOBACCO MOSAIC VIRUS



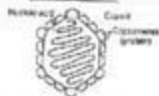
## COMPLEX SYMMETRY



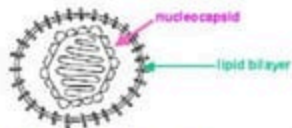
POXVIRUS FAMILY

## 5 BASIC TYPES OF VIRAL SYMMETRY

icosahedral nucleocapsid



ICOSAHEDRAL

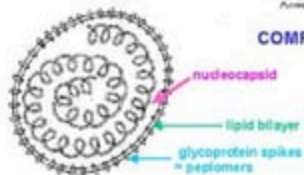


ENVELOPED ICOSAHEDRAL

helical nucleocapsid



HELICAL



ENVELOPED HELICAL



COMPLEX

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 genome 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

- (a)   
Single-stranded
- (b)   
Double-stranded
- (c)   
Double-stranded  
fragmented

RNA virus genomes.

# DNA

(a)   
Single-stranded

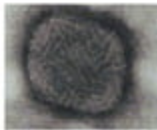
(b)   
Double-stranded

(c)   
Circular  
(single and double-stranded)

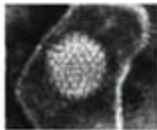


## Chemical composition of viruses.

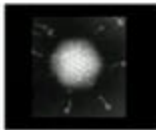
- **Viral protein**, the structural proteins of viruses have several important functions:
  - Facilitate transfer of the viral nucleic acid from one host cell to another;
  - Protect the viral genome against inactivation by nucleases.
  - Participate in the attachment.
  - Provide the structural symmetry 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 infectivity  
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.



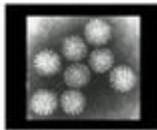
Poxviridae



Herpesviridae

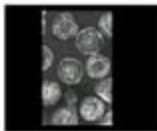


Adenoviridae

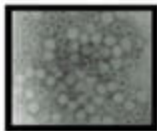


Papovaviridae

human papilloma



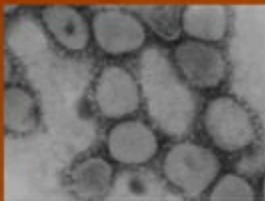
Hepadnaviridae



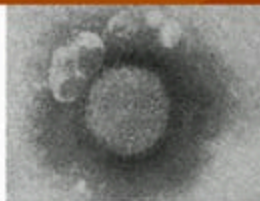
Parvoviridae

## DNA Viruses

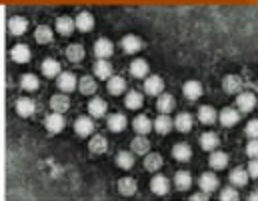
— 100 nanometers



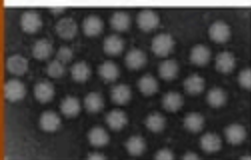
Coronaviridae (NS+)



Arenaviridae (S, ambi)



Picornaviridae (NS+)



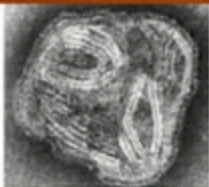
Calciviridae (NS+)

**RNA viruses Positive strand (+)**

S=segmented NS=non-segmented

Ambi: part + and part -

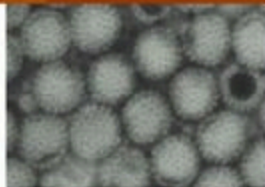
—  
100nm



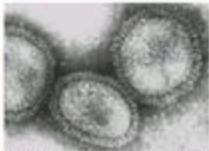
Paramyxoviridae (NS-)



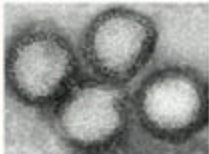
Rhabdoviridae (NS-)



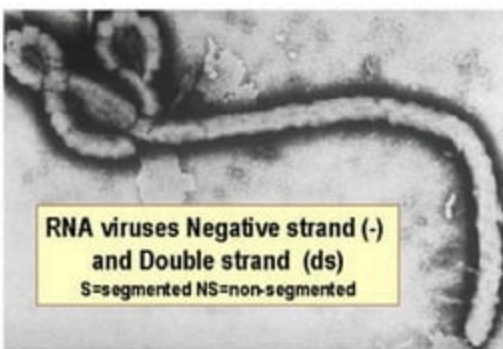
Reoviridae (S, ds)



Orthomyxoviridae (S-)



Bunyaviridae (S-)



100nm

RNA viruses Negative strand (-)  
and Double strand (ds)  
S=segmented NS=non-segmented

Filoviridae (NS-)

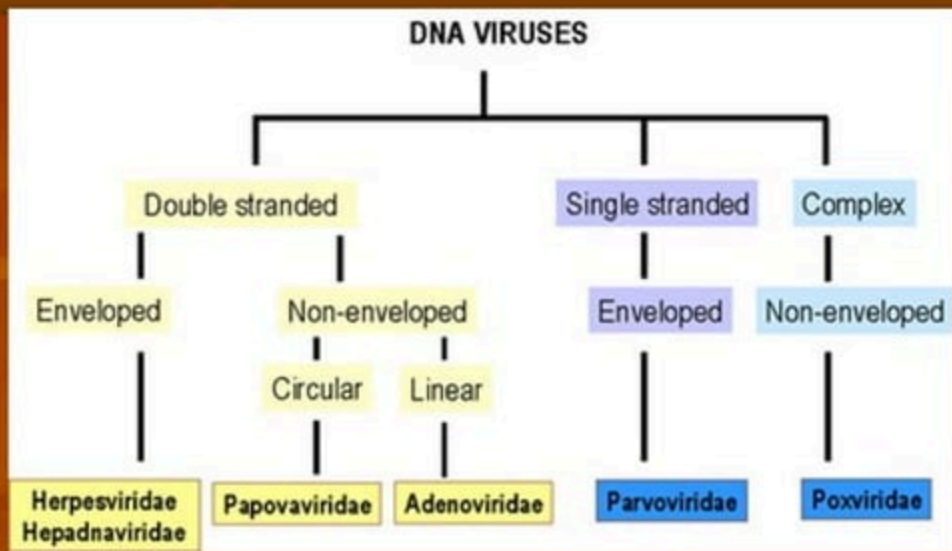
**- The main criteria which used for the classification of viruses are:**

- 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.

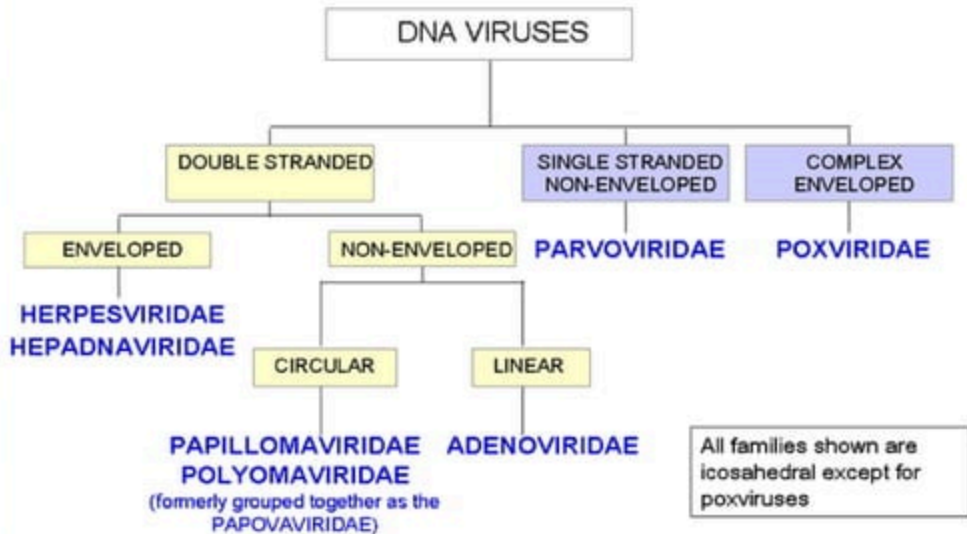
For example:

- 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

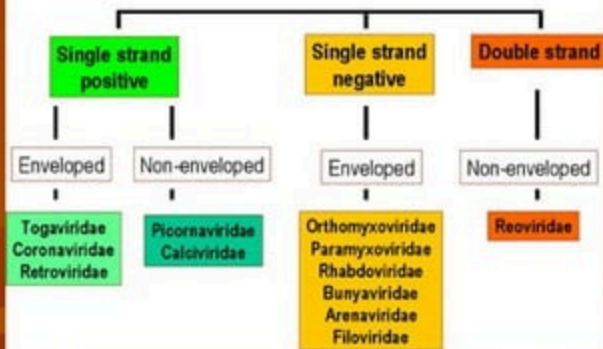


Families of DNA viruses. All families shown are icosahedral except poxviruses

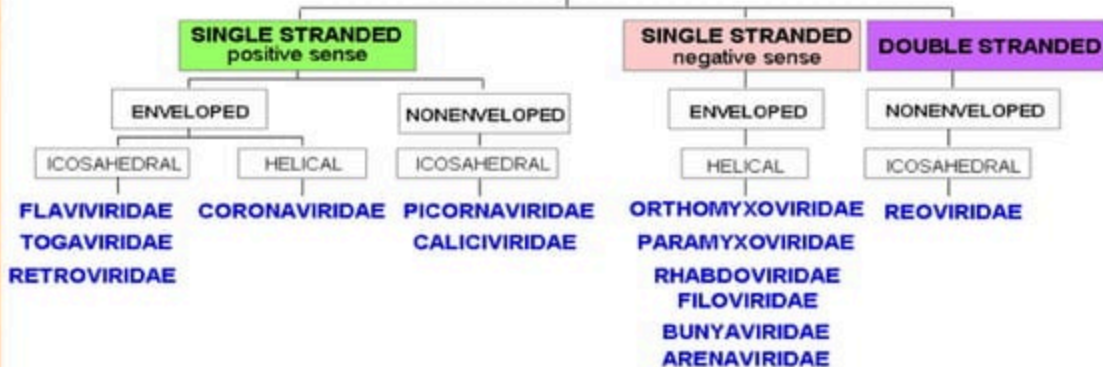




## RNA VIRUSES



# RNA VIRUSES



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

# 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 protomers.
- 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 protomers. When protomers 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 protomers aggregate to form a capped tube, they are said to have helical morphology. Any other arrangement of the protomers 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.

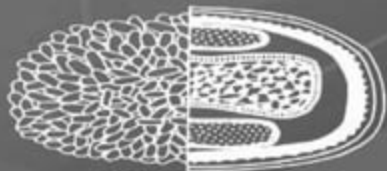


## .)Summary (Cont

- 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