General Virology
Structure and classification

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Objectives:

To understading of : General properties of viruses and the define structure of viruses.

Also, its going through a general classification of viruses depending on different rules. In addition, evolutionary Origin of Viruses and Universal System of Virus Taxonomy are included within objectives.

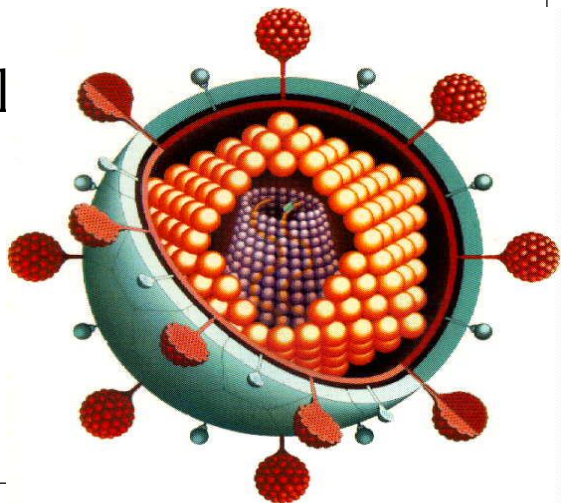
Assessment: Homework, quizzes, examination, poster and mini-research discussion.

References: Main textbook: Medical Microbiology, Jawetz, Melnick 26th ed.,2013

Medical virology

Is the science that deals with the study of medically important viruses infected all forms of life (human, animal, plant), bacteria and fungi.

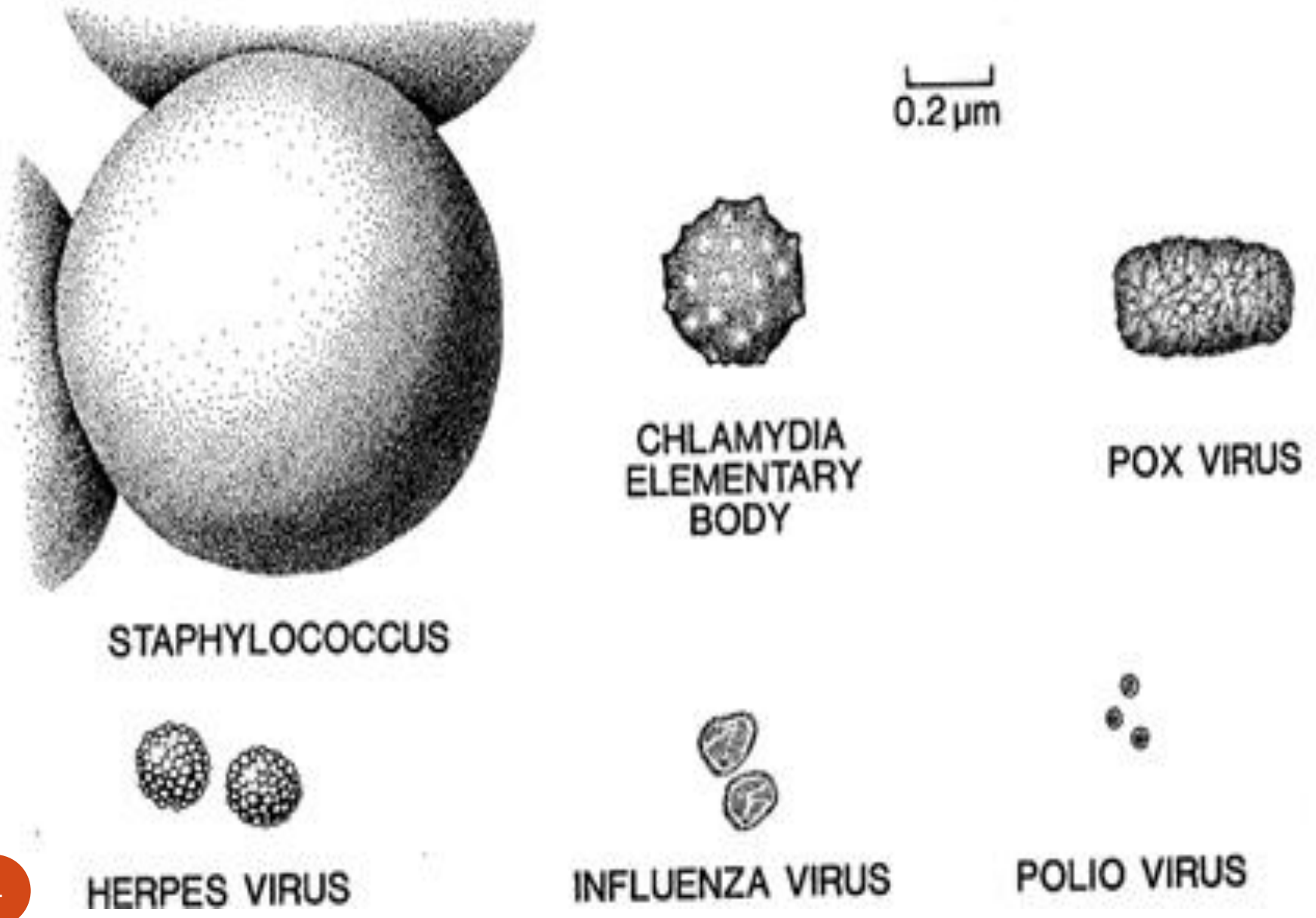
- Viruses: are the smallest infectious agents (20-300nm) in size, composed of nucleic acid surrounding by protein shell which is in some type of viruses surrounding by lipid envelope.
- Viruses are small, sub cellular that are unable to multiply outside a living host cell.
- Containing only one kind of nucleic acid (DNA or RNA) as their genome
- Nucleic acid is enclosed in a protective protein shell surrounded by lipid containing membrane
- Viruses replicate only in living cells.



Viruses differ from other microorganisms in their structure, biology and way of replication

Property	Virus	Bacteria
Size	10-300nm	1000nm
Genome(nucleic acid)	DNA or RNA, but not both	DNA and RNA
Cell wall	Envelope present in some viruses	Have cell wall
Ribosome	No ribosome	Have ribosome
Multiplication by binary fission	(-)	(+)
Sensitivity to antibiotics	(-)	(+)
Growth in culture media	Grow only in living host cells	Grow in culture media

Virus particle = virion



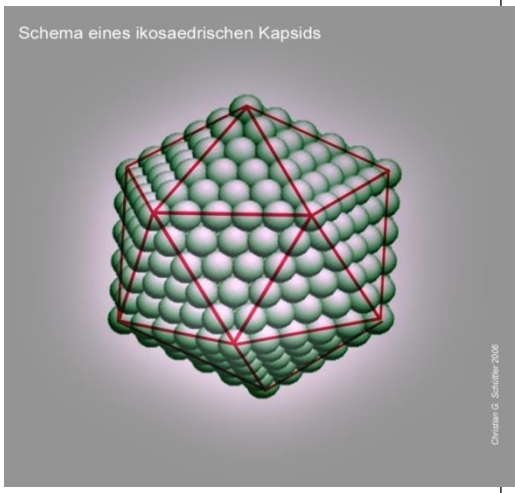
WHAT ARE VIRUSES?

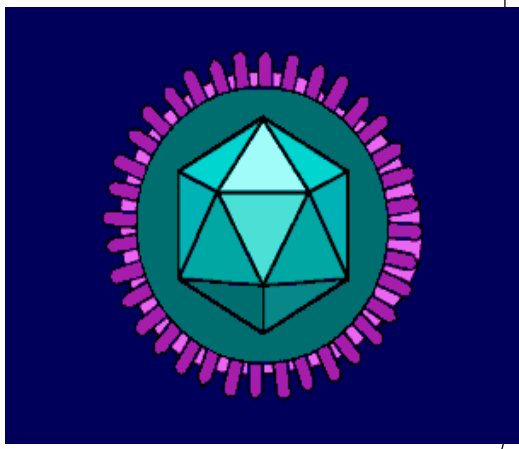
- They are inert in the extracellular environment. Viruses do not posses all the enzyme systems necessary for the synthesis of new viral materials, therefore they are dependent on the parasitized cell for survival and multiplication.
- They are parasite at genetic level.
- Viral nucleic acid containing information causing programming the infected host cell to synthesize number of virus specific macromolecule for the production of virus progeny.
- The coat protein assemble together to form a capsid which stabilize the virus against the extracellular environment (such as nucleases) and facilitate attachment and perform penetration of the virus to the susceptible host cell.
- The virus is obligatory intracellular microorganism , so the virus does not live outside the cell.

VIRAL STRUCTURE – SOME TERMINOLOGY

Capsid:is the outer protein shell, or coat that encloses the nucleic acid genome.
The capsid has specific receptors that are responsible for binding to specific type of cells and it is composed of specific number of identical subunits called Capsomeres
Capsomeres: Morphologic units seen in the electron microscope on the surface of icosahedral virus particles. Capsomeres represent clusters of polypeptides.
Defective virus: A virus particle that is functionally deficient in some aspect of replication.
Envelope: A lipid-containing membrane that surrounds some virus particles. It is acquired during viral maturation by a budding process through a cellular membrane.
Nucleocapsid: The protein-nucleic acid complex representing the packaged form of the viral genome.

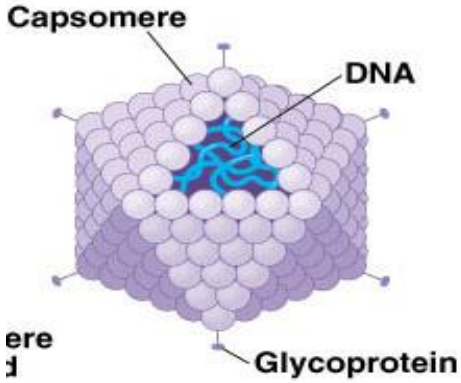
Virion: The complete virus particle. In some instances (eg, papilloma viruses, picorna viruses), the virion is identical with the nucleocapsid.



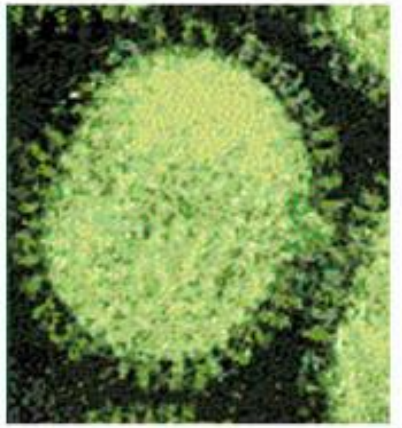


Types of symmetry of virus particles

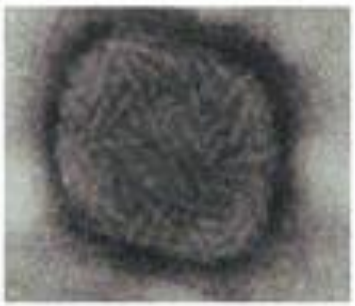
- **Icosahedral symmetry (cubic):** composed of 12 vertices and 20 equal triangular sides, with approximate outline of sphere, e.g Herpes virus and Adenovirus.



- **Helical symmetry:** the capsomeres are arranged like steps in a spiral strain case or hollow, rod shaped, the helix rigid or flexible, e.g influenza and parainfluenza viruses.



- **Complex viruses:** e.g Poxvirus, in which there are many layers around the capsid.



Basis of Classification

The following properties have been used as a basis for the classification of viruses: **A- Based on chemical and physical criteria :**

(1) Virion morphology, including **size, shape, type of symmetry, and presence or absence of membranes.**

(2) Virus genome properties, including:

- **Type of nucleic acid (DNA or RNA).**
- **Size of genome in kilobases (kb) or kilobase pairs (kbp).**
- **strandedness (single or double).**
- **Whether linear or circular**
- **Segments (number, size).**
- **Nucleotide sequence.**
- **G + C content.**
- **Positive or Negative Sense (Polarity).**

- **In some RNA viruses they are positive polarity and in other are negative polarity.....**

1- Positive polarity means that the RNA sequence is as the same as the sequence of mRNA, so do not need transcription.

2- Negative polarity means that the base sequence is different from the sequence of mRNA.

(3) Physicochemical properties of the virion, including:

- **Molecular mass,**
- **pH stability,**
- **Thermal stability,**
- **Susceptibility to physical and chemical agents, especially ether and detergents.**

(4) Virus protein properties, including: **number, size, and functional activities of structural and nonstructural proteins, amino acid sequence, modifications (glycosylation, phosphorylation), and special functional activities (transcriptase, reverse transcriptas ,neuraminidase and fusion activity).**

(5) Genome organization and replication, including:

- **gene order,**
- **Strategy of replication (patterns of transcription, translation).**
- **Cellular sites (accumulation of proteins, virion assembly, virion release).**

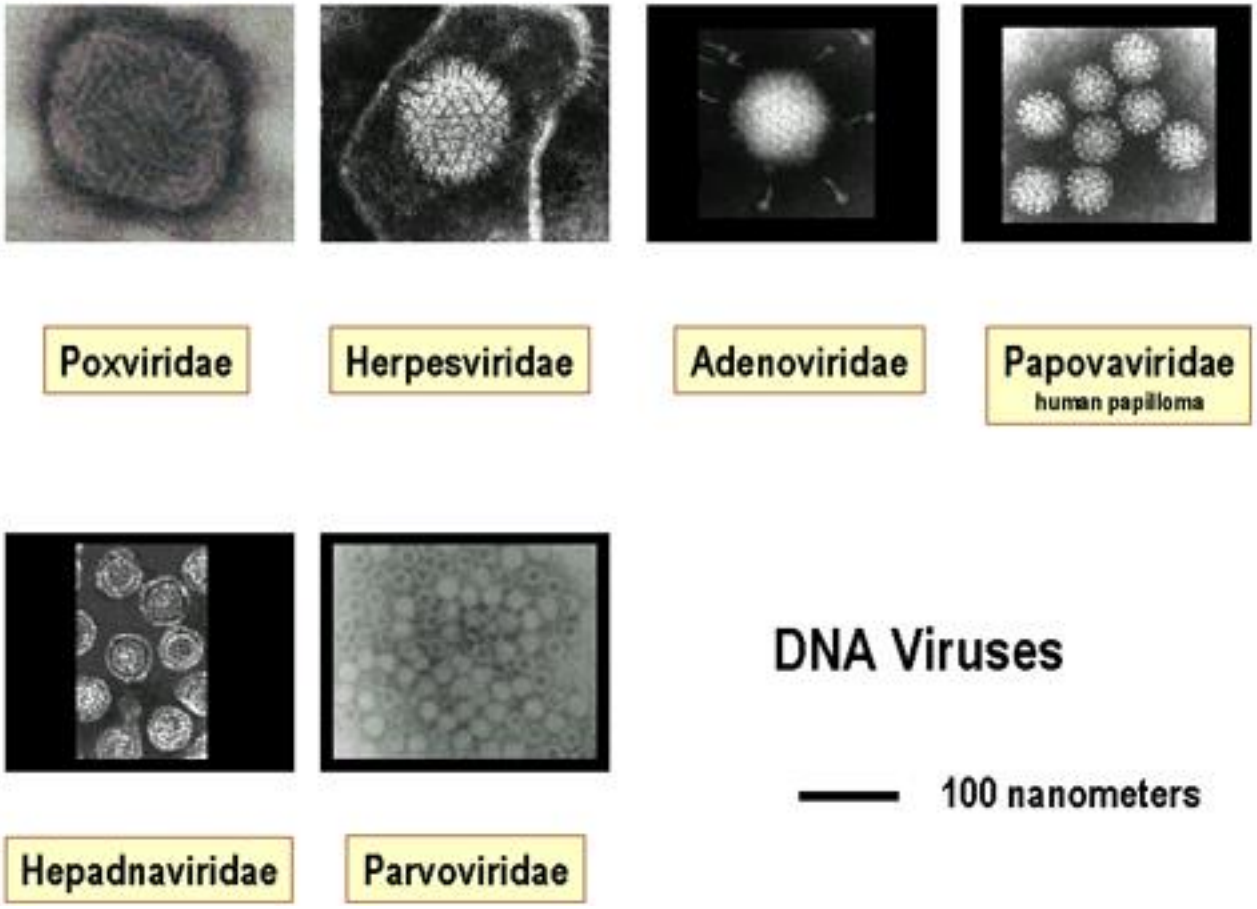
(6) Antigenic properties.

(7) Biologic properties, including:

- **Natural host range.**
- **Mode of transmission.**
- **Vector relationships.**
- **Pathogenicity.**
- **Tissue tropisms and pathology.**

B- Classification of viruses based on nucleic acid genome

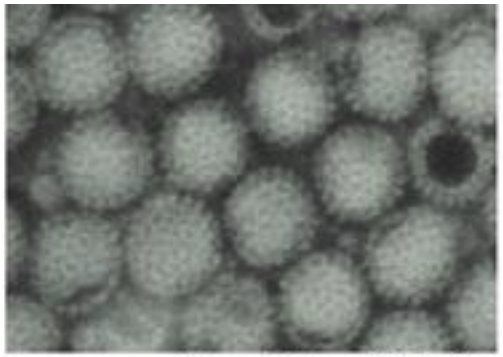
DNA viruses



RNA viruses

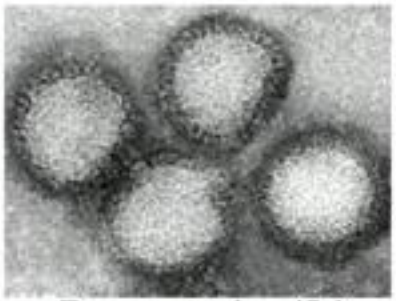
Paramyxoviridae (NS-)

Rhabdoviridae (NS-)

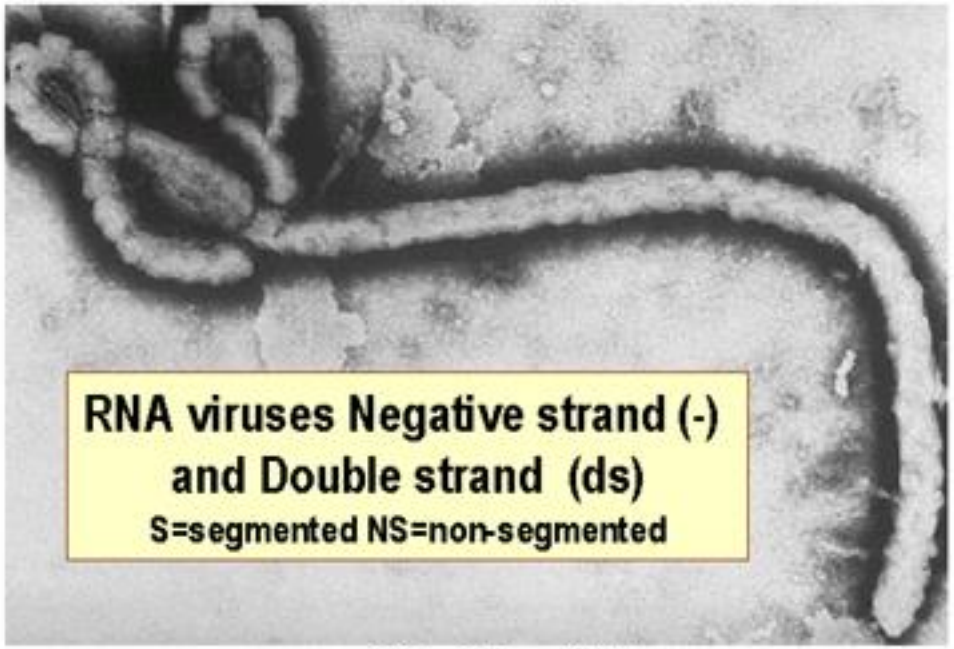


Reoviridae (S,ds)

Orthomyxoviridae (S-)

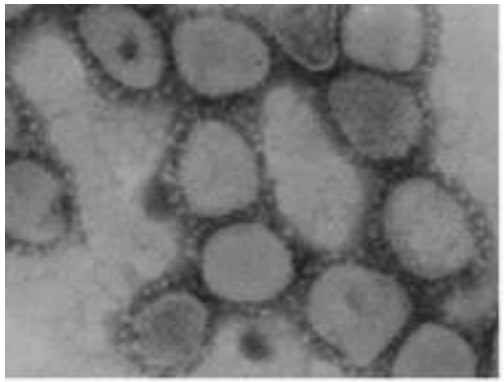


Bunyaviridae (S-)

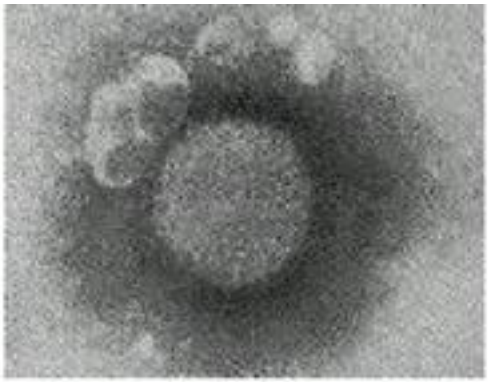


Filoviridae (NS-)

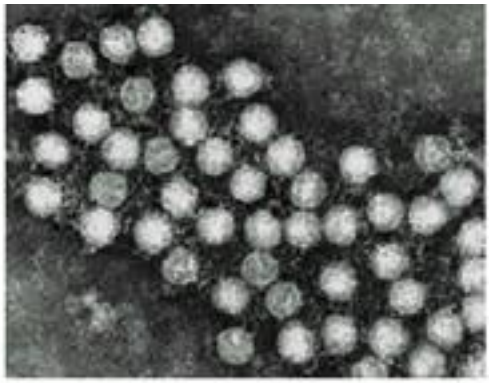
RNA viruses



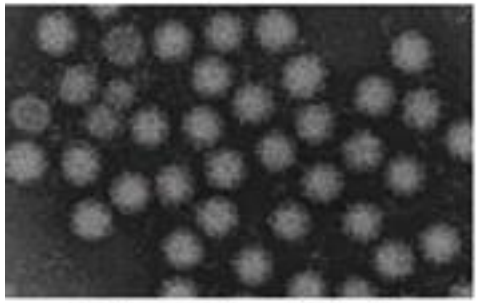
Coronaviridae (NS+)



Arenaviridae (S, ambi)



Picornaviridae (NS+)



Calciviridae (NS+)

RNA viruses Positive strand (+)

S=segmented NS=non-segmented

Ambi: part + and part -

100nm

C- Classification according to diseases they produce:

- Generalized diseases: in which virus is spread throughout the body via blood stream and in which multiple organs are affected, Skin rashes may occur, these include Measles, rubella, chicken pox, yellow fever and Enteroviruses.
- Diseases primarily affected specific organs:

a- Diseases of CNS, such as poliomyelitis, rabies, aseptic meningitis and herpes simplex.

b- Diseases of liver, such as hepatitis type A,B,C,D,E ,yellow fever and rubella virus.

d- Diseases of skin or mucous membranes, such as herpes simplex, molluscum contagiosum, warts and herpes zoster.

e- Diseases of Eye, such asadenovirus, herpes keratoconjunctivitis and epidemic haemorragic conjunctivitis.

f- Diseases of the gastrointestinal tract, such as rotavirus and enteric adenviruses.

g- Sexually transmitted diseases, such as herpes, hepatitis B virus, papilloma viruses, retroviruses (HIV) and cytomegalovirus.

Evolutionary Origin of Viruses

Two theories of viral origin can be summarized as the following

(1) Viruses derived from DNA or RNA nucleic acid of host cells that became able to replicate autonomously and evolve independently (some viral sequences are related to cellular genes encoding protein functional domains.

(2) Viruses degenerate forms of intracellular parasites. There is no evidence that viruses evolved from bacteria, though other obligately intracellular organisms, eg, rickettsiae and chlamydiae, presumably did so.

(However, poxviruses are so large and complex that they might represent evolutionary products of some cellular ancestor)

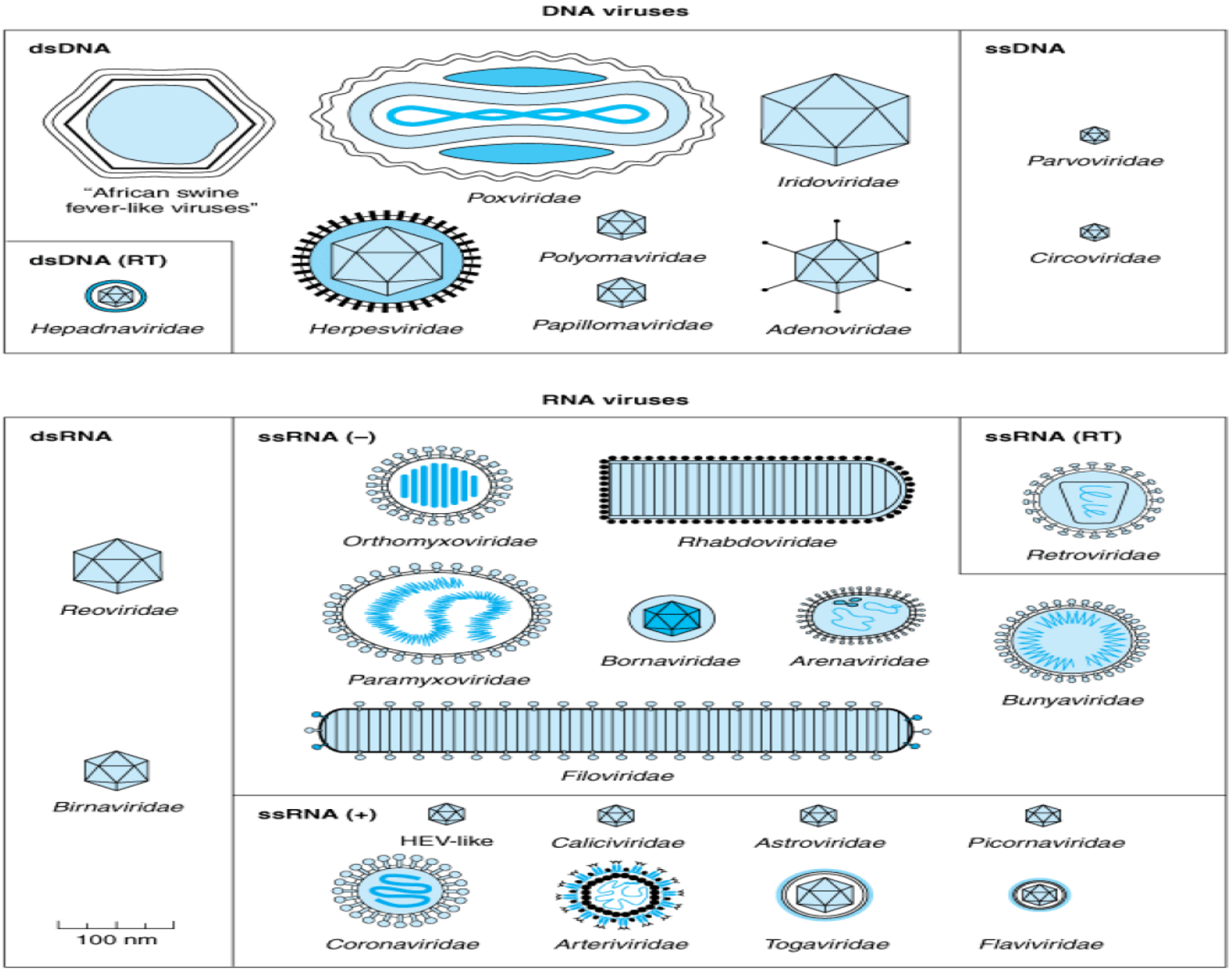
Universal System of Virus Taxonomy

A system has been established in which viruses are separated into major groupings called families on the basis of virion morphology, genome structure, and strategies of replication. Virus family names have the suffix –(viridae). And each family is divided to subfamily (virinae) within each subfamily, subdivisions called genera are usually based on physicochemical or serologic differences. Criteria used to define genera vary from family to family. Genus names carry the suffix (virus).

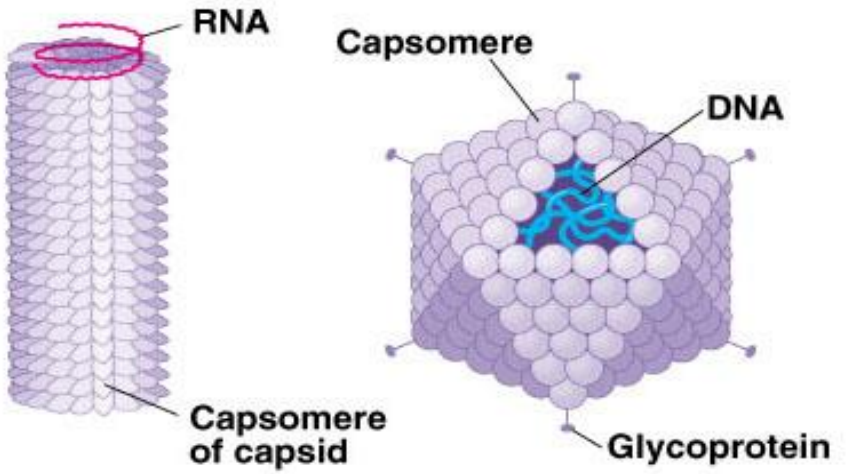
Viruses By 2000, the International Committee on Taxonomy of had organized more than 4000 animal and plant viruses into 56 families, 9 subfamilies, and 233 genera, 24 families contain viruses that infect humans and animals.

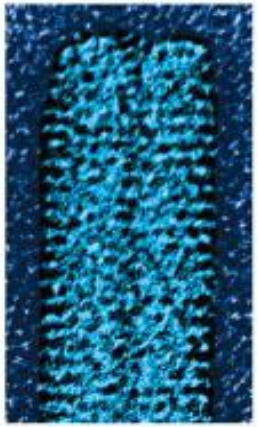
Table 29–1. Families of Animal Viruses that Contain Members Able to Infect Humans.

Nucleic Acid Core	Capsid Symmetry	Virion: Enveloped or Naked	Ether Sensitivity	Number of Capsomeres	Virus Particle Size (nm)[1]	Size of Nucleic Acid in Virion (kb/kbp)	Physical Type of Nucleic Acid[2]	Virus Family
DNA	Icosahedral	Naked	Resistant	32	18–26	5.6	ss	Parvoviridae
				72	45	5	ds circular	Polyomaviridae
				72	55	8	ds circular	Papillomaviridae
				252	70–90	26–45	ds	Adenoviridae
		Enveloped	Sensitive	180	40–48	3.2	ds circular[3]	Hepadnaviridae
				162	150–200	125–240	ds	Herpesviridae
	Complex	Complex coats	Resistant[4]		230 x 400	130–375	ds	Poxviridae
RNA	Icosahedral	Naked	Resistant	32	28–30	7.2–8.4	ss	Picornaviridae
					28–30	6.4–7.4	ss	Astroviridae
				32	27–40	7.4–8.3	ss	Caliciviridae
					60–80	16–27	ds segmented	Reoviridae
		Enveloped	Sensitive	42	50–70	9.7–11.8	ss	Togaviridae
	Unknown or complex	Enveloped	Sensitive		40–60	9.5–12.5	ss	Flaviviridae
					50–300	10–14	ss segmented	Arenaviridae
					120–160	27–32	ss	Coronaviridae
					80–110	7–11[5]	ss diploid	Retroviridae
	Helical	Enveloped	Sensitive		80–120	10–13.6	ss segmented	Orthomyxoviridae
					80–120	11–21	ss segmented	Bunyaviridae
					80–125	8.5–10.5	ss	Bornaviridae
					75 x 180	13–16	ss	Rhabdoviridae

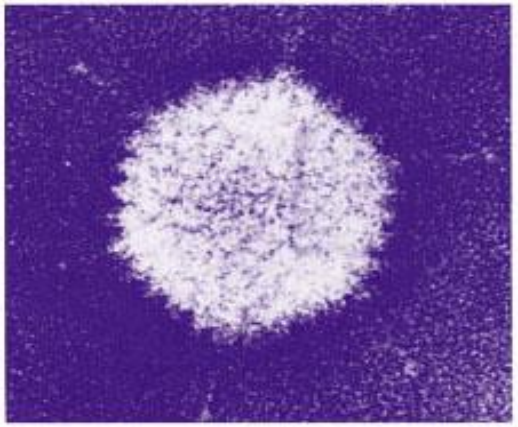


Source: Brooks GF, Butel JS, Morse SA: *Jawetz, Melnick, & Adelberg's Medical Microbiology*, 24th Edition: http://www.accessmedicine.com

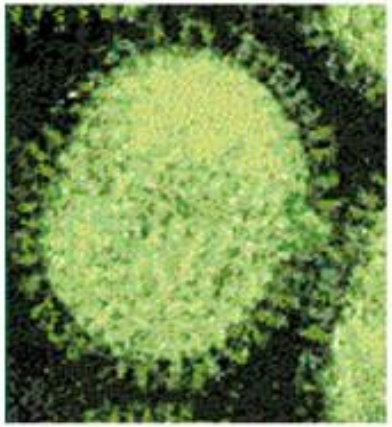



10 nm

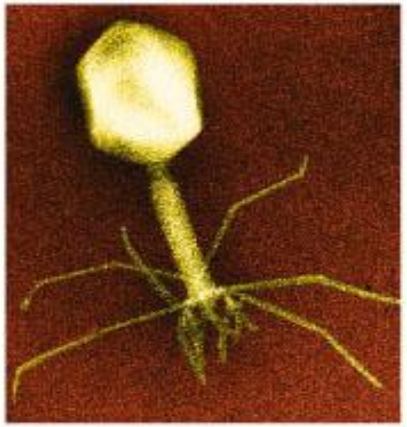
(a) Tobacco mosaic virus


50 nm

(b) Adenoviruses


50 nm

(c) Influenza viruses


50 nm

(d) Bacteriophage T4

Thank you

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