# Lect.2
# Classification of animals viruses

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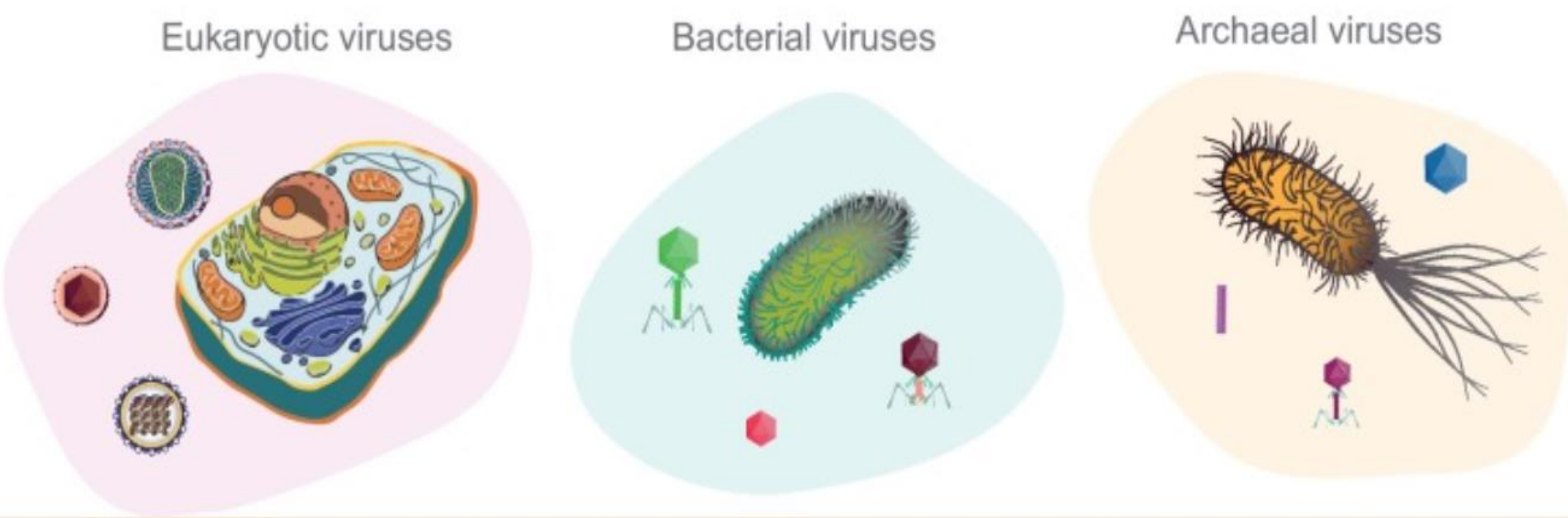
## Classification of viruses

- In the early days, viruses were discovered as the etiological agents of the disease they caused. Then, viruses were named after, and often classified based on, the diseases that they caused, such as yellow fever virus, and rabies virus.
- Until the 1980s we had no genome sequences; hence most categories were based on other properties, such as the size of the virus particle, whether or not it has a membrane, its type of symmetry, and much more.
- Establishing of the genome-based classification was correlated to molecular technologies. The nucleotide sequence relatedness allows a more precise classification of virus species. Furthermore, the genome-based classification allows to predict the mode of viral genome replication. Today it is s all about the genome
- For instance, SARS virus, a new emerging virus in 2003, was immediately identified as a new member of the coronavirus family by the nucleotide sequence analysis.

# Host Domain classification




Host Domain classification groups viruses based on the host domain that they infect. Three groups are formed: eukaryotic, bacterial and archaeal viruses

# Systems of classification

**Virus taxonomy is an essential element in the description of viruses and acts as a unified catalogue of their vast diversity and genetic interrelationships**

**3 Systems**

- **Hierarchical virus classification system**
- **Baltimore virus classification system**
- **International Committee for Taxonomy of Viruses**

# Hierarchical system

- **Proposed by Andre Lwoff, R. W. Horne and P. Tournier in the year 1962**
- **On the basis of shared properties viruses are grouped at different hierarchical levels of order, family, subfamily, genus and species.**

On the basis of shared properties viruses are grouped at different hierarchical levels of order, family, subfamily, genus and species.

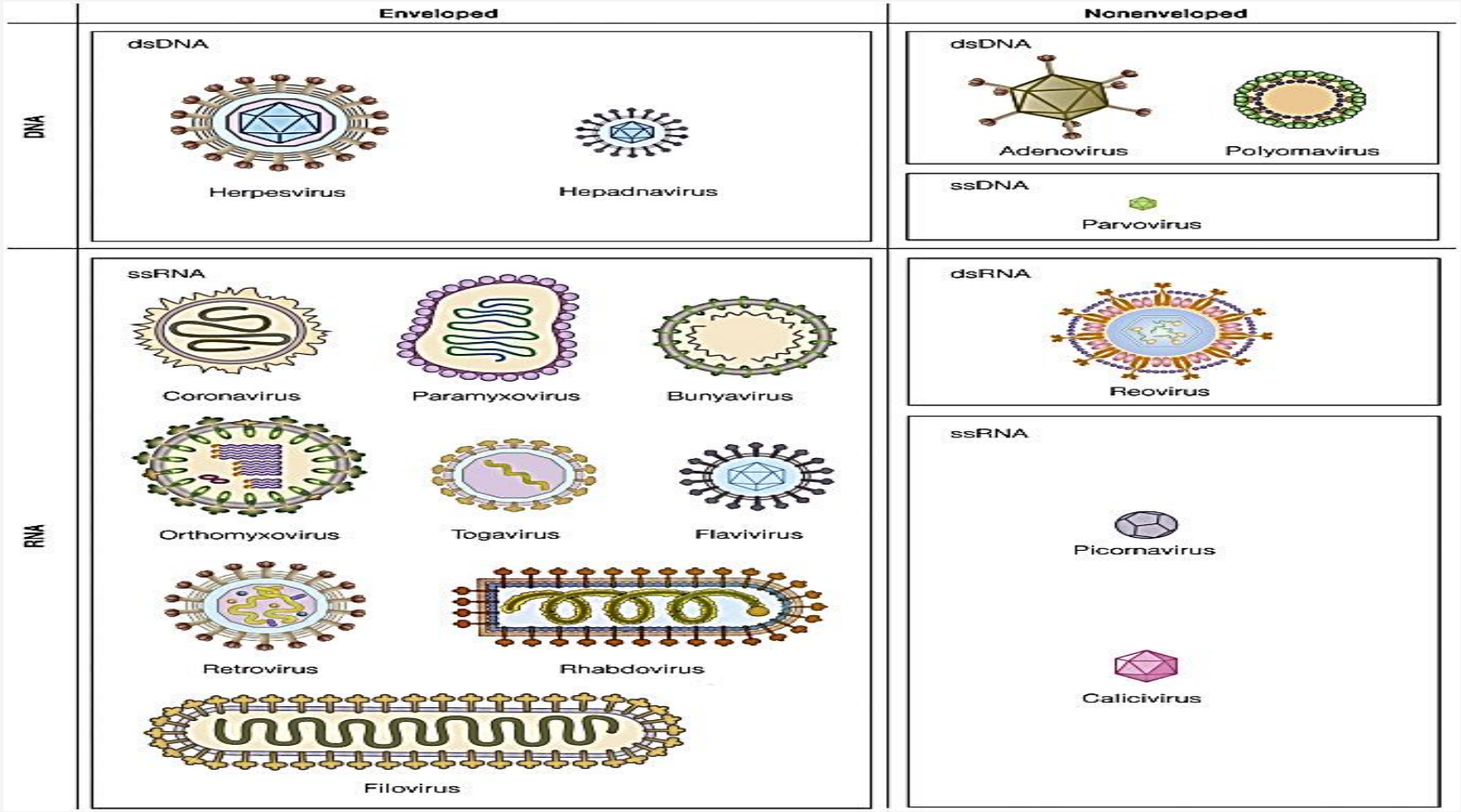
More than 30,000 different virus isolates are known and grouped in more than 3,600 species, in 164 genera and 71 families. Viral morphology provides the basis for grouping viruses into families.

A virus family may consist of members that replicate only in vertebrates, only in invertebrates, only in plants, or only in bacteria. Certain families contain viruses that replicate in more than one of these hosts

- **Characters used in classification**
  - ❑ **Nature of the nucleic acid: RNA or DNA**
  - ❑ **Symmetry of the capsid**
  - ❑ **Presence or absence of an envelope**
  - ❑ **Dimensions of the virion and capsid**
  - ➢ **Orders to have suffix –*virales* e.g *Mononegavirales***
  - ➢ **Families to have the suffix -*viridae* e.g. *Paramyxoviridae*, *Picornaviridae*, *Reoviridae***
  - ➢ **Sub-family to have the suffix –*virinae* e.g *Alphaherpesvirinae***
  - ➢ **Genus to have the suffix –*virus* e.g *Avulavirus***
  - ➢ **Species – difficult to define, more subjective.**

The nature of the nucleic acids in the genome is the criteria of the genome-based classification.

- Animal nature of the nucleic genome (ie, DNA or RNA).
- morphological features according to the existence of envelope, it can be called either an enveloped virus or naked (nonenveloped virus).

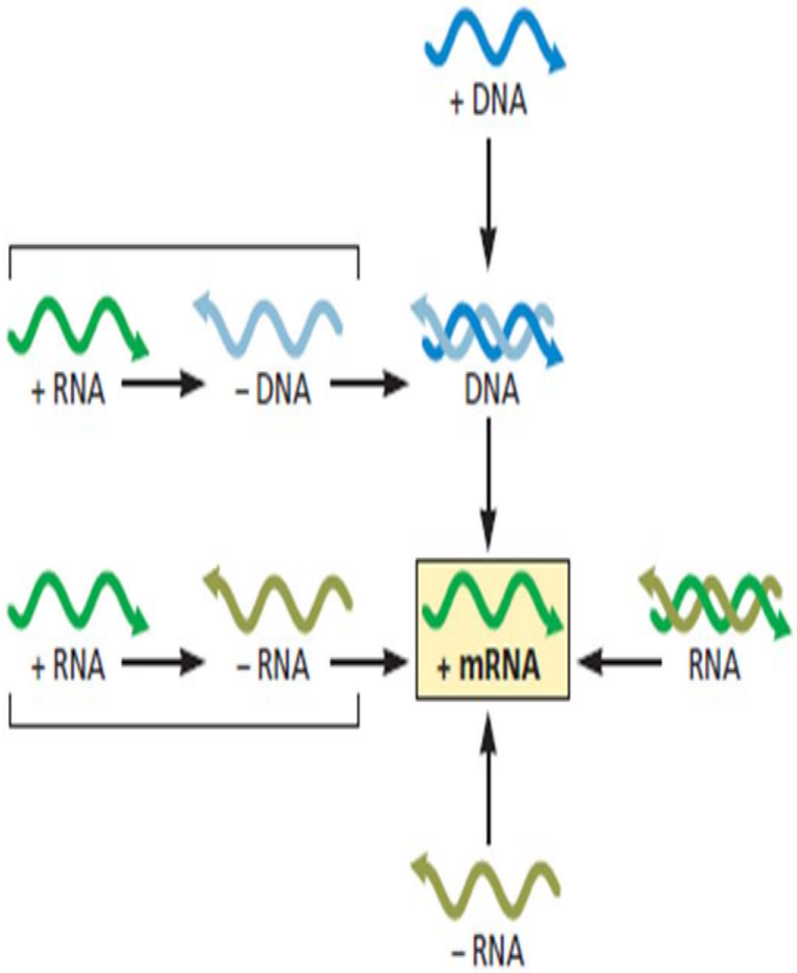


# Classification by Genome Type: the Baltimore System

**The most commonly used system of virus classification was developed by Nobel Prize-winning biologist David Baltimore in the early 1970s.**
**In addition to the differences in morphology and genetics mentioned above, the Baltimore**
**All viruses must direct the synthesis of mRNA that is decoded by the host's translational machinery**
Baltimore had introduced a non-hierarchical classification of viruses which groups viruses into just seven (originally six) classes according to their genome type and its relation to the synthesis of mRNA.

I. Double-stranded DNA .
II. Single-stranded DNA.
III. Double-stranded RNA,
IV. Positive-sense RNA,
V. Negative-sense RNA,
VI. Reverse-transcribing RNA
VII. Reverse-transcribing DNA

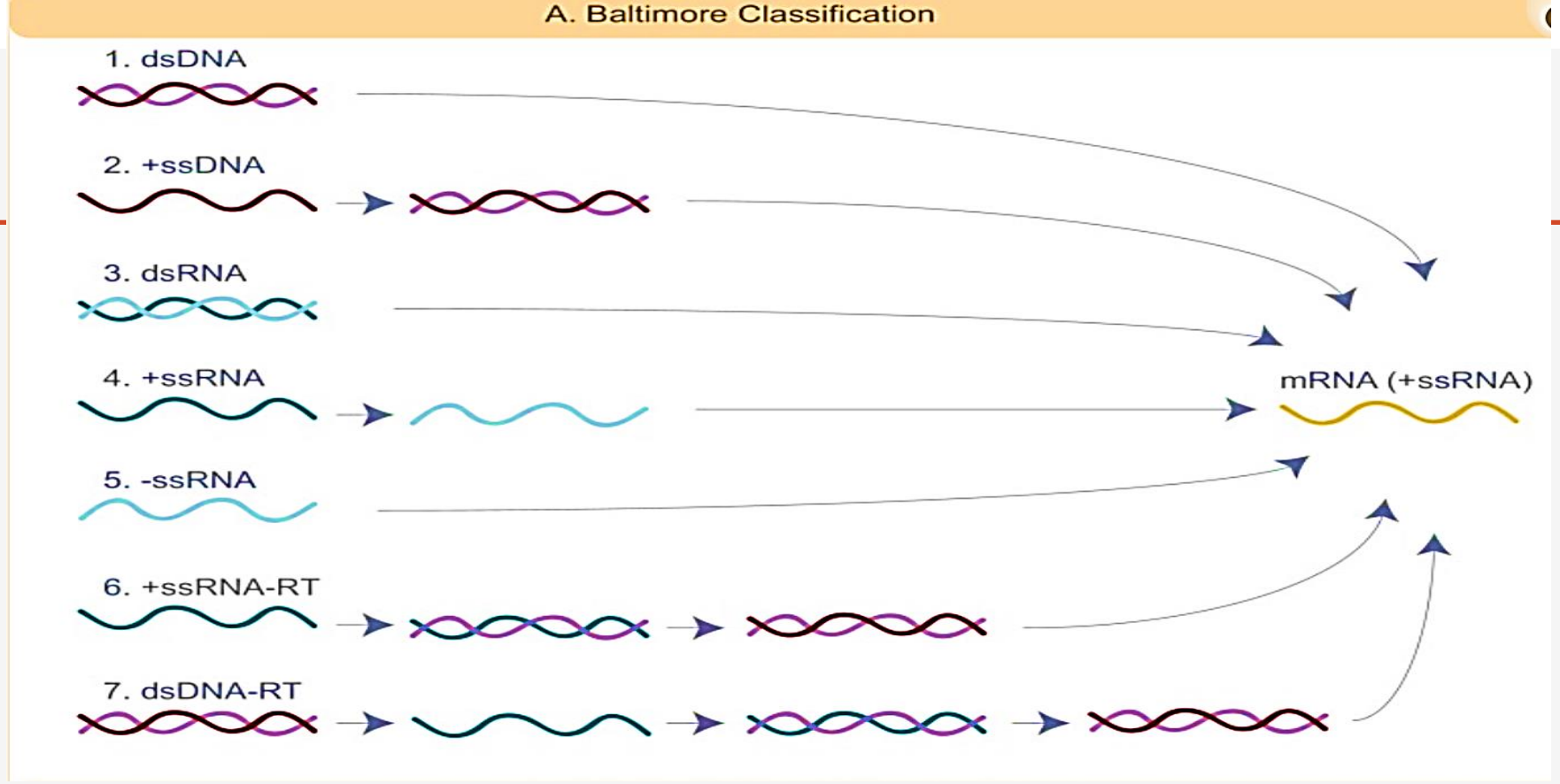
**classification scheme groups viruses according to how the mRNA is produced during the replicative cycle of the virus.**
**DNA → RNA → protein**




## BOX 1.2 Baltimore Classification

David Baltimore was the one who proposed the genome-based classification of animal viruses. It was a truly visionary insight that foretold the era of molecular virology. Undoubtedly, the Baltimore classification serves as a gold standard of virus classification. In addition to his contribution as a virologist, Baltimore has profoundly influenced international science, including key contributions to immunology, virology, cancer research, biotechnology, and recombinant DNA research, through his accomplishments as a researcher, administrator, educator, and public advocate for science and engineering. He shared the Nobel Prize in 1975 with Howard Temin for the discovery of reverse transcriptase (see Box 17.1) at the age of only 37. Even afterward, he continued to be productive as a research scientist not only in virology but also in the field of immunology. He is also well known as the discoverer of transcription factor NF-kB. In addition, his contribution extended to his role as a university administrator. He has served as the president of California Institute of Technology (Caltech) from 1997 to 2006. He is currently the President Emeritus and Robert Andrews Millikan Professor of Biology at Caltech.

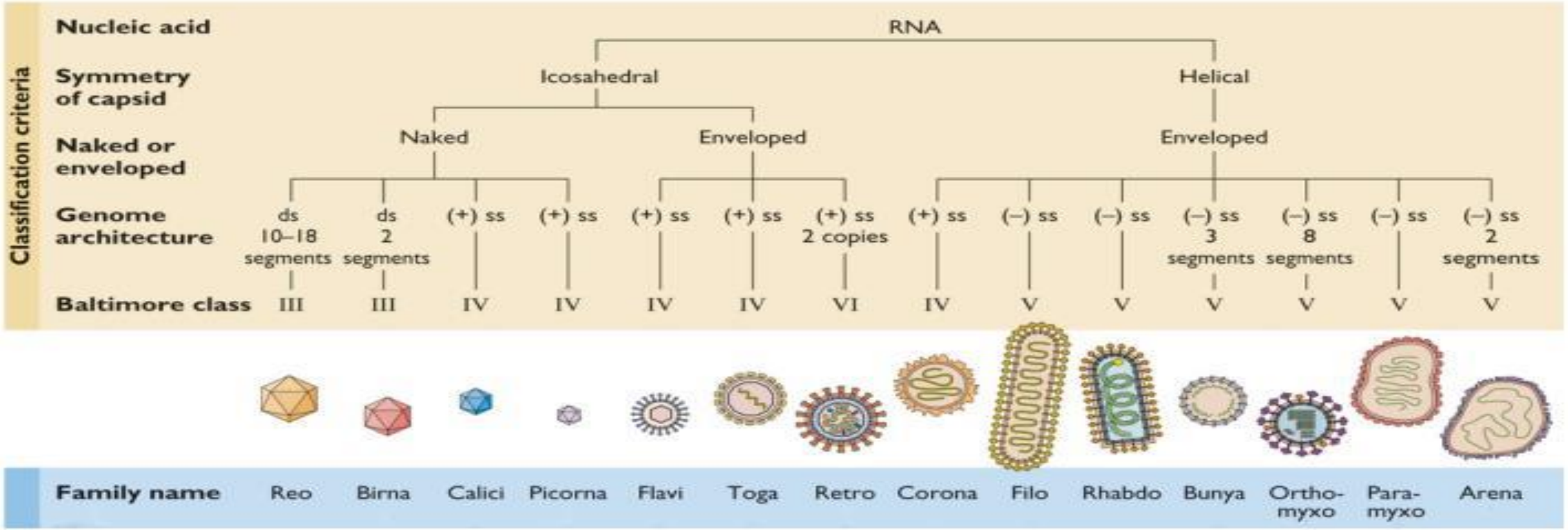
Photo of David Baltimore (1938–).




The Baltimore classification divides all viruses into seven groups based on how the viral mRNA is produced. DNA strands are denoted in red (+ssDNA in darker shade of red than -ssDNA). Similarly RNA strands are denoted in green (+ssRNA in darker shade of green than -ssRNA).

In the case of Baltimore groups 1,2,6, and 7, the genome either is or is converted to dsDNA, which is then converted to mRNA through the action of DNA-dependent RNA polymerase. In the case of Baltimore groups 3, 4 and 5, the genome is or is converted to +ssRNA, which is mRNA, through the action of RNA-dependent RNA polymerase

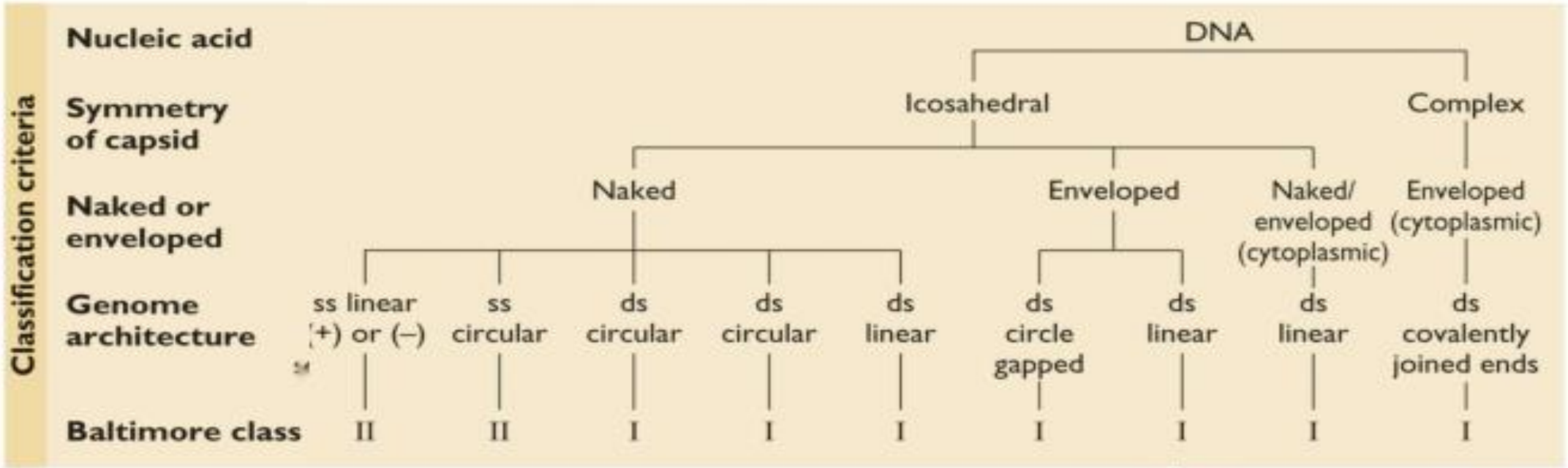
# RNA Virus Families




Several general features are evident from the classification:

- None of the dsRNA viruses are enveloped.
- The minus-strand viruses are enveloped with helical nucleocapsids.
- Most of the plus-strand strand viruses have icosahedral nucleocapsids.
- Plus strand viruses vary in having envelopes.
- Most of the plus strand viruses have a single genomic RNA.

# DNA Viruses




DNA Viruses differ in many features from RNA Viruses:

Only three families are enveloped.

All families except for the poxviruses replicate in nuclei.

Many families have very complex nucleocapsids.

| Group I: dsDNA Viruses | | | |
|---|---|---|---|
| **Family (Subfamily)** | **Genus** | **Type Species** | **Hosts** |
| *Adenoviridae* | *Mastadenovirus* | *Human adenovirus C* | Vertebrates |
| | *Aviadenovirus* | *Fowl adenovirus A* | Vertebrates |
| *Asfarviridae* | *Asfivirus* | *African swine fever virus* | Vertebrates |
| *Herpesviridae:* *Alphaherpesvirinae* | *Simplexvirus* | *Human herpesvirus 1* | Vertebrates |
| | *Varicellovirus* | *Human herpesvirus 3* | Vertebrates |

| | | | |
|---|---|---|---|
| *Betaherpesvirinae* | *Cytomegalovirus* | *Human herpesvirus 5* | Vertebrates |
| | *Muromegalovirus* | *Murine herpesvirus 1* | Vertebrates |
| | *Roseolovirus* | *Human herpesvirus 6* | Vertebrates |
| *Gammaherpesvirinae* | *Lymphocryptovirus* | *Human herpesvirus 4* | Vertebrates |
| | *Rhadinovirus* | *Simian herpesvirus 2* | Vertebrates |
| *Iridoviridae* | *Ranavirus* | *Frog virus 3* | Vertebrates |
| | *Lymphocystivirus* | *Lymphocystis disease virus 1* | Vertebrates |
| *Polyomaviridae* | *Polyomavirus* | *Simian virus 40* | Vertebrates |
| *Papillomaviridae* | *Papillomavirus* | *Cottontail rabbit papillomavirus* | Vertebrates |
| *Poxviridae:* | *Orthopoxvirus* | *Vaccinia virus* | Vertebrates |
| *Chordopoxvirinae* | *Parapoxvirus* | *Orf virus* | Vertebrates |
| | *Avipoxvirus* | *Fowlpox virus* | Vertebrates |
| | *Capripoxvirus* | *Sheeppox virus* | Vertebrates |
| | *Leporipoxvirus* | *Myxoma virus* | Vertebrates |
| | *Suipoxvirus* | *Swinepox virus* | Vertebrates |
| | *Molluscipoxvirus* | *Molluscum contagiosum virus* | Vertebrates |
| | *Yatapoxvirus* | *Yaba monkey tumor virus* | Vertebrates |
| *Baculoviridae* | *Nucleopolyhedrovirus* | *Autographa californica nucleopolyhedrovirus* | Invertebrates |

| | | | |
|---|---|---|---|
| **Group II: ssDNA Viruses** | | | |
| *Circoviridae* | *Circovirus* | *Porcine circovirus* | Vertebrates |
| | *Gyrovirus* | *Chicken anemia virus* | Vertebrates |
| *Parvoviridae:* *Parvovirinae* | *Parvovirus* | *Mice minute virus* | Vertebrates |
| | *Erythrovirus* | *B19 virus* | Vertebrates |
| | *Dependovirus* | *Adeno-associated virus 2* | Vertebrates |
| **Group III: dsRNA Viruses** | | | |
| *Birnaviridae* | *Aquabirnavirus* | *Infectious pancreatic necrosis virus* | Vertebrates |
| | *Avibirnavirus* | *Infectious bursal disease virus* | Vertebrates |
| *Reoviridae* | *Orthoreovirus* | *Mammalian orthoreovirus* | Vertebrates |
| | *Orbivirus* | *Bluetongue virus* | Vertebrates |
| | *Rotavirus* | *Rotavirus A* | Vertebrates |
| | *Coltivirus* | *Colorado tick fever virus* | Vertebrates |
| | *Aquareovirus* | *Golden shiner virus* | Vertebrates |

| Group IV: (+)sense RNA Viruses | | | |
|---|---|---|---|
| **Order *Nidovirales* – "Nested" Viruses** | | | |
| *Arteriviridae* | *Arterivirus* | *Equine arteritis virus* | Vertebrates |
| *Coronaviridae* | *Coronavirus* | *Infectious bronchitis virus* | Vertebrates |
| | *Torovirus* | *Equine totovirus* | Vertebrates |
| *Astroviridae* | *Astrovirus* | *Human astrovirus 1* | Vertebrates |
| *Caliciviridae* | *Lagovirus* | *Rabbit haemorrhagic disease virus* | Vertebrates |
| | Norwalk-like viruses | *Norwalk virus* | Vertebrates |
| | Sapporo-like viruses | *Sapporo virus* | Vertebrates |
| | *Vesivirus* | *Swine vesicular exanthema virus* | Vertebrates |
| *Flaviviridae* | *Flavivirus* | *Yellow fever virus* | Vertebrates |
| | *Pestivirus* | *Bovine diarrhea virus 1* | Vertebrates |
| | *Hepacivirus* | *Hepatitis C virus* | Vertebrates |
| *Picornaviridae* | *Enterovirus* | *Poliovirus* | Vertebrates |
| | *Rhinovirus* | *Human rhinovirus A* | Vertebrates |
| | *Hepatovirus* | *Hepatitis A virus* | Vertebrates |
| | *Cardiovirus* | *Encephalomyocarditis virus* | Vertebrates |
| | *Aphthovirus* | *Foot-and-mouth disease virus O* | Vertebrates |
| | *Parechovirus* | *Human parechovirus* | Vertebrates |
| | *Erbovirus* | *Equine rhinitis B virus* | Vertebrates |
| | *Kobuvirus* | *Aichi virus* | Vertebrates |
| | *Teschovirus* | *Porcine teschovirus* | Vertebrates |
| *Togaviridae* | *Alphavirus* | *Sindbis virus* | Vertebrates |
| | *Rubivirus* | *Rubella virus* | Vertebrates |

| Group V: (-)sense RNA Viruses | | | |
|---|---|---|---|
| **Order Mononegavirales** | | | |
| *Bornaviridae* | *Bornavirus* | *Borna disease virus* | Vertebrates |
| *Filoviridae* | Marburg-like viruses | *Marburg virus* | Vertebrates |
| | Ebola-like viruses | *Ebola virus* | Vertebrates |
| *Paramyxoviridae:* | *Respirovirus* | *Sendai virus* | Vertebrates |
| *Paramyxovirinae* | *Morbillivirus* | *Measles virus* | Vertebrates |
| | *Rubulavirus* | *Mumps virus* | Vertebrates |
| *Pneumovirinae* | *Pneumovirus* | *Human respiratory syncytial virus* | Vertebrates |
| | *Metapneumovirus* | *Turkey rhinotracheitis virus* | Vertebrates |
| *Rhabdoviridae* | *Vesiculovirus* | *Vesicular stomatitis Indiana virus* | Vertebrates |
| | *Lyssavirus* | *Rabies virus* | Vertebrates |
| | *Ephemerovirus* | *Bovine ephemeral fever virus* | Vertebrates |
| | *Novirhabdovirus* | *Infectious haematopoetic necrosis virus* | Vertebrates |
| *Arenaviridae* | *Arenavirus* | *Lymphocytic choriomeningitis virus* | Vertebrates |
| *Bunyaviridae* | *Bunyavirus* | *Bunyamwera virus* | Vertebrates |
| | *Hantavirus* | *Hantaan virus* | Vertebrates |
| | *Nairovirus* | *Nairobi sheep disease virus* | Vertebrates |
| | *Phlebovirus* | *Sandfly fever Sicilian virus* | Vertebrates |
| *Orthomyxoviridae* | *Influenza A virus* | *Influenza A virus* | Vertebrates |
| | *Influenza B virus* | *Influenza B virus* | Vertebrates |
| | *Influenza C virus* | *Influenza C virus* | Vertebrates |
| | *Thogotovirus* | *Thogoto virus* | Vertebrates |

| | | | |
|---|---|---|---|
| | *Thogotovirus* | *Thogoto virus* | Vertebrates |
| **Group VI: RNA Reverse Transcribing Viruses** | | | |
| *Retroviridae* | *Alpharetrovirus* | *Avian leukosis virus* | Vertebrates |
| | *Betaretrovirus* | *Mouse mammary tumor virus* | Vertebrates |
| | *Gammaretrovirus* | *Murine leukemia virus* | Vertebrates |
| | *Deltaretrovirus* | *Bovine leukemia virus* | Vertebrates |
| | *Epsilonretrovirus* | *Walley dermal sarcoma virus* | Vertebrates |
| | *Lentivirus* | *Human immunodeficiency virus 1* | Vertebrates |
| | *Spumavirus* | *Human spumavirus* | Vertebrates |
| **Group VII: DNA Reverse Transcribing Viruses** | | | |
| *Hepadnaviridae* | *Orthohepadnavirus* | *Hepatitis B virus* | Vertebrates |

# International Committee on Taxonomy of Viruses

**ICTV classification: As for classification of bacteria, a separate committee called International Committee on Taxonomy of Viruses decides the grouping and regrouping of viruses.**
**ICTV was established in 1966 to establish, refine, and maintain a universal system of virus taxonomy.**
**Changes and updates to virus taxonomy take place annually and are the (ICTV) result of a multi-stage process.**

- **In this system certain aspects of classical system of classification like Both hierarchical grouping under family, genera and Baltimore specifications**
- **Written in italics with first letter capitalized**
- **Characters used to classify viruses**
- **Nature of virus genome**
- **Method of replication**
- **Structure of virion**

- **ICTV online website: http://ictv.global/msl.htm.**

## Changes to virus taxonomy and the International Code of Virus Classification and Nomenclature ratified by the International Committee on Taxonomy of Viruses (2019)

| Rank | Number of established Taxa |
|---|---|
| Realm | 1 |
| Phylum | 1 |
| Subphylum | 2 |
| Class | 6 |
| Order | 14 |
| Suborder | 7 |
| Family | 150 |
| Subfamily | 79 |
| Genus | 1019 |
| Subgenus | 59 |
| Species | 5,560 |

**realm** is the highest taxonomic rank established for viruses by the International Committee on Taxonomy of Viruses Kuhn, J. H. (2021). Virus Taxonomy. Encyclopedia of Virology, 28.

Phylum A rank in the classification of organisms, below kingdom and above class; also called a divisio or a division

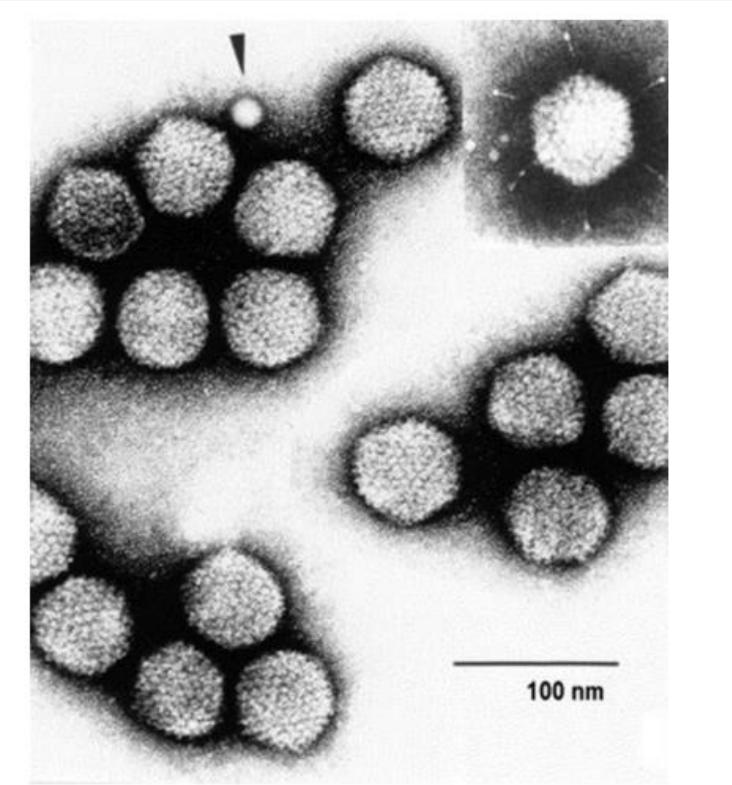
**TABLE 1.2** ICTV Nomenclature of Some Representative Viruses

| Family | Genus | Species |
|---|---|---|
| *Picornaviridae* | *Enterovirus* | Poliovirus 1 |
| *Flaviviridae* | *Hepacivirus* | Hepatitis C virus |
| *Herpesviridae* | *Simplexvirus* | Herpes simplex virus 1 |
| *Retroviridae* | *Lentivirus* | HIV |

# Subviral agents

Subviral agents are composed of three kinds: satellite viruses, viroids, and prions
These transmissible agents are classified as subviral agents as they are less than a virus in some respects.

- ❑ The first subviral agent is the "**satellite virus,**" which is morphologically indistinguishable from ordinary virus particles, but it depends on another virus, a host or helper virus, for propagation. Therefore, a satellite virus is often called "a parasite of a parasite," as it relies on another parasite, a virus.
- Satellite viruses found in plants typically possess their own capsid For instance, tobacco mosaic virus (TMV) is a helper virus of satellite tobacco mosaic virus (STMV). only a few satellite viruses are found in animal viruses.
- Two representative satellite viruses among human viruses are adeno-associated virus (AAV) and hepatitis delta virus (HDV). AAV is a satellite virus of adenovirus , while HDV is a satellite virus of hepatitis B virus (HBV) . AAV depends on adenovirus for its genome replication , while HDV relies on HBV for its envelope glycoprotein (ie, HBsAg).
- ❑ The second subviral agent are "**viroids**" found in plants. Viroids are comprised of "RNA only," and are devoid of any protein component. Remarkably, it is a circular RNA molecule itself about only 0.3 kb in length. Nonetheless, the viroid RNA is transmissible and causes pathogenic lesions in plants with economic importance.
- ❑ The third subviral agent are "**prions,**" which are etiological agents of neurodegenerative diseases, such as mad cow disease. In contrast to the viroids, prions are transmissible agents that are comprised of "protein only," and are devoid of any nucleic acid components.




Electron micrograph of adenovirus and its satellite virus, adeno-associated virus (AAV). Electron microscopic image of AAV particles. AAV particle (arrow head) is seen in the midst of adenovirus particles, a helper virus. Note that the morphology of AAV, a satellite virus, is distinct from that of adenovirus particle, a host virus

**TABLE 20.1** The Major Features of Subviral Agents

| Features | Satellite Virus | Viroids | Prions |
|---|---|---|---|
| Nucleic acid | RNA or DNA | RNA | No |
| Protein-coding | Yes (capsid) | No | Yes (host) |
| Protein in particles | Yes (capsid) | No | Yes (PrP) |
| Helper-dependency | Yes | No | No |
| Infectivity | Yes | Yes | Yes |
| Disease | Yes | Yes | Yes |

PrP :prion protein

Prion Hypothesis: The “prion hypothesis” or “a protein-only hypothesis” states that a protein is the only etiologic component of the pathogen that causes the disease.
What is the evidence for the lack of nucleic acids in prion agents? Four kinds of biochemical evidences were obtained.

1. First, the infectivity of prions is not inactivated by heating to 90C for 30 min (or even at 360C for 1 h), a condition that would completely inactivate any nucleic acid.

2. Second, the infectivity of scrapie agents is resistant to the inactivation by UV radiation and ionizing radiation. Because UV radiation and ionizing radiation inactivates infectious organisms by causing damage to their nucleic acid genome, The scrapie agent was found to be highly resistant to both UV light and ionizing radiation, indicating that any nucleic acid present must be extremely small, probably less than 1 kb nucleotides.

3. Third, scrapie agent was resistant to DNase and RNase treatment but sensitive to proteinase treatment, indicating that the infectivity is conferred by proteins.

4. Fourth, scrapie was sensitive to any protein-denaturing agents such as urea, sodium dodecyl sulfate, phenol, and other chaotropic agents.

| Animal prion diseases | Host | Symptoms |
|---|---|---|
| Scrapie | Sheep, goat | Fatal neurodegenerative disease |
| Bovine spongiform encephalopathy (BSE) | Cattle | Fatal neurodegenerative disease |
| Transmissible mink encephalopathy (TME) | Mink | Fatal neurodegenerative disease |
| Chronic wasting disease (CWD) | Deer and Elk | Fatal neurodegenerative disease |

Scrapie, the archetype transmissible spongiform encephalopathy (TSE), is a naturally occurring prion disease of sheep, goats, and mouflon (*Ovis musimon*)( domestic sheep). قعاص الغنم أو الراعوش
Scrapie It refers to a fatal, degenerative disease that affects the nervous systems of sheep and goats. The name "scrapie" is derived from one of the clinical signs of the condition, wherein affected animals will compulsively scrape off their fleeces(The fine soft under hair is called fleece ) against rocks, trees, or fences.

# SUMMARY

- Classification: Animal viruses are classified into three groups: DNA viruses, RNA viruses, and reverse transcribing (RT) viruses. They are further classified into seven groups, according to their genome or by the Baltimore classification.

- Subviral agent: Virus-like transmissible agents, which do not comply with the classical definition of a “virus” are termed “subviral agents.” Satellite viruses, viroids, and prions are the tree types of subviral agents