



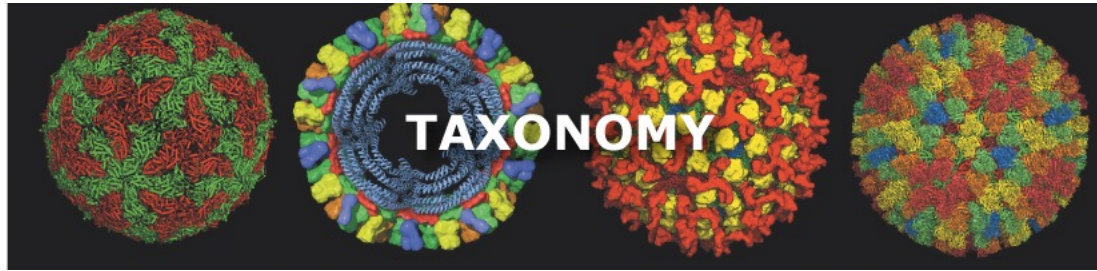
The new challenge in virus taxonomy: a binomial nomenclature for virus species



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Taxonomic classification is a scientific endeavor whereby biological organisms are **grouped** together and placed into their **proper taxonomic hierarchy** based on the characteristics that form a **unique descriptor identifying a particular organism**.

As new data are obtained, the **classification may change**.

Taxonomy = classification + nomenclature

Classification: the arrangement of biological entities into taxonomic categories (taxa)

Nomenclature: the assignment of names to taxa according to international rules

International Commission on Zoological Nomenclature

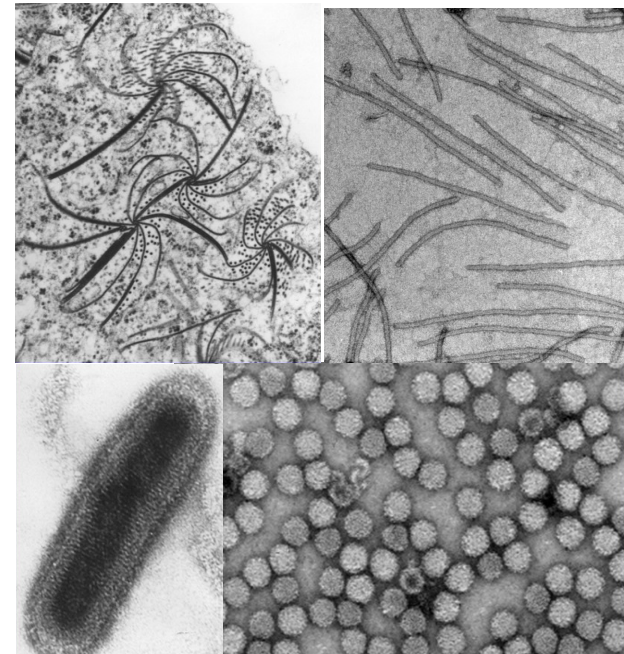
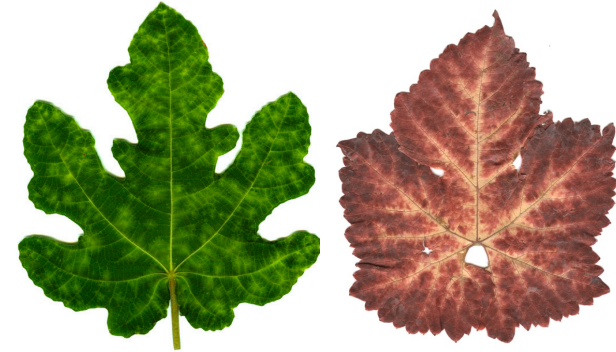
International Committee on Systematic Bacteriology

International Association for Plant Taxonomy

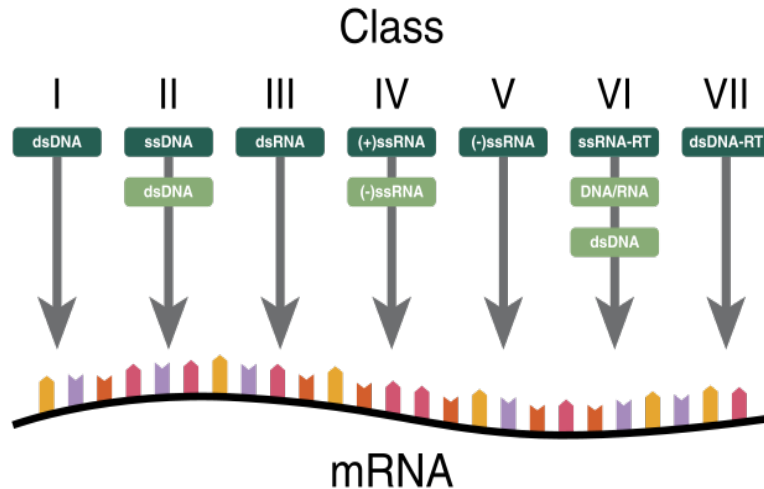
In animal, plant, fungal and prokaryote taxonomies, the corresponding committees deal exclusively with nomenclature; classification is agreed based on the published literature.

A brief history of virus taxonomy

- Early days: 1920's and 1930's
 - **Biological properties** of viruses
- Johnson & Hoggan, 1935
 - **Descriptive keys** based on five properties:
 - Mode of transmission
 - Host range
 - Symptoms
 - Longevity *in vitro*
 - Thermal inactivation point
 - **50 viruses classified into groups**
- 1950's and 1960's
 - **Electron microscopy**
 - **Serology**
- Brandes & Wetter, 1959
 - Classification based on **particle morphology**



A brief history of virus taxonomy



Baltimore classification partitioned virus diversity into clusters

- Today
 - **Species demarcation criteria** consisting of a combination of **biological properties** (e.g., host range, transmission, morphology, cytopathology) and **molecular data** (e.g., genome organization, nucleotide and amino acid sequence identity, replication strategies)



International Committee on Taxonomy of Viruses

ICTV

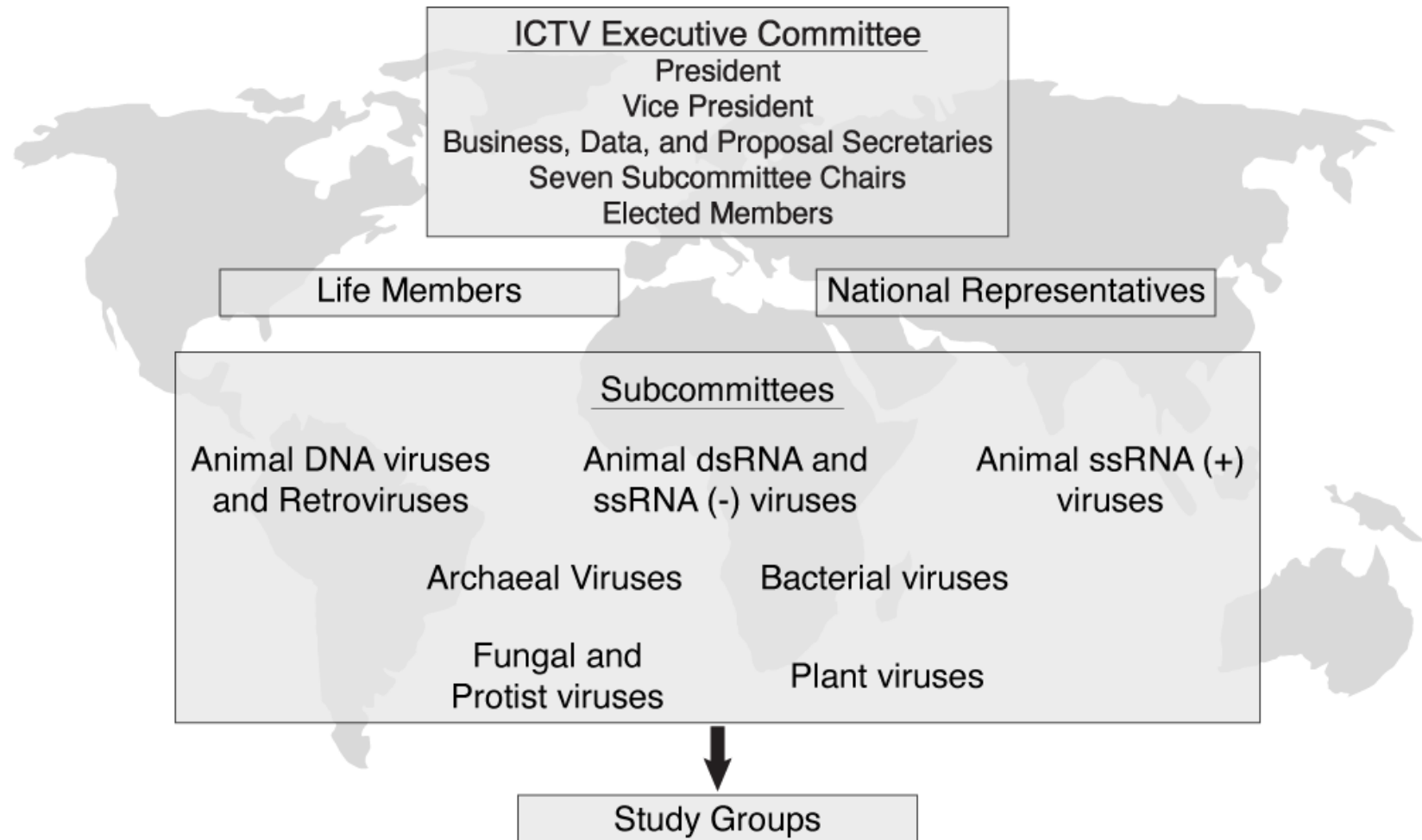
The ICTV has the following objectives:

1. To develop an **internationally agreed taxonomy** for viruses
2. To establish **internationally agreed names** for virus taxa
3. To **communicate** the decisions reached concerning the classification and nomenclature of viruses to virologists by holding **meetings** and publishing **reports**
4. To maintain an **official index** of agreed names of virus taxa in an **open-access, public website**

<https://ictv.global/>



International Committee on Taxonomy of Viruses Organizational Chart



Virologists serving in the ICTV are part of the global virology community



Recent advances in virus taxonomy

- Classification of viruses from **metagenomics**
- **Upper taxonomy ranks**: 15 ranks are now permitted (Realm, Kingdom, Phylum, Class...Species)
- Taxa can now be named after **people**
- **Linnean (binomial) nomenclature** for virus species

Virus taxonomy in the age of metagenomics

High-throughput sequencing and metagenomic approaches have radically changed virology, revealing a striking abundance of viruses in environmental samples.

Verified virus sequences do not provide information on biological properties .

Taxonomy of sequences or taxonomy of viruses?

Properties of a virus are encoded by its genome, thus sequence analyses could provide the '**multiple criteria**' that are required for classification into species, provided that a **strict sequence quality control** is carried out.

The pace of virus discovery does not reconcile with the biological characterization of new viruses. **Sharing raw data in public databases** may improve the biological characterization of viruses.



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Current Opinion in
Virology



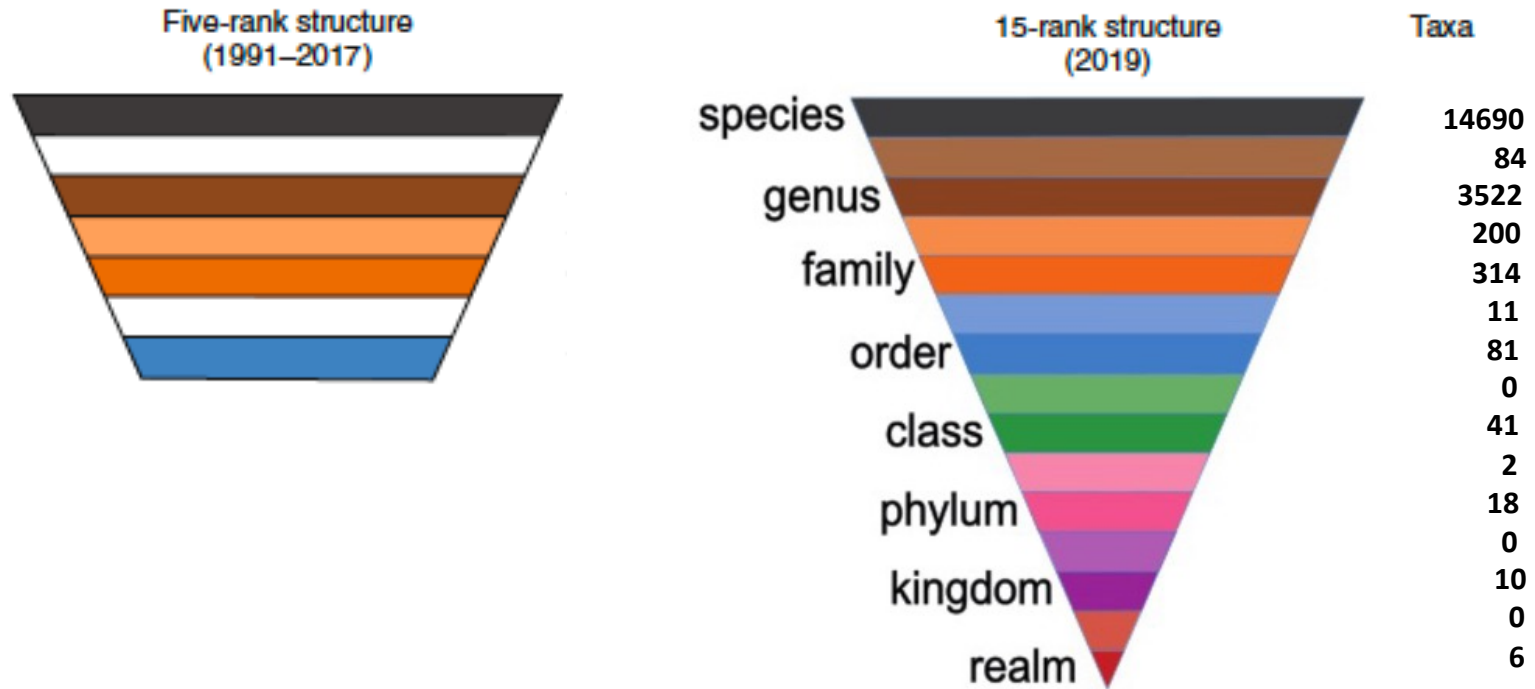
<https://doi.org/10.1038/s41587-023-01844-2>

Perspective on taxonomic classification of uncultivated viruses

Bas E Dutilh^{1,2}, Arvind Varsani^{3,4}, Yigang Tong⁵, Peter Simmonds⁶, Sead Sabanadzovic⁷, Luisa Rubino⁸, Simon Roux⁹, Alejandro Reyes Muñoz¹⁰, Cédric Lood^{11,12}, Elliot J Lefkowitz¹³, Jens H Kuhn¹⁴, Mart Krupovic¹⁵, Robert A Edwards¹⁶, J Rodney Brister¹⁷, Evelien M Adriaenssens¹⁸ and Matthew B Sullivan¹⁹

Guidelines for public database submission of uncultivated virus genome sequences for taxonomic classification

Partitioning the virosphere into 15 hierarchical ranks



Gorbalenya et al, 2019

The 15-rank classification closely aligns with the **Linnaean taxonomic system** and may accommodate the entire spectrum of genetic divergence in the virosphere

Monographs in Virology

Classification and Nomenclature of Viruses

Peter Wildy



S. Karger · Basel · München · Paris · London · New York · Sydney

1st Report of the ICNV (1971)

Summary of Rules Approved by the ICNV

- 1 The code of bacterial nomenclature shall not be applied to viruses.
- 2 Nomenclature shall be international.
- 3 Nomenclature shall be universally applied to all viruses.
- 4 An effort will be made towards a latinized binomial nomenclature.
- 5 Existing latinized names shall be retained whenever feasible.

NO standardized nomenclature format existed for virus species

— Genus: <i>Betacoronavirus</i>	Subfamily: <i>Orthocoronavirinae</i>	5 subgenera
— Subgenus: <i>Embecovirus</i>	Genus: <i>Betacoronavirus</i>	5 species
Species: <i>Betacoronavirus 1</i>	Subgenus: <i>Embecovirus</i>	
Species: <i>China Rattus coronavirus HKU24</i>	Subgenus: <i>Embecovirus</i>	
Species: <i>Human coronavirus HKU1</i>	Subgenus: <i>Embecovirus</i>	
Species: <i>Murine coronavirus</i>	Subgenus: <i>Embecovirus</i>	
Species: <i>Myodes coronavirus 2JL14</i>	Subgenus: <i>Embecovirus</i>	

Virus species: the taxon at the terminal rank of virus taxonomy

Due to the lack of a uniform, standardized nomenclature **VIRUS SPECIES** and **VIRUSES** used to have the same name, differing only in style (capital initial, italics)

Virus species and *virus* are two very different concepts

Virus species

- is an abstraction
- exists as a concept of mind;
- is a human-developed category

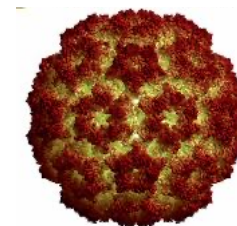
Cucumber mosaic virus



Virus

- is a physical entity
- exists on your bench;
- Infects its hosts

cucumber mosaic virus



Binomial nomenclature

The Latinized binomial format consists of two **italicized words** (a binomen or binary combination or scientific/Latin name), with the first capitalized word naming the genus to which the species belongs (“**genus name**”) and the second lower case word denoting the species (“**specific name/species epithet**”)

Saccharomyces cerevisiae

Arabidopsis thaliana

Homo sapiens

Escherichia coli

Abstractions (e.g. *Homo sapiens*, *Saccharomyces cerevisiae*) and **physical entities** (a human, yeast) **are clearly distinguishable**

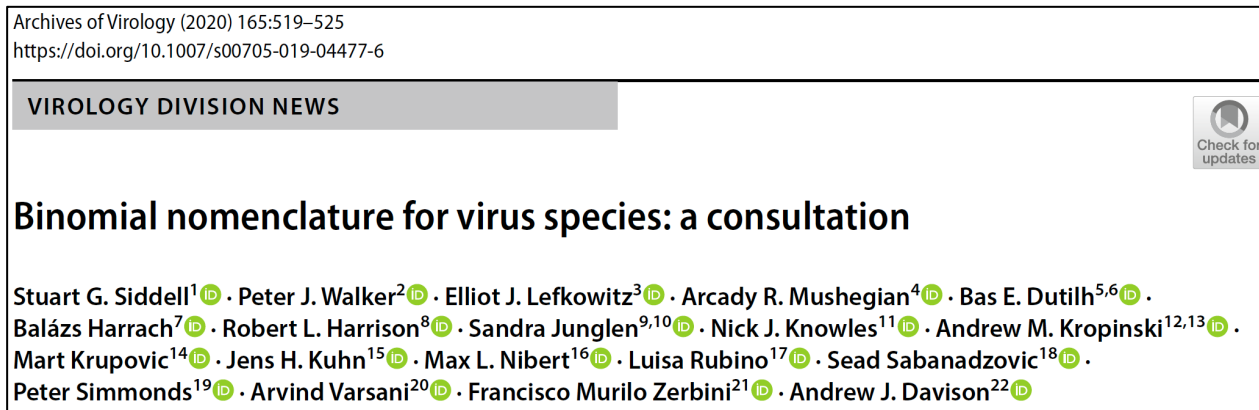
Advantages of a binomial nomenclature

- **Consistent** with all other biological taxonomies;
- Will **clarify** the difference between **virus** name and **species** name
- Latin is a **historic** language with a minimal character set that does not require diacritics and will not change in its syntax; as a result, it is **universal** and **stable**
- Would be represented in the **same form** in every language (i.e., would **never** be **translated**)

Virus names will continue to exist in **any language** and in any form

Language	Virus name	Virus species name
English	maize mosaic virus	<i>Alphanucleorhabdovirus maydis</i>
Arabic	فيروس موزاييك الذرة	
Chinese	玉米花叶病毒	
French	virus de la mosaïque du maïs	
Japanese	トウモロコシモザイクウイルス	
Russian	вирус мозаики кукурузы	
Spanish	virus del mosaico de la maíz	
Swahili	virusi vya Batobato ya mahindi	

The ICTV adopted a binomial nomenclature for virus species



- **Binomial nomenclature** for virus species **approved** in 2020
- The binomial is composed by the **genus name** and a **freeform species epithet**
- **3 years** to change all **existing** species names
- **Ratified** by **all** ICTV members (5 Mar 2021)

In 2024 the binomial nomenclature has been implemented for all virus species

How the **binomial nomenclature** has been implemented for **plant virus species**

- Latinized binomials (Genus + Latin *or* Latinized epithet)
- Genus + acronym (a combination of uppercase and lowercase letters)

Family	Genus	Virus name/ former species name	Virus name/ binomial species name
<i>Bromoviridae</i>	<i>Anulavirus</i>	grapevine line pattern virus <i>Grapevine line pattern virus</i>	grapevine line pattern virus <i>Anulavirus GLPV</i>
<i>Secoviridae</i>	<i>Fabavirus</i>	grapevine fabavirus <i>Grapevine fabavirus</i>	grapevine fabavirus <i>Fabavirus vitis</i>
<i>Fimoviridae</i>	<i>Emaravirus</i>	rose rosette virus <i>Rose rosette virus</i>	rose rosette virus <i>Emaravirus rosae</i>
<i>Tombusviridae</i>	<i>Tombusvirus</i>	Cymbidium ringspot virus <i>Cymbidium ringspot virus</i>	Cymbidium ringspot virus <i>Tombusvirus cymbidii</i>
<i>Caulimoviridae</i>	<i>Badnavirus</i>	sugarcane bacilliform MO virus <i>Sugarcane bacilliform MO virus</i>	sugarcane bacilliform MO virus <i>Badnavirus deltasacchari</i>
<i>Kitaviridae</i>	<i>Cilevirus</i>	Hibiscus yellow blotch virus <i>Hibiscus yellow blotch virus</i>	Hibiscus yellow blotch virus <i>Cilevirus oahuense</i>
<i>Tospoviridae</i>	<i>Orthotospovirus</i>	tomato spotted wilt virus <i>Tomato spotted wilt virus</i>	tomato spotted wilt virus <i>Orthotospovirus tomatomaculae</i>

Binomials apply to virus species only. **Common virus names will not change**

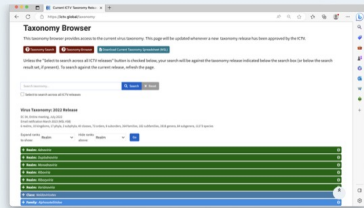
Serving the community: the ICTV website

Log in



International Committee on Taxonomy of Viruses: ICTV

Official Taxonomic Resources



ICTV Taxonomy Browser

Search and browse the virus taxonomy



Master Species List

MSL: Spreadsheet of all current species



Virus Metadata Resource

VMR: Virus exemplars for every species

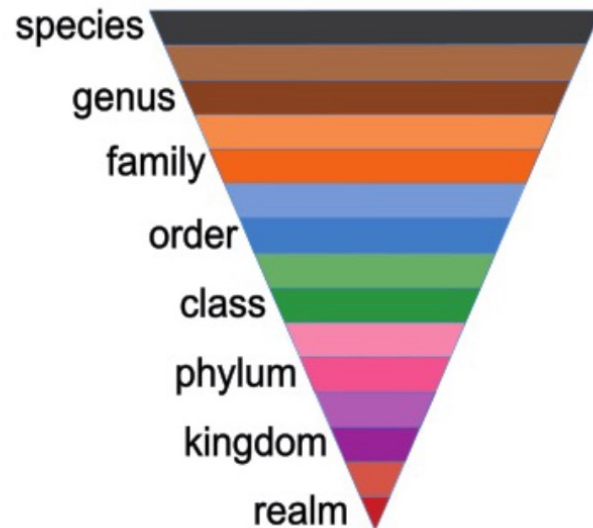
The ICTV website offers a number of useful resources open to all virologists and users

Virus Metadata Resource (VMR)

The human brain

TAXA

(with binomial names
and
demarcation criteria)



The real world

VIRUSES

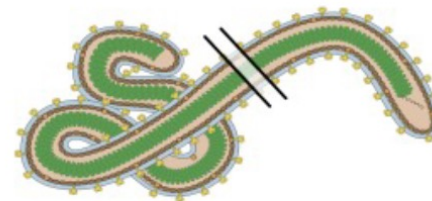
(with common names
and
properties)



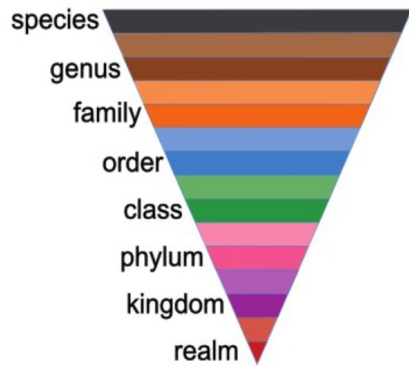
African swine fever virus



measles virus



Ebola virus



Virus Metadata Resource (VMR)

AutoSave VMR_MSL38_v2

Home Insert Draw Page Layout Formulas Data Review View Developer Tell me

Clipboard Font Alignment Cells Editing Styles Number Add-ins Assistance

	Realm	Sub realm	Kingdom	Sub kingdom	Phylum	Sub phylum	Class	Sub class	Order	Sub order	Family	Sub family	Genus	Sub genus	Species	Exemplar additional isolate	Virus name(s)
1																	
2	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Alphalipothrrixvirus		Alphalipothrrixvirus SBFV2	E	Sulfolobales Beppu filamentous virus 2
3	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Alphalipothrrixvirus		Alphalipothrrixvirus SFV1	E	Sulfolobus filamentous virus 1
4	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Betalipothrrixvirus		Acidianus filamentous virus 3	E	Acidianus filamentous virus 3
5	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Betalipothrrixvirus		Acidianus filamentous virus 6	E	Acidianus filamentous virus 6
6	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Betalipothrrixvirus		Acidianus filamentous virus 7	E	Acidianus filamentous virus 7
7	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Betalipothrrixvirus		Acidianus filamentous virus 8	E	Acidianus filamentous virus 8
8	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Betalipothrrixvirus		Acidianus filamentous virus 9	E	Acidianus filamentous virus 9
9	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Betalipothrrixvirus		Sulfolobus islandicus filamentous virus	E	Sulfolobus islandicus filamentous virus
10	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Deltalipothrrixvirus		Acidianus filamentous virus 2	E	Acidianus filamentous virus 2
11	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Lipothrrixviridae		Deltalipothrrixvirus		Deltalipothrrixvirus SBFV3	E	Sulfolobales Beppu filamentous virus 3
12	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Azorudivirus		Azorudivirus SRV	E	Stygiolobus rod-shaped virus
13	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Hoswirutdivirus		Hoswirutdivirus ARV2	E	Acidianus rod-shaped virus 2
14	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Hoswirutdivirus		Hoswirutdivirus ARV3	E	Acidianus rod-shaped virus 3
15	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Hoswirutdivirus		Hoswirutdivirus MRV1	E	Metallosphaera rod-shaped virus 1
16	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Hoswirutdivirus		Hoswirutdivirus SSRV1	E	Saccharolobus solfataricus rod-shaped virus 1
17	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Icerudivirus		Icerudivirus SIRV1	E	Sulfolobus islandicus rod-shaped virus 1
18	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Icerudivirus		Icerudivirus SIRV2	E	Sulfolobus islandicus rod-shaped virus 2
19	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Icerudivirus		Icerudivirus SIRV3	E	Sulfolobus islandicus rod-shaped virus 3
20	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Itarudivirus		Itarudivirus ARV1	E	Acidianus rod-shaped virus 1
21	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Japarudivirus		Japarudivirus SBRV1	E	Sulfolobales Beppu rod-shaped virus 1
22	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Mexirudivirus		Mexirudivirus SMRV1	E	Sulfolobales Mexican rod-shaped virus 1
23	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Usarudivirus		Usarudivirus SIRV10	E	Sulfolobus islandicus rod-shaped virus 10
24	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Usarudivirus		Usarudivirus SIRV11	E	Sulfolobus islandicus rod-shaped virus 11
25	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Usarudivirus		Usarudivirus SIRV4	E	Sulfolobus islandicus rod-shaped virus 4
26	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Usarudivirus		Usarudivirus SIRV5	E	Sulfolobus islandicus rod-shaped virus 5
27	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Usarudivirus		Usarudivirus SIRV8	E	Sulfolobus islandicus rod-shaped virus 8
28	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Rudiviridae		Usarudivirus		Usarudivirus SIRV9	E	Sulfolobus islandicus rod-shaped virus 9
29	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Ligamenvirales		Ungulaviridae		Captovirus		Captovirus AFV1	E	Acidianus filamentous virus 1
30	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Maximovirales		Ahmuviridae		Yumkaaxvirus		Yumkaaxvirus pescaderoense	E	Methanophagales virus PBV300
31	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Primavirales		Tristromaviridae		Alphatristromavirus		Alphatristromavirus PFV1	E	Pyrobaculum filamentous virus 1
32	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Primavirales		Tristromaviridae		Alphatristromavirus		Alphatristromavirus PFV2	E	Pyrobaculum filamentous virus 2
33	Adnaviria		Zilligvirae		Taleaviricota		Tokiviricetes		Primavirales		Tristromaviridae		Betatristromavirus		Betatristromavirus TTV1	E	Thermoproteus tenax virus 1

VMR_MSL38_v2 Column definitions +

A new mindset in virus taxonomy



Community



Proactivity



Knowledge



Preparedness



Thank you for your kind attention