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The Classification and Nomenclature of Viruses Summary of Results of Meetings of the International Committee on Taxonomy of Viruses in Madrid, September 1975¹

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INTRODUCTION

The International Committee on the Taxonomy of Viruses (ICTV), which is a committee of the Section on Virology of the International Association of Microbiological Societies (IAMS), completed a round of meetings during the Third International Congress for Virology that was held in Madrid from September 10-17, 1975. Since ICTV only meets during these conferences, which are held every four years, the meetings are important occasions for reviewing the classification and nomenclature of viruses. Decisions on new names, which encapsulate the recognition of natural "groups" of viruses, evolve slowly. Official approval for new names depends upon a series of sequential steps; recommendations by one or more of the subcommittees of the Executive Committee of ICTV (subcommittees on Bacterial, Invertebrate, Plant, and Vertebrate Viruses, respectively, and for some of the larger viral groups which span several kinds of hosts, the Coordination Subcommittee), which are considered by the Executive Committee of ICTV, and may finally be submitted for approval by ICTV itself. Only after this

final approval does a name become "official."

The results of the last five years of work by ICTV and its committees will be published early next year as a separate volume of "Intervirology," the official journal of the Section on Virology of IAMS, and additional copies will be produced for sale as separates. This "Second Report" will include, besides "approved" and common names of virus groups, a brief description of the properties of each group and a listing of probable and possible members of the group. To ensure that information upon the present state of viral taxonomy is available to as many virologists as possible, as soon as possible, the following brief paper has been prepared. It includes an up-to-date version of the Rules of Nomenclature, the names of all members of the new Executive Committee of ICTV, and a summary of the present position regarding viral families, genera, and groups and their names. For the convenience of working virologists, the last part has been set out with some relation to the "host-directed" interests of most virologists, although it will be seen that in several cases viral groupings transgress such boundaries.

The Rules of Viral Nomenclatures

The official approval of names for viral groups is subject to their legitimacy in terms of several "Rules," which are set out in the First Report on the Classification and Nomenclature of Viruses (Wildy, 1971). At the meetings in Madrid several minor and two major changes in the Rules

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² The rules and names are those officially approved, or suggested; the comments are the responsibility of the author.

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were approved by ICTV. The latter relate to Rule 4 (previously "An effort will be made towards a latinized binomial nomenclature") and Rule 7 [New sigla (i.e., "names made up from a few or initial letters) shall not be introduced"].

Over the nine years that have elapsed since the formation of ICTV (initially known as the International Committee on the Nomenclature of Viruses), it has become clear that virologists and teachers of virology greatly value the grouping of viruses into genera and families, based primarily on their chemistry, morphology, and strategy of multiplication. Latinized names, ending in "... *virus*" for a genus and "... *viridae*" for a family name, have been widely accepted. On the other hand, there has been no support for latinized specific names (i.e., a latinized binomial nomenclature); virologists have preferred to use vernacular names usually accompanied by a precise description of the strain and antecedents of the virus used for the investigations described. This situation was recognized by ICTV by the deletion of the word "binomial" from Rule 4.

The use of sigla (e.g., "reovirus" from respiratory enteric orphan viruses) was popular with animal virologists prior to 1966, when ICNV was established, but in the interests of achieving a uniform and international nomenclature Rule 7, introduced at the first meetings of ICNV in Moscow in 1966, forbade the use of new sigla. The Plant Virus Subcommittees of the ICNV, which worked from 1966 to 1970, took exception to this rule and devised sigla for all the viral groups for which it recommended names at the meeting of ICNV in Mexico City in 1970. Since according to the Rules they were not legal, these names could not be approved by ICNV, and were therefore published in the First Report only as suggestions made by the Plant Virus Subcommittee (Wildy, 1971). To break the deadlock that threatened international agreement on a single system of nomenclature for all viruses, several proposals were made for the modification of Rule 7. That finally accepted at the Madrid meeting led to the

replacement of old Rule 7 by the following: "Sigla may be accepted as names of viruses or virus groups, provided that they are meaningful to workers in the fields and are recommended by international virus study groups." This change allowed ICTV, at the Madrid meeting, to approve the names for plant virus groups that were first proposed in 1970, and have been widely used by plant virologists since then.

Currently, the Rules are as set out below:

Rule 1. The code of bacterial nomenclature shall not be applied to viruses.

Rule 2. Nomenclature shall be international.

Rule 3. Nomenclature shall be universally applied to all viruses.

Rule 4. An effort will be made towards a latinized nomenclature.

Rule 5. Existing latinized names shall be retained whenever feasible.

Rule 6. The law of priority shall not be observed.

Rule 7. Sigla may be accepted as names of viruses or virus groups, provided that they are meaningful to workers in the fields and are recommended by international virus study groups.

Rule 8. No person's name shall be used.

Rule 9. Names should have international meaning.

Rule 10. The rules of Orthography of names and epithets are listed in Chapter 3, Section 6, of the proposed international code of nomenclature of viruses (Appendix C; Minutes of 1966, Moscow meeting).

Rule 11. For pragmatic purposes the species is considered to be a collection of viruses with like characters.

Rule 12. Numbers, letters, or combinations thereof may be accepted in constructing the names of species.

Rule 13. These symbols may be preceded by an agreed abbreviation of the latinized name of a selected host genus or, if necessary, by the full name.

Rule 14. The genus is a group of species sharing certain common characters.

Rule 15. The ending of the name of a

viral genus is "... *virus*."

Rule 16. A family is a group of genera with common characters, and the ending of the name of a viral family is "... *viridae*."

Elections to the Executive Committee, ICTV

On 17 September, 1975, Professors Fenner, Ginsberg, Melnick, and Vago retired from their positions as President, Vice-President, and members, respectively, and elections were held to replace them. The present composition of the Executive Committee is as follows: *President*, Professor R. E. F. Matthews; *Vice-President*, Dr. H. G. Pereira; *Secretaries*, Dr. J. Maurin and Dr. V. Valenta; *Elected members*, Professor A. Eisenstark, Professor H. Fraenkel-Conrat, Dr. A. J. Gibbs, Professor K. Maramorosch, Professor J. L. Melnick, Professor E. Norrby, Professor A. J. Rhodes, Professor J. P. H. van der Want, and Professor V. M. Zhdanov.

The Chairmen of all subcommittees also resigned or retired; their replacements were the responsibility of the new Executive Committee. Professor Matthews informs me that the following virologists have accepted appointment: *Bacterial Virus Subcommittee*, Professor H.-W. Ackermann; *Code and Data Subcommittee*, Dr. J. G. Atherton; *Coordination Subcommittee*, the President, Professor R. E. F. Matthews; *Fungal Virus Subcommittee* (new), Dr. M. Hollings; *Invertebrate Virus Subcommittee*, Professor K. Aizawa; *Plant Virus Subcommittee*, Dr. R. I. B. Francki; and *Vertebrate Virus Subcommittee*, Dr. F. A. Murphy.

Viruses Primarily of Interest to Vertebrate Virologists

Because of their medical and veterinary implications, and the availability of good cell culture systems for over twenty years, the range of viruses that cause disease in man and his domestic animals (although not several individual viruses like tobacco mosaic virus and some bacterial viruses) has been more thoroughly studied than those of other hosts. The description and nomenclature of these viruses is correspondingly more advanced. However, it is clear that in several cases viruses that are taxonomically similar to those that primarily infect vertebrates are found among invertebrates and plants, although not as yet among prokaryotes. Further, many viruses that infect vertebrates (and plants) also multiply in invertebrates (especially insects and acarids). Although these invertebrates are usually regarded by vertebrate and plant virologists as "vectors," they may indeed be the primary hosts in which these viruses evolved.

In the listing that follows are set out, first, viral groups that are represented by genera or other groupings in invertebrates and/or plant hosts as well as in vertebrate hosts; then, taxa that have so far been found only among vertebrates. For brevity, only approved names and minor comments are included except where the viral group involved was not described at all in Wildy (1971). At the Madrid meetings, most of the distinctive groups of viruses of vertebrates were designated as families, some of which remain monogeneric at this stage, but may be expected to become polygeneric as knowledge increases.

A. FAMILIES INVOLVING VIRUSES OF VERTEBRATES AND OTHER HOSTS

Family

Poxviridae (Fenner *et al.*, 1974)

Genera

| | | | |
|-----------------------|-------------------------------------|---|-----------------------------|
| <i>Orthopoxvirus</i> | (vaccinia and related viruses) | } | Viruses of vertebrate hosts |
| <i>Avipoxvirus</i> | (fowlpox and related viruses) | | |
| <i>Capripoxvirus</i> | (sheep pox and related viruses) | | |
| <i>Leporipoxvirus</i> | (myxoma and related viruses) | | |
| <i>Parapoxvirus</i> | (milkers' node and related viruses) | | |

Entomopoxvirus (poxviruses of insects; three morphologically distinct subgroups)

Family

Parvoviridae (formerly genus *Parvovirus*; Wildy, 1971, p. 41)

Genera

Parvovirus (latent rat virus group; viruses of vertebrates)
Densovirus (viruses of insects)

Other Genus (no name approved) Adenoassociated virus group (viruses of vertebrates)

Family

Reoviridae (Fenner *et al.*, 1974)

Genera

Reovirus (viruses of vertebrates)
Orbivirus (viruses of vertebrates, but multiply in insects also)

Probable Genera (no names approved)

"Rotaviruses" or "duoviruses" of vertebrates
 Cytoplasmic polyhedrosis viruses of insects
 Clover wound tumor and Fiji disease viruses of plants (probably two distinct genera)

Family

Rhabdoviridae (formerly genus *Rhabdovirus*; Wildy, 1971, p. 51)

Genera

Vesiculovirus (vesicular stomatitis virus group; viruses of vertebrates and insects)
Lyssavirus (rabies virus group; viruses of vertebrates)

Probable genera (no names approved)

Exemplified by:

ephemeral fever virus (viruses of vertebrates and insects)
 hemorrhagic septicemia of trout virus (viruses of vertebrates)
 sigmavirus group (viruses of insects)
 lettuce necrotic yellows, potato yellow dwarf, and many other viruses of plants

B. FAMILIES INVOLVING VIRUSES OF VERTEBRATES

Family

Herpetoviridae (formerly genus *Herpesvirus*; Wildy, 1971; p. 33)

Genus

Herpesvirus [human herpesvirus 1 (herpes simplex) and closely related viruses]

Probable Genera (no names approved)

There are many herpetoviruses of vertebrates that do not fall into the genus *Herpesvirus* but their classification has proved difficult. Viruses morphologically resembling herpetoviruses have also been found in molluscs and algae.

Family

Adenoviridae (formerly genus *Adenovirus*; Wildy, 1971; p. 36)

Genera

Mastadenovirus (adenoviruses of mammals)

Aviadenovirus (adenoviruses of birds)

Family

Papovaviridae (Wildy, 1971; p. 38, 39, 74)

Genera

Papillomavirus (producing papillomas in several species of animal)

Polyomavirus (found in rodents, man and other primates)

Family

Retroviridae (RNA tumor virus group formerly genus *Leukovirus*; Wildy, 1971; p. 46, and related agents)

Subfamilies

Oncovirinae (RNA tumor virus group)

Spumavirinae (foamy agents)

Lentivirinae (visna and related agents)

Genera

Several genera and subgenera of Oncovirinae have been defined but names for these are not yet approved.

Family

Paramyxoviridae (formerly genus *Paramyxovirus*; Wildy, 1971; p. 47)

Genera

Paramyxovirus (Newcastle disease virus group)

Morbillivirus (measles virus group)

Pneumovirus (respiratory syncytial virus and related agents)

Family

Orthomyxoviridae (formerly genus *Orthomyxovirus*; Wildy, 1971, p. 49)

Genus

Influenzavirus (influenza types A and B virus)

Probable Genus (no name approved)

Influenza type C virus

Family

Togaviridae (Fenner *et al.*, 1974)

Genera

Alphavirus (group A arboviruses)

Flavivirus (group B arboviruses)

Pestivirus (hog cholera and related viruses)

Rubivirus (rubella virus)

Family

Coronaviridae (formerly genus *Coronavirus*; Wildy, 1971; p. 71)

Genus

Coronavirus (avian infectious bronchitis virus and related viruses; may be subdivided later)

Family

Arenaviridae (formerly genus *Arenavirus*; Wildy, 1971, p. 73)

Genus

Arenavirus (lymphocytic choriomeningitis virus and related viruses; may be subdivided later)

Family

Picornaviridae (Wildy, 1971; pp. 56, 57, 75)

Genera

Enterovirus (acid-resistant, mainly viruses of enteric tract)

Rhinovirus (acid-labile, mainly viruses of upper respiratory tract)

Possible Genus

Calicivirus (vesicular exanthem of swine and related viruses)

New Family

Bunyaviridae (see Porterfield *et al.*, 1976), formerly known as the "Bunyamwera Supergroup of Viruses"

Enveloped virions 90–100 nm in diameter with at least one kind of peplomer and an internal ribonucleoprotein filament 2–2.5-nm wide. Single-stranded RNA, total molecular weight about 6×10^6 probably in several segments.

Genus

Bunyavirus (Bunyamwera and serologically closely related viruses)

Several other genera will probably be defined later.

Viruses Primarily of Interest to Plant Virologists

As mentioned above, the Plant Virus Subcommittee that operated between 1966 and 1970 presented 12 named subgroups to ICNV in 1970, but only three names—*Bromovirus*, *Cucumovirus*, and *Nepovirus*—were then deemed legitimate and approved by ICNV. Following the change in Rule 7, which relates to sigla, and with the assurance that the group names suggested in 1970 were now in widespread use among plant virologists, the other nine names then proposed were approved by ICTV at the Madrid meeting. In addition the Plant Virus Subcommittee defined four new groups and their names were approved. The Plant Virus Subcommittee was reluc-

tant to designate groups as either "families" or "genera"; their current names accord with the rules relating to genera but they are probably equivalent taxonomically to what vertebrate, invertebrate, and bacterial virologists regard as families. However, most virus groups that are known only as viruses of plants are relatively homogenous; if they were designated as families most would contain only one genus, often with many species.

Plant virology is in some respects in a less advanced state than vertebrate virology, because there are far fewer workers in the field and they lack a well-developed cell culture system, hence the concentration on disease characteristics, transmissibility, and the physical characters of virions.

Groups

| | | |
|---------------------|------------------------------------|----------------------|
| <i>Bromovirus</i> | (brome mosaic virus group) | (Wildy, 1971, p. 65) |
| <i>Carlavirus</i> | (carnation latent virus group) | (Wildy, 1971, p. 69) |
| <i>Caulimovirus</i> | (cauliflower mosaic virus group) | (Wildy, 1971, p. 37) |
| <i>Comovirus</i> | (cowpea mosaic virus group) | (Wildy, 1971, p. 48) |
| <i>Cucumovirus</i> | (cucumber mosaic virus group) | (Wildy, 1971, p. 67) |
| <i>Nepovirus</i> | (tobacco ringspot virus group) | (Wildy, 1971, p. 59) |
| <i>Potexvirus</i> | (potato virus X group) | (Wildy, 1971, p. 70) |
| <i>Potyvirus</i> | (potato virus Y group) | (Wildy, 1971, p. 68) |
| <i>Tobamovirus</i> | (tobacco mosaic virus group) | (Wildy, 1971, p. 60) |
| <i>Tobravirus</i> | (tobacco rattle virus group) | (Wildy, 1971, p. 58) |
| <i>Tombusvirus</i> | (tomato bushy stunt virus group) | (Wildy, 1971, p. 62) |
| <i>Tymovirus</i> | (turnip yellow mosaic virus group) | (Wildy, 1971, p. 61) |

New Groups

| | |
|----------------------|---|
| <i>Closterovirus</i> | (beet yellows virus group) Long very flexuous rods containing 5-6% single-stranded RNA |
| <i>Hordeivirus</i> | (barley stripe mosaic virus group) Straight tubular virions 110-160-nm long and 20-25 nm in diameter, whose single-stranded RNA comprises 4% of particle weight and consists of two to four components of which two to three are required for infectivity. |
| <i>Luteovirus</i> | (barley yellow dwarf virus group) Isometric virions 25 nm in diameter containing one molecule of single-stranded RNA with molecular weight 2 million, persistent retention by insect vectors. |
| <i>Iarvirus</i> | (isometric labile ringspot virus group) At least three isometric components of different size from 26-35 nm in diameter, with four single-stranded RNA components in different virions, seed- and pollen-borne. |

Viruses Primarily of Interest to Invertebrate Virologists

There is growing evidence of the occurrence of viruses among all groups of invertebrates, including not only insects but also crustacea, molluscs, etc. Some viruses that multiply in invertebrates have been mentioned already (see Poxviridae, Reoviridae, Parvoviridae, Rhabdoviridae, and Togaviridae); some other plant viruses are transmitted by insects but have not been shown to *multiply* in their vectors.

Two groups previously designated as genera have been raised to family status.

Family

Baculoviridae (formerly genus *Baculovirus*; Wildy, 1971, p. 32)

Genus

Baculovirus (*Bombyx mori* nuclear polyhedrosis virus group). There are proba-

bly several other genera that await description.

Family

Iridoviridae (formerly genus *Iridovirus*; Wildy, 1971, p. 31)

Genus

Iridovirus (iridescent viruses of insects)

Other Probable Genera

Cytoplasmic icosahedral DNA viruses of vertebrates (e.g., African swine fever virus, lymphocytic virus of fish, Frog Virus 3) may belong to the same family but not to the genus *Iridovirus*.

Viruses Primarily of Interest to Bacterial Virologists

Molecular biology has been based upon the intensive study of a few bacterial viruses, and more is known of the chemistry

and replicative mechanisms of some of these viruses than about any other living things. However, since they are of minor economic importance, comparative studies of bacterial viruses as such have hardly begun. Work by the Bacterial Virus Subcommittee over the past four years has revealed the great variety of different kinds of bacterial viruses, few of which have been characterized adequately to permit their grouping. The Bacterial Virus Subcommittee has suggested family names for six groups defined in the First Report (Wildy, 1971) and has described two additional groups of bacterial viruses and suggested family names for them. However, no definitive family or generic names were proposed for approval at the Madrid meeting. It was decided that the families and names suggested for them should be exposed to working virologists to determine their usefulness. A suggestion was made in Madrid, but not discussed at length, that names of viruses of prokaryotes should contain the syllables "bacti-" before "virus" or "viridae"; thus, "Myobactviridae," etc., as set out (for genera) in the text of the Report of the Bacteriophage Subcommittee in 1970 (Wildy, 1971, p. 13-14).

The groups proposed so far clearly fail to include many morphological types of bacteriophages (see Ackermann and Eisenstark, 1974).

Proposed Families (names not official)

Myoviridae (T-even phage group) (Wildy 1971, p. 30): Linear double stranded DNA, molecular weight 120×10^6 , complex contractile tail.

Styloviridae (λ -phage group) (Wildy, 1971, p. 35): Linear double-stranded DNA, molecular weight 33×10^6 , long tail, non-contractile.

Corticoviridae (PM2 phage group)

(Wildy, 1971, p. 40): Cyclic double-stranded DNA, molecular weight 5×10^6 , isometric virion, lipid between protein shells, no tail.

Microviridae ($\phi\chi 174$ group) (Wildy, 1971, p. 42): Cyclic single-stranded DNA, molecular weight 1.7×10^6 , small "knobby" isometric virion.

Inoviridae (fd phage group) (Wildy, 1971, p. 43): Cyclic single-stranded DNA, molecular weight 1.7×10^6 , long filamentous virion.

Leviviridae (f2 phage group) (Wildy, 1971, p. 66): Linear single-stranded RNA, molecular weight 1.2×10^6 , small icosahedral virion.

Proposed New Families (name not official)

Pedoviridae (T7 and related phage groups): Linear double-stranded DNA, molecular weight $25-27 \times 10^6$, short tail. Probably a complex group with several genera, or requiring further subdivision.

Cystoviridae (Phage $\phi 6$ group): Linear double-stranded RNA, in three pieces; total molecular weight 13×10^6 . Isometric virion with lipid-containing envelope.

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