



Adams, M. J. et al. (2017) 50 years of the International Committee on Taxonomy of Viruses: progress and prospects. *Archives of Virology*, 162(5), pp. 1441-1446. (doi:[10.1007/s00705-016-3215-y](https://doi.org/10.1007/s00705-016-3215-y))

This is the author's final accepted version.

There may be differences between this version and the published version. You are advised to consult the publisher's version if you wish to cite from it.

<http://eprints.gla.ac.uk/135101/>

Deposited on: 03 March 2017

Enlighten – Research publications by members of the University of Glasgow
<http://eprints.gla.ac.uk>

Archives of Virology

50 years of the International Committee on Taxonomy of Viruses: progress and prospects --Manuscript Draft--

Manuscript Number:	ARVI-D-16-00894R1
Full Title:	50 years of the International Committee on Taxonomy of Viruses: progress and prospects
Article Type:	Virology Division News: Virus Taxonomy/Nomenclature
Keywords:	ICTV; history; taxonomy Reports
Corresponding Author:	Michael J. Adams, Ph. D. ICTV Stevenage, Herts UNITED KINGDOM
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	ICTV
Corresponding Author's Secondary Institution:	
First Author:	Michael J. Adams, Ph. D.
First Author Secondary Information:	
Order of Authors:	Michael J. Adams, Ph. D. Elliot J Lefkowitz Andrew M Q King Balázs Harrach Robert L Harrison Nick J Knowles Andrew M Kropinski Mart Krupovic Jens H Kuhn Arcady R Mushegian Max L Nibert Sead Sabanadzovic Hélène Sanfaçon Stuart G Siddell Peter Simmonds Arvind Varsani F Murilo Zerbini Richard J Orton Donald B Smith Alexander E Gorbalenya Andrew J Davison
Order of Authors Secondary Information:	

Funding Information:	
Abstract:	<p>We mark the 50th anniversary of the International Committee on Taxonomy of Viruses (ICTV) by presenting a brief history of the organization since its foundation, showing how it has adapted to advancements in our knowledge of virus diversity and the methods used to characterize it. We also outline recent developments, supported by a grant from the Wellcome Trust (UK), that are facilitating substantial changes in the operations of the ICTV and promoting dialogue with the virology community. These developments will generate improved online resources, including a freely available and regularly updated ICTV Virus Taxonomy Report. They also include a series of meetings between the ICTV and the broader community focused on some of the major challenges facing virus taxonomy, with the outcomes helping to inform the future policy and practice of the ICTV.</p>
Response to Reviewers:	<p>We have added a second paragraph to the 'Establishment' section to include mention of the species definition issue and some associated references as requested.</p> <p>A minor change to the wording has also been made to improve the sentence mentioned by reviewer#4 (point 2).</p>

[Click here to view linked References](#)

Virology Division News

1
2
3
4 50 years of the International Committee on Taxonomy of Viruses: progress and
5
6 prospects
7
8

9 Michael J. Adams^{1*}, Elliot J. Lefkowitz², Andrew M. Q. King³, Balázs Harrach⁴, Robert L. Harrison⁵,
10 Nick J. Knowles⁶, Andrew M. Kropinski⁷, Mart Krupovic⁸, Jens H. Kuhn⁹, Arcady R. Mushegian¹⁰, Max
11 L. Nibert¹¹, Sead Sabanadzovic¹², H  l  ne Sanfa  on¹³, Stuart G. Siddell¹⁴, Peter Simmonds¹⁵, Arvind
12 Varsani¹⁶, Francisco Murilo Zerbini¹⁷, Richard J. Orton¹⁸, Donald B. Smith¹⁹, Alexander E. Gorbalenya²⁰
13 and Andrew J. Davison²¹
14
15
16
17
18
19

20 ¹ 24 Woodland Way, Stevenage, Herts SG2 8BT, UK

21 e-mail: mike.adams.ictv@gmail.com

22 * Corresponding author
23
24
25
26

27 ² Department of Microbiology, University of Alabama at Birmingham (UAB), BBRB 276, 845 19th ST
28 South, Birmingham, AL 35294-2170, USA

29 e-mail: elliotl@uab.edu
30
31
32
33

34 ³ Sunfield, Dawney Hill, Pirbright, Woking, Surrey GU24 0JB, UK

35 e-mail: amqking@gmail.com
36
37
38
39

40 ⁴ Institute for Veterinary Medical Research, Centre for Agricultural Research, Hungarian Academy of
41 Sciences, H-1143 Budapest, Hung  ria krt. 21, Hungary

42 e-mail: harrach.balazs@agrar.mta.hu
43
44
45
46

47 ⁵ Invasive Insect Biocontrol and Behavior Laboratory, USDA, 10300 Baltimore Avenue, Bldg 007 Barc-
48 West, Beltsville, MD 20705, USA

49 e-mail: robert.l.harrison@ars.usda.gov
50
51
52
53

54 ⁶ The Pirbright Institute, Ash Road, Pirbright, Surrey GU24 0NF, UK

55 e-mail: nick.knowles@pirbright.ac.uk
56
57
58
59

60 ⁷ Departments of Food Science, Molecular & Cellular Biology and Pathobiology, University of Guelph,
61
62
63
64
65

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Guelph, Ontario N1G 2W1, Canada

e-mail: phage.canada@gmail.com

⁸ Department of Microbiology, Institut Pasteur, 25 rue du Dr Roux, 75015 Paris, France

e-mail: mart.krupovic@pasteur.fr

⁹ NIH/NIAID/DCR Integrated Research Facility at Fort Detrick (IRF-Frederick), B-8200 Research Plaza,
Fort Detrick, Frederick, MD 21702, USA

e-mail: kuhnjens@mail.nih.gov

¹⁰ Division of Molecular and Cellular Biosciences, National Science Foundation, Arlington, VA 22230,
USA

e-mail: mushegian2@gmail.com

¹¹ Department of Microbiology & Immunobiology, Harvard Medical School, 77 Ave Louis Pasteur,
Boston, MA 02115, USA

e-mail: mnibert@hms.harvard.edu

¹² Department of Biochemistry, Molecular Biology, Entomology and Plant Pathology, Mississippi
State University, 100 Old Hwy 12 Mail Stop 9775, Mississippi State, MS 39762, USA

e-mail: ssabanadzovic@entomology.msstate.edu

¹³ Summerland Research and Development Centre, Agriculture and Agri-Food Canada, 4200 Highway
97, Summerland, British Columbia V0H 1Z0, Canada

e-mail: helene.sanfacon@agr.gc.ca

¹⁴ School of Cellular and Molecular Medicine, Faculty of Biomedical Sciences, University of Bristol,
University Walk, Bristol BS8 1TD, UK

e-mail: stuart.siddell@bristol.ac.uk

¹⁵ Nuffield Department of Experimental Medicine, University of Oxford, Peter Medawar Building,
South Parks Road, Oxford OX1 3PS, UK

e-mail: peter.simmonds@ndm.ox.ac.uk

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

¹⁶ The Biodesign Center for Fundamental and Applied Microbiomics, School of Life Sciences, Center for Evolution and Medicine, P.O. Box 874701, Arizona State University, Tempe, AZ 85287-4701, USA
e-mail: arvind.varsani@asu.edu

¹⁷ Departamento de Fitopatologia/BIOAGRO, Universidade Federal de Viçosa, Viçosa, MG 36570-900, Brasil
e-mail: zerbini@ufv.br

¹⁸ MRC – University of Glasgow Centre for Virus Research, Sir Michael Stoker Building, 464 Bearsden Road, Glasgow G61 1QH, UK
e-mail: richard.orton@glasgow.ac.uk

¹⁹ Centre for Immunity, Infection and Evolution, Ashworth Laboratories, University of Edinburgh, King's Buildings, West Mains Road, Edinburgh EH9 3JT, UK
e-mail: donald.smith.ictv@gmail.com

²⁰ Department of Medical Microbiology, Leiden University Medical Center, P. O. Box 9600, E4-P, rm. E4-72, 2300 RC Leiden, The Netherlands; Faculty of Bioengineering and Bioinformatics, Lomonosov Moscow State University, 119899 Moscow, Russia
e-mail: a.e.gorbalenya@lumc.nl

²¹ MRC – University of Glasgow Centre for Virus Research, Sir Michael Stoker Building, 464 Bearsden Road, Glasgow G61 1QH, UK
e-mail: andrew.davison@glasgow.ac.uk

1 **Abstract**

2
3 We mark the 50th anniversary of the International Committee on Taxonomy of Viruses (ICTV) by
4 presenting a brief history of the organization since its foundation, showing how it has adapted to
5 advancements in our knowledge of virus diversity and the methods used to characterize it. We also
6 outline recent developments, supported by a grant from the Wellcome Trust (UK), that are
7 facilitating substantial changes in the operations of the ICTV and promoting dialogue with the
8 virology community. These developments will generate improved online resources, including a freely
9 available and regularly updated ICTV Virus Taxonomy Report. They also include a series of meetings
10 between the ICTV and the broader community focused on some of the major challenges facing virus
11 taxonomy, with the outcomes helping to inform the future policy and practice of the ICTV.
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1 From the beginnings of virology more than a hundred years ago, viruses were often named by
2 researchers after the diseases they caused. The development of various methods to characterise
3 viruses (physicochemical methods, tissue culture, electron microscopy, serology, etc.) led to a steady
4 increase in the number known and helped demonstrate some relationships among them. As a result,
5 the need for oversight of virus nomenclature and classification was recognized, and this led
6 eventually to the founding of the International Committee on Nomenclature of Viruses (ICNV) in
7 1966. The ICNV changed its name to the International Committee on Taxonomy of Viruses (ICTV) in
8 1975, reflecting the fact that the ICTV regulates both the creation and the naming of taxa. To mark
9 the 50th anniversary of the organisation, we now provide a brief historical overview and describe
10 some recent significant developments that are helping it adapt to the future.
11
12
13
14
15
16
17
18
19
20

21 **Foundation**

22 The ICNV was established on 22 July 1966 in Moscow during the 9th Congress of the International
23 Association of Microbiological Societies (IAMS). A provisional steering committee established three
24 years earlier had invited each of the national microbiological societies affiliated to IAMS to appoint a
25 virology representative, and these became the founding members of the ICNV. An Executive
26 Committee (EC) elected by the members to oversee the ICNV drew up a set of rules that were
27 approved by the National Members at a subsequent meeting during the same congress. Key
28 decisions of these founding meetings were that the ICNV would establish a universal system of
29 classification and nomenclature for viruses (i.e. one for all viruses, irrespective of host), that the
30 bacterial code of nomenclature would not be applied to viruses, and that the rule of priority of
31 publication would not be observed. These principles established a system in which the decisions of
32 the ICNV (and later the ICTV) would determine both the creation and the naming of taxa, and thus
33 set virus taxonomy apart from most biological taxonomy (botanical, zoological, etc.), for which the
34 international codes regulate only the names that are used. The founding meeting of the ICNV also
35 agreed that ‘an effort should be made towards a latinized binomial nomenclature’.
36
37
38
39
40
41
42
43
44
45
46
47
48

49 To begin its task, the EC created four host-based Subcommittees to propose genera and families for
50 the known viruses of insects, vertebrates, plants and bacteria. Each Subcommittee was chaired by a
51 member of the EC, and consisted of specialists representing each of the major groups of viruses
52 within their remit. These specialists in turn chaired Study Groups to propose a classification and
53 nomenclature in their areas. The taxonomy proposed by the Study Groups was discussed by the
54 relevant Subcommittee and by the EC, and (once agreement had been reached) then required final
55
56
57
58
59
60
61
62
63
64
65

1 approval of the entire ICNV. The same basic pattern continues to this day – most taxa and taxon
2 names originate in proposals made by specialist Study Groups, whose work is co-ordinated and
3 overseen by the EC.
4
5

6
7 The 1st Report of the ICNV was published in 1971 [1] and provided the first indication of progress in
8 virus classification. Most of the vertebrate viruses listed in that Report were classified into 19 genera
9 and two families (*Papovaviridae* and *Picornaviridae*), and the remaining viruses were presented in 24
10 groups pending further information to determine appropriate classification levels. Each genus or
11 group had a type member and a list of ‘other members’, all specified using the common (vernacular)
12 name of the virus. A total of 290 viruses were listed as members of these genera or groups, together
13 with a similar number listed as ‘possible members’. The taxonomy established by the 1st Report is
14 available at http://www.ictvonline.org/virusTaxonomy.asp?msl_id=1. Each subsequent release of
15 the ICNV/ICTV taxonomy is available at <http://www.ictvonline.org/taxonomyReleases.asp>.
16
17
18
19
20
21
22
23

24 **Consolidation**

25 A process was soon established upon these foundations that lasted for some 25 years. Taxonomic
26 proposals for genera and families (and later a few subfamilies and orders) were prepared (usually)
27 by the Study Groups, discussed and modified where necessary in consultation with the relevant
28 Subcommittee and the EC, and finally presented to the voting membership of the ICTV at a plenary
29 session of the triennial International Congress of Virology (ICV) or occasionally by postal ballot.
30 Voting members consisted of the National Members, the EC members and a small number of
31 honorary Life Members. Changes to taxonomy were sometimes reported as journal articles, and the
32 2nd to 6th ICTV Reports were published in 1976 [2], 1979 [3], 1982 [4], 1991 [5] and 1995 [6]. The
33 Reports were initially journal supplements but soon became independent publications that were
34 standard reference works, providing the authoritative viral taxonomy and also a comprehensive
35 overview of the properties of the viruses classified. In most cases, the groups listed in the 1st Report
36 were eventually recognised and named as genera, and member viruses (together with separate lists
37 of ‘probable members’ and sometimes also ‘possible members’) were listed at the discretion of the
38 respective Study Groups that prepared the chapters. The main efforts were thus directed at the rank
39 of genus and above. The early intention to adopt a latinized binomial nomenclature was abandoned
40 as a result of direct opposition by some virologists and differences of view about the feasibility and
41 merits of recognising virus species [7].
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56

57 **Establishment**

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

An important conceptual change occurred with the formal recognition of virus species as proposed by van Regenmortel [8] and adopted by the ICTV in 1991 [9]. This change was largely approved by the community and universally implemented in the 7th Report, which was published in 2000 [10]. From then on, Study Groups classified viruses into species, and taxonomic proposals became necessary for the creation and naming of new species. Each species could include numerous viruses differing antigenically or pathogenically, one of which was designated as the representative isolate. This step-change in virus taxonomy led to drastic revisions in some genera. For example, the 96 viruses that had been listed as independent members of the genus *Enterovirus* in the 6th Report were classified into a mere eight species in the 7th Report. However, in many other cases the lists of species in the 7th Report corresponded largely with the viruses listed as genus members in earlier Reports. To distinguish them as virus species, their names were now printed in italics and with an initial capital letter. Species names to this day have many different styles, often reflecting the differing approaches to naming viruses among researchers working with various virus groups (e.g. bacteriophages, plant viruses, arboviruses, etc.). Efforts continue to be made to achieve consistency of species naming styles within certain genera and families, often incorporating the genus name (e.g. *Enterovirus A* and *Rabies lyssavirus*).

Virus taxa (including species) are usually accepted to be man-made categories (although see [11]). Thus, the decision to create a new species in a particular genus is inevitably a matter of scientific judgement and pragmatism, usually guided by genus- or family-specific criteria established by the relevant Study Group. The formal definition of a virus species has been controversial [12], and there are differing viewpoints on what that definition should contain, whether a universally agreed definition is necessary (botanical taxonomy, for example, does not have one), and what the consequences of adopting different definitions might be. Despite considerable criticism from some eminent virologists [13], the 1991 definition: “A virus species is defined as a polythetic class of viruses that constitutes a replicating lineage and occupies a particular ecological niche” was replaced by majority vote in 2013 with: “Species shall be created in accordance with the following definition: A species is the lowest taxonomic level in the hierarchy approved by the ICTV. A species is a monophyletic group of viruses whose properties can be distinguished from those of other species by multiple criteria”. The view that the ICTV should have a species definition that endorses the polythetic concept is still being advocated [14].

Growth

1 The early years of the 21st century have seen significant changes in the rate of virus discovery and
2 characterisation, driven mainly by the explosion in high-throughput sequencing and the
3 development of sophisticated bioinformatic tools. This has resulted in an ever-increasing workload
4 for Study Groups and the EC and in the creation of many more virus taxa. Following the latest (2016)
5 ratification vote [15], an untold number of viruses are classified within 3704 species, 609 genera, 111
6 families (including 27 subfamilies) and 7 orders. This rapid expansion has only become possible by
7 changes within the EC to increase the numbers of Subcommittees (now six, some of them based on
8 genome type as well as on host) and Study Groups (now 99). Nonetheless, in organisational terms,
9 the ICTV has retained many of its early characteristics. It is now a committee of the Virology Division
10 of the International Union of Microbiological Societies (IUMS; the successor of IAMS), and its
11 governance is determined by Statutes, the latest version of which can be found at
12 <http://www.ictvonline.org/statutes.asp>. A separate Code containing the rules governing the creation
13 and naming of virus taxa is available at <http://www.ictvonline.org/codeOfVirusClassification.asp>.

14 An internet home page for the ICTV was created in 1995, and since then a web presence has become
15 increasingly integral to ICTV operations. It now provides open access to a wealth of information
16 including past and present virus taxonomy, taxonomic proposals under consideration and the
17 opportunity to contribute to discussions. Although Study Groups continue to play a leading role in
18 preparing taxonomic proposals, submissions are welcomed from any virologist, and forms and
19 instructions for this purpose are available at [https://talk.ictvonline.org/files/taxonomy-proposal-
20 templates/](https://talk.ictvonline.org/files/taxonomy-proposal-templates/). The web site includes lists of EC Members, Subcommittee Members, Study Group
21 Members, Life Members (to which the previous President was added recently [16]) and National
22 Members. Study Group chairs were added to the ICTV voting membership in 2005, in recognition of
23 the important role they play in developing virus taxonomy and encouraging the involvement of the
24 wider virology community. The final vote on all proposals approved by the EC has been conducted
25 by an email ballot since 2009, and now takes place annually. The up-to-date list of currently
26 approved virus taxa (the Master Species List) can be downloaded in its entirety from
27 <https://talk.ictvonline.org/files/master-species-lists/m/msl/5945>, or its contents explored online at
28 <http://www.ictvonline.org/virusTaxonomy.asp>. An important recent development has provided
29 access to the complete history of all taxonomic changes during the past 50 years and, in many cases,
30 access to the formal proposals that introduced these changes [17]. The web site is also a source of
31 news and information relevant to virus taxonomy, including the annual ICTV newsletter available at
32 https://talk.ictvonline.org/files/ictv_documents/m/newsletters.

Recent developments

1 Experience in producing the 8th [18] and 9th [19] Reports (published in 2005 and 2012, respectively)
2 convinced the EC that it was no longer desirable to produce these as physical volumes through a
3 commercial publisher. Although the printed Reports have served the community well for nearly 50
4 years, this approach now has significant disadvantages, including the work involved in producing a
5 large book (the 9th Report has nearly 1500 pages), the price of the volume and the inevitable delays
6 between writing and publication, especially at a time when both science and virus taxonomy are
7 advancing rapidly. Historically, the costs of running the ICTV (largely for holding the annual EC
8 meeting) have been met by grants from IUMS, the American Society of Virology and the
9 Microbiology Society (UK), together with royalties from sales of the published Reports. There have
10 been minimal funds to use for technological and other developments, and the EC Members were
11 therefore delighted when, in 2015, three of their number were awarded a five-year Bioresource
12 Grant by the Wellcome Trust (UK). This support commenced at the beginning of 2016 and is now
13 being used to drive substantial changes to the operations and public contributions of the ICTV, as
14 described below.

15
16
17
18
19
20
21
22
23
24
25
26
27
28 **Open access resources.** The ICTV Taxonomy Report is being made freely available at
29 <http://www.ictvonline.org/Report> in a greatly enhanced format, starting in January 2017. Over a
30 three-year cycle, the Study Groups will update the information in the chapters of the 9th Report and
31 produce chapters for newly created taxa. In addition to internal links to the latest ICTV taxonomic
32 database, bi-directional links will also be provided to external databases. Following an agreement
33 with the Microbiology Society (UK), summaries of the online Report chapters (usually corresponding
34 to individual families), also prepared by the Study Groups, are being published as citeable, freely
35 available articles in the Journal of General Virology and indexed in literature search engines such as
36 PubMed. These summaries will include links to the full online Report, and thus will provide definitive
37 citations to the more comprehensive information available therein.

38
39
40
41
42
43
44
45
46
47
48 **Bioinformatic resources.** To facilitate the development of taxonomy and the involvement of the
49 virology community in this process, the ICTV web site will provide bioinformatic and database
50 resources designed to simplify the processes involved in generating and approving taxonomic
51 proposals. To enhance the rigour with which virus taxonomy is advanced, the web site will also
52 provide information and tools aimed at ensuring data consistency and integrity, including
53 standardised alignments for representative sequences from virus groups (typically, families)
54 produced in collaboration with the Study Groups. Collectively, these resources are expected to
55
56
57
58
59
60
61
62
63
64
65

1 greatly simplify the submission and ratification of taxonomic proposals, and also significantly
2 enhance the ability of the ICTV to keep taxonomy abreast of virus discovery.
3
4

5 **Focused meetings.** A series of focused meetings is providing a much-needed channel through which
6 the expertise of those working in virology, evolutionary biology and bioinformatics will be able to
7 contribute to the work of the ICTV in the short and long terms. The first of these meetings was
8 organized for Study Group chairs and EC Members, and took place on 1-2 February 2016 at Hinxton,
9 near Cambridge (UK), with an attendance of 76 virologists. This very successful workshop gave the
10 opportunity for wide-ranging discussions of the operations of the ICTV, the development of the
11 online Report and the challenges facing virus taxonomy. A summary is available at
12 http://talk.ictvonline.org/meetings/sg_hinxton/w/sg_meeting.
13
14
15
16
17
18
19
20

21 The second meeting, held on 9-11 June 2016 in Boston (USA), was aimed at considering the
22 challenges posed by metagenomics to virus discovery and taxonomy. The 25 attendees included
23 experts in the fields of high-throughput sequencing and virus discovery, along with many EC
24 Members. An important outcome from this meeting was a series of consensus proposals for
25 classifying viruses identified from metagenomic datasets, a summary of which has recently been
26 published [20]. Further focused meetings are planned on other key areas, with the anticipation of
27 again publishing the outcomes and using these to help inform the future policy and practice of the
28 ICTV.
29
30
31
32
33
34
35
36

37 **Virus taxonomy in the age of metagenomics.** At the EC meeting on 22-24 August 2016 in Budapest
38 (Hungary), the consensus proposals developed at the Boston (USA) meeting were welcomed and
39 thanks were recorded for the stimulating contributions made by the participants to various
40 discussions on the challenges and opportunities posed by increasing volumes of genomic and
41 metagenomic data to virus taxonomy. The EC emphasized that proposals to create taxa on the basis
42 of genomic sequences alone are welcomed, regardless of the technology used to determine those
43 sequences and even in the absence of all other biological data (including host), provided that there is
44 credible evidence for the accuracy of the sequence assembly and that the genome sequence is
45 coding complete. The EC noted that it has been accepting proposals on this basis for some time, at
46 least for species in well-established genera and families, and that it does not believe that any
47 changes to the taxonomic code (including the virus species definition) are required to continue and
48 extend this practice. The EC concluded that species created only on the basis of sequence data
49 should be accommodated in the same classification hierarchy and using the same nomenclatural
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1 rules as those created on the basis of traditional biological characterization. The EC recognized that
2 there are additional challenges to the creation of taxa, and particularly higher taxa, where the new
3 viruses are highly diverged from members of currently established taxa, and plans to use expertise
4 within and outside the Committee to develop appropriate methods and standards to meet those
5 challenges.
6
7

10 **Prospects**

11
12 Virus taxonomy, like any biological taxonomy, is never perfect or complete. However, a transparent
13 and functional system for virus classification is essential, particularly in view of the explosion in virus
14 discovery that is currently underway and may continue for the next 50 years. Interest in virus
15 taxonomy is also increasing with the awareness that viruses have a major impact on the health of
16 humans, livestock and crops, and also on the functioning of terrestrial and aquatic ecosystems.
17 Metagenomic studies are revealing the presence of large numbers of distinct viruses that may have
18 little or no adverse effects on their hosts and may even be beneficial to them [21]. The new era of
19 virus discovery poses many exciting challenges and opportunities for virus taxonomists and a
20 motivation for ensuring that formal classification remains relevant to the needs of the community
21 and vital for our understanding of the relationships among viruses. As this brief overview
22 demonstrates, the ICTV is adapting to meet challenges that could not have been foreseen at its
23 foundation. Financial and workload pressures will likely increase, but the EC welcomes the
24 involvement of virologists everywhere to ensure continued progress with this endeavour.
25
26
27
28
29
30
31
32
33
34
35
36

37 **Acknowledgements and funding**

38
39 The authors are the current ICTV EC Members together with two researchers (R.J.O., D.B.S.)
40 supported by the Wellcome Trust grant detailed below. We gladly acknowledge the dedicated,
41 voluntary efforts of hundreds of virologists based in various parts of the world over the entire period
42 of the existence of the ICTV. The work of the organisation through its EC and Study Groups has
43 always depended upon that contribution and will continue to do so.
44
45
46
47
48

49
50 The ICTV is supported by grants from IUOMS, the American Society of Virology and the Microbiology
51 Society, and by a grant from the Wellcome Trust (WT108418AIA) to P.S., A.J.D. and S.G.S. The
52 involvement of J.H.K. was supported in part through Battelle Memorial Institute's prime contract
53 with the US National Institute of Allergy and Infectious Diseases (NIAID) under Contract No.
54 HHSN272200700016I. A subcontractor to Battelle Memorial Institute who performed this work is
55 J.H.K., an employee of Tunnell Government Services, Inc. The involvement of A.R.M. was supported
56
57
58
59
60
61
62
63
64
65

1 in part by the National Science Foundation Individual Research and Development program. The
2 views and conclusions contained in this document are those of the authors and should not be
3 interpreted as necessarily representing the official policies, either expressed or implied, of the US
4 Department of Health and Human Services, US National Science Foundation, or of the institutions
5 and companies affiliated with the authors.
6
7
8
9

10 **Statement of competing financial interests**

11 The authors declare that they have no competing financial interests.
12
13
14
15

16 **References**

- 17 1. Wildy P (1971) Classification and nomenclature of viruses. First report of the International
18 Committee on Nomenclature of Viruses. *Monog Virol* 5:1-81.
- 19 2. Fenner F (1976) Classification and nomenclature of viruses. Second report of the International
20 Committee on Taxonomy of Viruses. *Intervirol* 7:1-115
- 21 3. Matthews REF (1979) Classification and nomenclature of viruses. Third report of the
22 International Committee on Taxonomy of Viruses. *Intervirol* 12:129-296
- 23 4. Matthews REF (1982) Classification and nomenclature of viruses. Fourth report of the
24 International Committee on Taxonomy of Viruses. *Intervirol* 17:1-199
- 25 5. Francki RIB, Fauquet CM, Knudson DL, Brown F (1991) Classification and nomenclature of
26 viruses. Fifth report of the International Committee on Taxonomy of Viruses. *Arch Virol Suppl* 2
27 Springer-Verlag, Wein, New York
- 28 6. Murphy FA, Fauquet CM, Bishop DHL, Ghabrial SA, Jarvis AW, Martelli GP, Mayo MA, Summers
29 MD (1995) *Virus taxonomy*. Sixth report of the International Committee on Taxonomy of Viruses.
30 Springer-Verlag, Wien, New York
- 31 7. Matthews REF (1983) The history of viral taxonomy. In: REF Matthews (ed.), *A critical appraisal*
32 *of viral taxonomy*, Boca Raton, Florida (CRC Press): 1-35
- 33 8. van Regenmortel MHV (1989) Applying the species concept to plant viruses. *Arch Virol* 104:1-17
- 34 9. Pringle CR (1991) The 20th meeting of the executive committee of the ICTV. Virus species, higher
35 taxa, a universal database and other matters. *Arch Virol* 119:303-304
- 36 10. van Regenmortel MHV, Fauquet CM, Bishop DHL, Carsten, EB, Estes MK, Lemon SM, Maniloff J,
37 Mayo MA, McGeoch DJ, Pringle CR, Wickner RB (2000) *Virus taxonomy*. Seventh report of the
38 International Committee on Taxonomy of Viruses. Academic Press, San Diego
- 39 11. Lauber C, Gorbalenya AE (2012) Toward genetics-based virus taxonomy: comparative analysis of
40 a genetics-based classification and the taxonomy of picornaviruses. *J Virol* 86:3905-3915
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

12. Gibbs AJ (2003) Viral nomenclature, where next? *Arch Virol* 148: 1645–1653
13. van Regenmortel MH, Ackermann HW, Calisher CH et al. (2013) Virus species polemics: 14 senior virologists oppose a proposed change to the ICTV definition of virus species. *Arch Virol* 158:1115-1119
14. van Regenmortel MHV (2016) Classes, taxa and categories in a hierarchical virus classification: a review of current debates of definitions and names of virus species. *Bionomina* 10:1–21
15. Adams MJ, Lefkowitz EJ, King AMQ et al. (2016) Ratification vote on taxonomic proposals to the International Committee on Taxonomy of Viruses (2016). *Arch Virol* 161:2921-2949
16. Adams MJ, Davison AJ (2016) Eric Carstens: new life member of the International Committee on Taxonomy of Viruses (ICTV). *Arch Virol* 161:3601
17. Adams MJ, Hendrickson RC, Dempsey DM, Lefkowitz EJ (2015) Tracking the changes in virus taxonomy. *Arch Virol* 160:1375-1383
18. Fauquet C, Mayo MA, Maniloff J, Desselberger U, Ball LA (Eds) (2005) *Virus taxonomy: Eighth Report of the International Committee on Taxonomy of Viruses*. Elsevier Academic Press, London, San Diego
19. King AMQ, Adams MJ, Carstens EB, Lefkowitz EJ (Eds) (2012) *Virus Taxonomy. Ninth Report of the International Committee on Taxonomy of Viruses*. Elsevier Academic Press, London, San Diego
20. Simmonds P, Adams MJ, Benkő M et al. (2016) Virus taxonomy in the age of metagenomics. *Nat Rev Microbiol*, in press
21. Roossinck MJ (2015) Plants, viruses and the environment: Ecology and mutualism. *Virology* 479-480:271-277. doi: 10.1016/j.virol.2015.03.041