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## SYSTEMS OF VIRUS CLASSIFICATION AND NOMENCLATURE

*Met een samenvatting:*

*Systemen van classificatie en nomenclatuur van viren*

BY

JAMES JOHNSON

(Professor of Horticulture and Plant Pathology, University of Wisconsin,  
Madison, Wisc., U.S.A.)

The first discovery that a virus disease was transmissible from one host species to another species or genus indicated the need of a form of nomenclature to avoid confusion in the identification of disease. The further need for virus disease classification and nomenclature was established by the recognition of more than one kind of virus disease on a single host species. Thus the early work of QUANJER on potato virus disease differentiation was a pioneer effort in this direction (35, 36). In QUANJER's, and in most of the later descriptions of virus diseases, symptom expression was the chief basis for differentiation (39). With the discovery of distinct virus diseases in larger numbers and with the accumulation of more information about their causal agents, it became evident that symptom expression alone was both insufficient and unreliable as a criterion for the differentiation of many virus diseases. Such variables as the variety and growth stage of the host at the time of infection, the environmental conditions and other circumstances were found to influence symptoms to a remarkable degree. The discovery of the presence of viruses in symptomless hosts added to these difficulties.

Other means of differentiation and identification were consequently sought such as those based on the properties of the virus. These studies developed into the logical conception that the virus entity itself, as the causal agency of disease, was the primary subject in need of description and differentiation. The disease symptoms, though highly useful in the identification of certain viruses, seemed destined to find their greatest usefulness in distinguishing strains of the same virus. Some progress was made before 1930 in the differentiation of many viruses on the basis of modes of transmission, properties, host-range, symptomatology and other criteria. The origin of the common names applied to the different viruses, and especially the increase of synonymyous names for a single virus soon became highly confusing to research workers and students of pathology alike. A single technical designation for the virus entity itself seemed to be the logical way of avoiding further confusion.

## THE NUMBERING AND LETTERING SYSTEM

In 1927, it was suggested that a virus entity be named from the host on which it was first found and adequately described, with a number showing the chronological order of new and distinct viruses found and described on one host species (21). For the host name, a choice between the common English name, the Latin generic name or the Latin binomial name was indicated. With some modifications, this system of nomenclature has been widely used, although publication of this scheme in final form has not yet been made. Recognizing the confusion which would result from the use of more than one system of nomenclature, effort was made to secure international cooperation and agreement on a single system. In August 1930, an appeal was made for such an agreement before the Fifth International Botanical Congress meeting at Cambridge, England (22, 23). Because of the support given this idea by QUANJER and other virus workers (40) in attendance at the Congress, an International Committee on Plant Virus Classification and Nomenclature was appointed to report and make recommendations to the Sixth International Botanical Congress (Amsterdam 1935). The committee members were: H. M. QUANJER, J. HENDERSON-SMITH, PAUL A. MURPHY, GEOFFREY SAMUEL and JAMES JOHNSON. A tentative system of nomenclature based on the name of the host with the appropriate numbers to indicate the virus species and letters to indicate the virus strains was presented to the phytopathologists at Amsterdam. The report was favorably received and the system adopted „in principle” by the Congress (20). The committee was then empowered to continue its work and to present a more complete form at the next meeting of the International Congress scheduled for 1940 (Stockholm). The following new members were invited to assist in the study: C. W. BENNETT, JEAN DUFRENOY, L. O. KUNKEL, L. PETRI, H. H. STOREY and T. H. THUNG. By 1939 a thirty-two page mimeographed prospectus had been prepared and distributed to many virus workers for comment and suggestions. The committee was invited to meet with the International Microbiological Congress in New York City in September 1939. The expressed hope was that some joint system of virus nomenclature could be developed among the animal and plant virus workers in conference. On the day of this conference war was declared in Europe and the deliberations on virus nomenclature came to an abrupt end as far as international cooperation was concerned. The International Botanical Congress has not met since 1935 and this has naturally resulted in delay in further agreements.

Post-war revival of the International Committee's efforts have also been delayed for other reasons. The chief of these was a series of publications and proposals from other sources on the subject of virus classification and nomenclature. In 1937, K. M. SMITH (41) published his Text-book of Plant Virus Diseases, classifying and naming most of the known plant viruses, following „in principle” the system recommended by the International Plant Virus Committee. Some of the plans of the committee such as that of the chronological order of numbering were not followed, with confusing results to the committee despite the usefulness of the compilation to other workers. Anticipating further confusion and synonymy in virus nomenclature, the officers of the American Phytopathological Society appealed to its members in 1938 (27) to refrain from adopting any new system of nomenclature until some committee agreement could be reached. A committee of this Society was then appointed consisting of L. O. KUNKEL,

C. W. BENNETT, EUBANKS CARNSER, H. H. MCKINNEY, E. S. SCHULTZ, W. D. VALLEAU and JAMES JOHNSON. This committee, with several changes in membership, has not been able to reach a final agreement during a ten-year period, although it did sponsor publication of the synonymy and description of some virus groups (7, 48, 49, 50). With the appearance in 1939 of HOLMES' Handbook of Phytopathogenic Viruses (15) extending the Latin binomial system of nomenclature to the viruses (14), the point of issue with this committee became the relative merits of the proposed systems. Regardless of one's views on the subject of classification of viruses and usage of names for viruses, the HOLMES' publication naturally delayed hopes of early international agreement.

A flood of proposals, several in published form, were now brought to the attention of the two committees. All of them had some desirable features, but were difficult to coordinate into a single system of classification and nomenclature.

#### THE LATIN BINOMIAL SYSTEM

Binomials such as *Strongyloplasma Iwanowskii* PALM (33) and *Protobios mosaicus* var. *tabaci* d'HERELLE (44) had been suggested for the causal agent of the ordinary tobacco mosaic virus, but it remained for HOLMES to develop the idea (15). HOLMES proposed *Marmor tabaci* for the virus referred to as *Tobacco virus x* by JOHNSON and *Nicotiana virus x* by SMITH. The choice for the virus workers thus seemed to lie between the Latin and numbering system or continued use of the common name (19). All these systems have now been widely used, some going as far as to apply two technical names to one virus (34).

The Latin binomial system attracted many suggestions for modifications of Latin and Greek prefixes and suffixes, sometimes combined with English. Thus, „*tobacco virus altathermus*”, *Paracrystalis altathermus* or *tobacco virus altathermovir* were suggested by BENNETT (5). FAWCETT (12) believed the suffix „vir” should be included in the generic name, as for example, „*Solanivir*”. VALLEAU (44, 45) proposed *Musivum tabaci*, and THORNBERRY (43) suggested *Phytovirus nicomosaicum*. CARNSER (9) suggested that the sugar beet curly-top virus should be changed from *Chlorogenus eutetticola* to *Ruga verrucosans*.

MCKINNEY (31, 32) after giving very thorough consideration to the Latin genera of the viruses, and the derivation of the binomials as used by HOLMES, proposed several modifications in generic names. His reclassification of certain species has been accepted in part by HOLMES in his 1948 revision (18). Perhaps because it is yet too early to satisfactorily differentiate virus genera except on an arbitrary basis, repeated reclassification is to be expected under a binomial system and this will often require alteration of the generic name of a virus. It is difficult to predict, for example, what influence on virus relationship may result from the discovery of new insect vectors (24, 28, 42) or new serological evidence (6, 10).

The interest in virus nomenclature in Europe has been somewhat less pronounced than in America, except for K. M. SMITH's work. In Great Britain, AINSWORTH (1, 2) and BAWDEN (4) have retained a critical attitude and with the Review of Applied Mycology (19) have preferred to refrain from applying any new system of nomenclature for the viruses. MANIL (30) in Belgium, LIMASSET (29) in France, and BUCHWALD in Scandinavia (8) have recently expressed views but evidently most workers are awaiting more general agreement on the subject.

The interest in a uniform system of animal virus nomenclature has been less

evident than that in the plant virus field. VERGE and GORET (47) in 1935 and many others have considered virus classification on one basis or another without altering the common name. Further designation has been usually limited to variable forms of lettering and numbering systems which could be improved by some effort toward uniformity and stability (13). The most ambitious effort in the animal field is the recent extension of the Latin binomial system for plant and bacterial viruses to the animal viruses by HOLMES (18). It is yet too early to judge how far this system will be accepted by the workers in these latter fields but some disagreement on classification has already been expressed (3). As far as nomenclature is concerned, it is evident that the virus species are more generally based on the host species than in the instance of the plant viruses.

#### THE PRESENT STATUS

It may be quite unprofitable to discuss the merits of all individual and committee efforts in the problem now under consideration. The contention may be made that the best or the most generally accepted system will survive regardless of its origin. This is as it should be but nevertheless something is to be gained by coordination and cooperation. Nomenclature development in particular differs from technical research, which may be conducted independently by individuals, in that names in some form must be used by all concerned with the subject involved. Efforts at escaping or ignoring a common usage are usually unsatisfactory to others. International effort in nomenclature has therefore become practically a tradition in biology and others sciences. Thus, *BERGEY's Manual of Determinative Bacteriology* devotes a chapter to rules of nomenclature and international agreement through committee action. This principle seems to be disregarded in the publication of Supplement 2 in the same volume. However logical this manner of publication may be, the significant point is that international agreement on one system of nomenclature before publication is more likely to achieve universal acceptance than are several individual systems published independently.

The synonymy and confusion in virus nomenclature now existing may continue for many years. The International Botanical Congress, through its plant virus committee, may aid in reducing confusion by adopting and recommending one system of nomenclature. If at the same time coordination and cooperation should be secured with the International Microbiological Congress for the bacterial and animal viruses, it would be doubly advantageous. Such agreement may require more time and effort than can now be anticipated. In the meantime some benefits may be realized from the present situation involving a test of the proposed systems now in actual application. This situation should enable better judgment to be formed of relative merits and aid in final selection through international agreement.

The first meeting, since 1935, of the International Botanical Congress is planned for 1950. At this time the International Committee on plant virus classification and nomenclature may be expected to submit a delayed report and to make recommendations. Recommendations prepared in 1939 for the anticipated 1940 meetings which did not take place because of the war, have not yet been officially considered. This report, largely in the form of „A Tentative International System of Plant Virus Nomenclature”, exists only in mimeograph form not available for publication or literature citation. It is not to be expected that

the ten members of this committee organized in 1935 and representing five nations can revive equal interest and enthusiasm in the subject after a long period of inactivity. It also seems likely that international group interest in the subject such as existed in Amsterdam in 1935 cannot be restored adequately until the meetings of the congress, at which time conferences of a committee and other workers interested in virus nomenclature should be arranged.

Preliminary to the next meeting of the Botanical Congress it now seems to be an appropriate time to renew discussion on virus nomenclature. This appears to be doubly justified following the recent revision (1948) of the Latin Binomial System as published by HOLMES in BERGEY's Manual of Determinative Bacteriology (18). It is recognized that the existence of a proposed system in published and available form constitutes an advantage over an unfinished and unpublished system. However if completion and publication is to determine nomenclatural usage, then K. M. SMITH's modification of the numbering system constitutes priority (41). On the other hand if more recent meritorious individual effort is to determine acceptance, then future publications of modified systems may later become adopted, with added confusion. The true import of this is that it matters not so much what name is applied to a virus, as that preventable and unprofitable synonymy and confusion be avoided. Cooperative effort by the virus workers may be advantageously devoted to this end.

The viruses as such are a most unusual group of entities as evidenced by the HOLMES proposal to erect a new kingdom for their classification (15). On this basis no precedent exists for a system of nomenclature. Hence it seems both logical and desirable to consider usage on the basis of simplicity and convenience rather than on a tradition which is questionable in application. Although it is probable that no other system than that of the Latin binomial could have been devised for the plant and animal kingdom, which would have served the universal purpose of the period equally well, it does possess certain limitations (11). The progress of education and science in other fields has shown that international understanding is not necessarily based on a universal language. But with due regard to the Latin binomial as now universally applied, it is logically limited to entities which may be described on a morphological basis. Viruses have not yet been definitely shown to be in this category and assumptions on this point may be premature, especially for those who would place the viruses among the non-living forms of matter.

Although it is generally agreed that certain distinct viruses may be classified into obvious groups, it is yet too early to draw any satisfactory conclusion as to their natural or evolutionary relationship, except in the instances where support is furnished by serological means (10). Including other distinct viruses in these basic groups is largely a matter of conjecture. A whole group of viruses such as represented by Family V: *Savoiaceae* HOLMES (18) are based on such inadequate description as should hardly be accepted for a specific virus only. Efforts at bolstering generic classification on the basis of symptoms by the inclusion of a second and distinct character such as the modes of transmission introduces inescapable difficulties due to overlapping. Such situations may best be avoided by full reliance on a single dichotomous key with distinct differential characters at each level of classification (24).

Recognizing the numerous difficulties in any proposed system of classification, it is generally acknowledged that a natural classification is not yet possible. Nor

is it essential to a convenient and useful system of nomenclature. It is highly convenient and useful for example to be able to ask a merchant for a man's low 10B shoe, without being too concerned at the outset about the origin of the leather. Efforts at genetic classification of viruses should by all means be continued. Grouping and regroupings are to be expected with the progress of virus research to an even greater extent than with the fungi and bacteria because of the absence of morphological grounds of distinction. It should remain possible to exercise scientific opinion on classification without the necessity of changing the name of one or more viruses at the same time (11). Perhaps the most outstanding weakness of the Latin Binomial System for the viruses is that it permits, encourages or necessitates future changes of nomenclature following increasing knowledge of virus relationship.

Other difficulties arise under the Latin Binomial System, such as that of deriving a descriptive and suitable Latin name for the virus in question. When only a single virus occurs on a host species, such terms as *Rimocortius kwanzani* is quite simply derived from the species name of the host. Where single host species such as those of tobacco or potato may be subject to twenty or more distinct viruses as well as to a number of virus strains, the derivation of a suitable virus name becomes difficult or meaningless. The present lack of any rules or suggestions for virus nomenclature for the HOLMES' Latin Binomial System does not minimize this difficulty for different persons working in different places.

The authority given for the virus name is a matter worthy of careful consideration. Under the Latin Binomial System the final authority is traditionally the person who applies the new name. At the present stage of virology this may impose a considerable handicap to both the old and the new students of the subject. The inclusion of the authority for the first reliable description of the virus in question, regardless of the nomenclature applied, would not be burdensome. It would add greatly to quick recognition of the identity of the virus even if the Latin name offered little in this direction. The identification of a virus from its assigned Latin binomial becomes even more acute when the synonymy is ignored, except for the Latin usage and one common name, as is done in HOLMES' recent publication (18). Further complications in this book are introduced by the omission of a list of viruses in the index under the common or the botanical name of the host, although this desirable feature is included for the animal viruses. Hence it is necessary to know the Latin name for the plant virus in order to directly locate the classification and the description in the text <sup>1)</sup>.

For further comments on the Latin Binomial System the reader is referred to BAWDEN and others (4, 26). Several criticisms of the numbering system of nomenclature are to be found in the literature (1, 5, 44). It is significant however that these unfavorable reactions are not directed at a biological principle of the system. The objections are aimed largely at details that are avoidable or correctable. Since the viruses are named from the host on which they are first described, the numerical system does not purport to be a biological or natural classification and consequently does not raise this controversial issue. Nevertheless, the use of the host name for the virus classifies it at once to some degree and hence is not a useless appendage, i.e. tobacco viruses are separated from rose viruses, whereas,

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<sup>1)</sup> This difficulty in the index has been corrected in a later and separate edition of Supplement No 2 (18).

to no useful purpose, they are in one genus under the binomial system. Hence the species name in such instances under the binomial system constitute a high level of differentiation, whereas in other instances the species name is equally applicable at low levels equivalent to strain differentiation.

BENNETT (5) believes that the simplicity of the numbering system may lead to confusion, that a number does not characterize a virus, that numbers are somewhat difficult to remember, and that numbers do not permit organization in concepts of relationship. It may be pointed out here that consecutive numbers characterize a virus to some degree, *virus 1* for each host being the first virus described on a particular host, a designation that automatically earmarks a particular virus and eliminates all other viruses known to effect the same host. With the use of a Latin species name this may not be always accomplished unless one is familiar with the viruses in this group. The criticisms of the numerical system as given by BENNETT are summarized by him as follows: „it is quite obvious, of course, that some of these difficulties and perhaps the most important ones, are possible of solution by agreement.”

The exact form of the technical name of a virus under the International System of Virus Nomenclature (ISVN) awaits final decision by the Virus Committee of the International Botanical Congress. If adopted, the numbering system may not be expected to vary basically from one of the forms already widely used. As is generally known, the numbering and lettering system consists essentially of assigned consecutive numbers to specific viruses in the chronological order of their published description or differentiation on the host concerned. In like manner strains of these specific or type viruses are to be designated by consecutive capital letters of the alphabet in chronological order of description, and substrains are to be indicated by small alphabetical letters in the same order. The virus name should be printed in italics.

The technical name of the virus may be, for example, the common or the Latin name of the host or both, followed by the word „*virus*” and the appropriate number (and letter in case of strains). The authority for the first adequate description is to be shown followed by the authority for the name of the virus such as ISVN.

Further details of this system exist as tentative rules of nomenclature and they can hardly be presented here without further action of the committee. It may suffice to point out that the numbering system is simple and easy to apply. It does not require final decision as to „genetic” classification before a technical designation can be applied. The authority for the designation needs to demonstrate only that the new virus differs from all other known viruses. Hence the authority for a new description may be familiar only with a limited group of viruses, sufficient for description, and the biological classification may remain in doubt. Efforts at natural classification may, of course, be made without affecting change in nomenclature. The virus name is quickly interpreted by others and is at once informative. It not only supplies the name of the host, but shows the number of viruses previously described on this same host. In the same manner it shows strain relationships were used, these being about the only positive relationships that can be determined. Obviously, *virus 1* of any species will carry a lot of meaning to most workers even if subsequent numbers may not do so until they are frequently used. The numbering system is a quick indexing method permitting rapid reference to hosts and viruses and to synonymy.

It is not believed that the numbering and lettering system lacks academic

dignity. The use of numbers and letters for classification purposes is now more widely used than any other designation in pure and applied science, as well as in industry. It is widely used for varieties and strains of green plants, fungi, bacteria and other organisms. In all other inanimate matter it is almost universally applied. Such usage for the viruses seems logical and practical until sufficient information is obtained about the true nature of, and particularly the relationship of viruses, which may justify some other form of nomenclature.

#### SAMENVATTING

De voor- en nadelen van de verschillende systemen van classificatie en nomenclatuur van viren worden besproken. Op het eerstvolgende Internationale Botanische Congres (1950) zal een nadere beslissing moeten worden genomen over de te volgen weg. Aanbevolen wordt het virus te noemen naar de waardplant (in de eigen taal, in het latijn of in beide), gevolgd door het woord virus en een nummer (en letter, voor het geval strains voorkomen). Deze naamsaanduiding is zuiver technisch, een „genetische” classificatie wordt er niet mee aangegeven.

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ENKELE ONDERZOEKINGEN EN WAARNEMINGEN  
OVER DE BRONSVLEKKENZIEKTE VAN DE TOMAAT  
EN OVER HET KOMKOMMERMOZAIK

*Avec un résumé: Quelques recherches et observations sur la maladie des taches bronzées de la tomate et sur la mosaïque du concombre*

DOOR

G. ROLAND

(Station de Phytopathologie. Gembloux, Belgique)

In dit korte artikel willen we enkele resultaten mededelen, die we verkregen hebben met het virus van de Bronsvlekkenziekte of Spotted wilt van de tomaat (*Lycopersicum-virus* 3, BRITTLEBANK) (6) en met het komkommermozaïek-virus (*Cucumis-virus* 1, DOOLITTLE). Het doel van ons werk was het bestuderen van de symptomen veroorzaakt door deze twee viren op Dahlia en tomaat. We hebben ook enkele waarnemingen gedaan op spinazie, biet en lelie.

Het virus van de tomaat werd geïdentificeerd door tabak of *Nicotiana glutinosa* met sap in te wrijven; daarbij treden grote nekrotische vlekken op en sterft daarna dikwijls de gehele plant. Soms vormen deze vlekken op tabak zeer typische