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PROPOSAL FOR A SYSTEM OF BIOLOGICAL NOMENCLATURE, WITH SPECIAL REFERENCE TO MICROORGANISMS [1]

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An absolute system of nomenclature, in which all of the characters employed for the identification of the organism are directly discernible from the name itself, is proposed.

Particularly in microbiology the use of the present system, as described by Briquet (1935), meets with many difficulties. There are the recurrent arguments over the concept of "major" and "minor" characters in delimiting the "species," the grouping and regrouping maneuvers of the "lumpers" and the "splitters," the persistence of *nomina nuda*, the multiplicity of synonyms and homonyms, the lack of fixity of names in taxonomic areas which have not been monographed and the continuous infusion of erroneous identifications into the literature. The question was entertained by Siu (1951) whether it is feasible to borrow some of the features of the simpler and more stable system of chemical nomenclature; or to modify certain numerical keys, such as those used by Davidson *et al.* (1942) and Nobles (1948) for the wood-rotting fungi into pronounceable words; and to formulate a more functional system of biological nomenclature.

In this paper, the principle of the suggested system is given with several examples in the *Fungi Imperfecti*. This will suffice as the basis for an evaluation of the *idea*. The final expression of the method will require intensive work by experienced and skilled taxonomists.

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GENERAL RULES FOR PROPOSED SYSTEM OF NOMENCLATURE

The name of the organism shall consist of two words, each of which contains nine letters, comprising three syllables. The succession of letters in each word shall be

CVCCVCCVC

where C represents a consonant and V a vowel. This arrangement provides a pronounceable series of letters.

Each letter shall represent one or a group of observable taxonomic characters. Since there are twenty-one consonants and five vowels, each character can be divided into twenty-one or into five divisions depending upon the position the representative letter occupies in the name. If there is doubt concerning the accuracy of determination of the character in question or if the available specimen does not allow for a study of that character, the consonant "X" or the vowel "O" shall be used. Upon acquisition of the requisite data, these tentative letters shall be replaced by the final ones.

If more or less than the 18 characters stipulated above are required, the individual words may be lengthened or shortened by employing the same pronounceable succession of letters. If deemed necessary, a trinomial may be invoked. As a final resort even numbers may be used between words, in which case each numbered position is capable of 10 subdivisions, with zero representing a doubtful character. The need for these modifications can be determined only after an intensive study of the proposed system.

It is suggested that the more readily observable characters or those separating the larger phylogenetic groups be represented among the first letters. Those characters observable with the greatest difficulties, those of a more mutable nature, and those of occasional appearance should be relegated toward the terminal positions in the name.

In the case of a binomial system it would be desirable to arrange the succession of characters, such that the first word generally indicates what is currently considered the genus and the second, the species.

ILLUSTRATIVE EXAMPLES

It is believed that the proposed system can be applied to all organisms. The theoretical number of different names using 18 letters (12 of which are consonants and 6 vowels) is $20^{12} \times 4^6$ or 17,000,000,000,000,000,000. To illustrate the applicability of the system, five examples in the *Fungi Imperfecti* are given below. In this instance, the keys to the genera according to Clements and Shear (1931) are used. It is to be noted from the resulting characters (Table 1) that the first letter is used to separate fungi from other organisms. The second letter then divides the fungi into four large groups of which the *Fungi Imperfecti* is one. The examples have been developed with the thought that it will probably be necessary

to develop new sets of characters for each of the four major groups of fungi, i.e. beginning with the third letter in the name.

The following five examples show how genera in the *Fungi Imperfecti* would be coded according to the information from Table 1.

Present Name:	Illustrative New Name:
Aspergillus	**Fimmabbat**
Gliocladium	**Fimmapbam**
Penicillium	**Fimmapbat**
Oedocephalum	**Fimmebbat**
Stilbum	**Fismenbat**

Thus *Penicillium* and *Oedocephalum* differ by only one character from *Aspergillus* while *Stilbum* differs in three characters. *Gliocladium* differs from *Penicillium* in one character. How closely related two genera are phylogenetically would be indicated by how far from the end of the coded word they differ in a particular character, thus the third letter represents divergence in families, *Stilbum* being in a different family than the other three genera.

As a further example, a *nomen nudum* may be considered. Accordingly, Weston's *Aglaiocephalum* (Weston, 1933) would assume the name, *Fimmetbak*.

ADVANTAGES AND DISADVANTAGES OF PROPOSED SYSTEM

Two centuries of work have been based on the present binomial system. To suggest that this system be replaced by another requires a serious consideration of the resulting advantages and disadvantages. The difficulties inherent in the current system have been mentioned in the introductory paragraphs of this paper. The more significant advantages of the proposed system of nomenclature are:

1. Informative nature of names:

   The proposed name immediately provides the reader with a large amount of morphological and physiological information about the organisms. Phylogenetic relationships would also be readily apparent from the name. Thus, the degree of relationship would be indicated by how far from the first letter of the coded name a difference between the two names exists.

2. Fixity of names:

   Present rules permit many occasions for changes of names. It is not uncommon to find a dozen synonyms for the same organism. There is the question of historical priorities, for example. In the proposed scheme, once an organism is described, the name is not subject to change.

3. Clarity of tentative names:

   In the prevailing system, there is no way to know how "tentative"

a tentative identification is. In the proposed system, the use of the letters "X" and "O" clearly identifies those characters in which doubt exists. The proposed system minimizes the tendency of some investigators to force a culture into a known species even though doubt exists as to the fitness of several characters.

4. *Nomina nuda*:

Frequently names of organisms are mentioned in papers without accompanying descriptions. Since it is not possible to tell anything about the morphology and physiology from the name, these *nomina nuda* are of use only when they are later fortified with the proper descriptions. In many cases, the latter are not forthcoming and the meaningless names remain in the literature. If the proposed system of nomenclature is accepted, *nomina nuda* will be eliminated, for the mere presentation of the name itself provides considerable information about the organism. This has been exemplified earlier in this paper using Weston's *Aglaiocephalum*.

5. Objectivity:

Subjectivity is reduced to a minimum in the proposed system. For example, the question of relative importance of characters does not come into play in the proposed system nearly as much as it does in the present system. This eliminates the perennial argument between the "lumper" and the "splitter" as to whether a given difference in character is of sufficient magnitude to create, say, a new "species." According to the proposed system, the difference is merely taken care of by the appropriate letter, without need of changing the entire name of the organism.

6. Functional simplicity:

With its simple rules and freedom from historical priorities, the proposed system is much easier to follow than the present system particularly for the naming of new organisms. It is well within the grasp of the non-taxonomist, when the more typical organisms are concerned. Even the professional taxonomist is spared considerable time and effort by not being required to delve into the past literature with such intensity as required by the present system to make sure that the organism had not been previously named.

7. Reduction in number of synonyms, homonyms, and misidentifications:

Given a correct observation of the characters in the laboratory, two independent workers will arrive at exactly the same name using the proposed method. This is not true with the present system. As discussed in "5" above, one individual may decide to coin a new name for the organism while the other investigator may decide to use the closest available name.

8. Flexibility for special purposes:

(a) Names of organisms following the proposed system are readily adaptable to the IBM or punched card method of studying the correlation of characters. This opens up new scientific and industrial possibilities for the taxonomic researcher.

(b) Individual, scientific or industrial groups interested in minor, specialized traits such as strain differences and genetic mutations may, for their own purposes, expand the prevailing name to include special characters. Such characters are not part of the accepted name, of course, but correspond more to the presently used strain numbers or varieties. If in the future, some of these traits do, in fact, represent important taxonomic features, they can be readily added to the prevailing name, without vitiating the earlier results.

(c) Ease of handling herbarium specimens and filing library references is another advantage of the proposed system. The present scheme demands a knowledge of taxonomy on the part of a herbarium attendant and clerk, for frequently the organisms are filed according to families or phylogenetic groups. With the proposed system, ordinary alphabetical arrangement suffices.

As far as the authors can see, the proposed system is beset with no serious taxonomic difficulties, other than those inherent in any taxonomic endeavor. In this respect, it excels the present method. However, there are two disadvantages in the proposed scheme which must be considered. One is the seriousness of typographical errors. A mistake in a single letter may throw an organism into an entirely different class. The other is the difficulty in verbal presentation.

These disadvantages can be minimized by a careful choice of letters during the development of the basic keys, so that the more common species will have the more euphonious names. For this reason, the collaboration of phoneticists is clearly indicated. Furthermore, since not all of the letters possible for a given position will be used in the name, attention can be directed to the selection of letters which are as different as possible from each other in sound and appearance. It is believed that the difficulties of verbal presentation can be reduced to an acceptable level by such means. The seriousness of typographical errors, though decreased considerably, still remains and diligent proof-reading will be necessary. Actually this may not work out in practice to be as great as it may first appear, for usually the rest of the context will aid in the recognition of such errors. While one is tempted to prejudge the magnitude of such a source of error, probably it can be determined with accuracy only after the system has been developed and put into use for some time.

It may also be desirable that during the transition period, the present names are retained, followed by the proposed name in parenthesis. The use of dual names may be carried on until such a time that acquaintance with the new system becomes general.

SUMMARY

An absolute system of biological nomenclature has been proposed as a replacement for the present one. In the new system, all of the characters that enter into the final identification of the organism are directly discernible from the name itself. It is hoped that this proposal will stimulate a healthy reexamination of the system of nomenclature used heretofore, and of the various means which can be employed to minimize its inherent difficulties. The proposal in this paper is humbly presented as one approach to the problem.

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TABLE 1. ILLUSTRATIVE KEY FOR LETTERS OF THE FIRST NAME ACCORDING TO PROPOSED SYSTEM OF NOMENCLATURE.

Position of letter	Description of Character		Letter
First			
	Plant phyla		
	Spermatophyta	Gymnosperms	G
		Angiosperms	H
	Pteridophyta	Ferns & allies	D
	Bryophyta	Mosses, etc.	M
	Thallophyta		
	with chlorophyll	Algae	C
	without chlorophyll		
	Filamentous	Fungi	F
	Nonfilamentous	Bacteria	B
	Fungi parasitic on Algae	Lichens	L
	Myxomycetes		K
	Animal Phyla		
	Protozoa		P

Position of letter	Description of Character		Letter
Second			
	Fungi		
	Possessing a known sexual stage		
	Mycelium coenocytic; sexual spores borne within a sporangium.	Phycomycetes	E
	Mycelium septate		
	Sexual spores, borne in a sac, usually 8 spores per ascus.	Ascomycetes	A
	Sexual spores borne externally on a basidium, usually 4 spores per basidium.	Basidiomycetes	U
	Possessing no known sexual stage, or if known, then rare or infrequent	Fungi Imperfecti	I
Third			
	Conidia borne in pycnidia		
	Pycnidia globoid, ostiolate or astomous		
	Pycnidia brown to black, membranous to carbonaceous	Phomaceae	P
	Pycnidia bright colored; fleshy, gelatinous or waxy	Zythiaceae	Z
	Pycnidia dimidiate, more or less radiate or hysterioid.	Leptostromaceae	L
	Pycnidia apothecium-like or hysterioid, opening circularly or by a cleft or lobes	Discellaceae	B
	Conidia not borne in pycnidia		
	Conidiophores borne on a more or less parenchymoid stroma	Melanconiaceae	G
	Conidiophores not on a stroma		
	Hyphae in cottony masses		
	Hyphae and spores hyaline or bright colored	Moniliaceae	M
	Hyphae and/or spores typically dark	Dematiaceae	D
	Hyphae compacted to form spore-body		
	Spore-body sessile, globose to applanate (sporodochium)	Tuberculariaceae	T
	Spore-body stalked, capitate to cylindric (synnema)	Stilbaceae	S
	Conidia absent	Sterile Mycelia	K
Fourth			
	Conidia one-celled	(Amerosporae)	
		Mucedineae	M
		Dematieae	N
	Conidia two-celled	(Didymosporae)	
		Mucedineae	T
		Dematieae	G
	Conidia 3-many celled, septa transverse	(Phragmosporae)	
		Mucedineae	B
		Dematieae	C

Position of letter	Description of Character		Letter
	Conidia 3-many celled, septa transverse & longitudinal	(Dictyosporae)	
		Mucedineae	P
		Dematieae	K
	Conidia filiform	(Scolecosporae)	
		Mucedineae	S
		Dematieae	L
	Conidia spirally twisted	(Helicosporae)	
		Mucedineae	D
		Dematieae	F
	Conidia forked, radiate or united	(Staurosporae)	
		Mucedineae	R
		Dematieae	V
Fifth			
	Hyphae very short or little different from the conidia		
	Spores catenate		I
	Spores not catenate		U
	Hyphae elongate & distinct from conidia		
	Spores catenate		A
	Spores not catenate		E
Sixth			
	Conidia exogenous		
	Conidiophore simple, unbranched:		
	Spores terminal		G
	Spores typically pleurogenous		L
	Conidiophore simple, branched:		
	Branching irregular; spores terminal		T
	Branching irregular; spores pleurogenous		D
	Branching verticillate; spores terminal		V
	Branching penicillate; spores terminal		P
	Conidiophore inflated:		
	Terminal swelling		B
	Joints inflated		J
	Conidiophore compound:		
	Spore bearing portion simple, globose		M
	Spore bearing portion simple, cylindric		N
	Spore bearing portion branched		S
	Conidia endogenous		F
Seventh			
	Conidia globose to subglobose		
	Smooth to somewhat rough		B
	Very rough i.e. tuberculate, spiny, stellate		D
	Conidia allantoid		K
	Conidia elliptic to cylindric		
	Smooth		G
	Rough		R

Position of letter	Description of Character	Letter
	Conidia fusoid	
	Smooth	M
	Rough	N
	Conidia ciliate	P
Eighth		
	Parasitic on plants	E
	Parasitic on animals	I
	Saprophytic	A
	Some forms parasitic, some saprophytic	U
Ninth		
	(Miscl. hodge-podge to catch various genera)	
	Spores held together by mucilaginous substance	M
	Sterile structures in spore bearing mass, spines, etc.	K
	Stroma present	L
	Subiculum present	S
	None of above	T