Appendix B *

PROPOSAL FOR A UNIFORM DESIGNATION OF CULTIVATED ALGAL STRAINS **

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The first time strains of unicellular algae were transferred to monospecific cultures was at the end of the last century (Beijerinck 1890). Later, many names of the classics of algology such as Chodat (1913), Pringsheim (1928, 1954), etc. became connected with the history of the first algal collections. Today there exist several thousands of isolated strains in various collections all over the world. Many isolates have become model organisms for laboratory experiments dealing with physiology, biochemistry, photosynthetic production, genetics (*Chlorella pyrenoidosa* strain Emerson 3, thermophilic strain Tx-71105 of *Chlorella* sp., isolated by Sorokin, *Anacystis nidulans*, strain isolated by Allen, etc.).

Examples of contemporary collections:

Czechoslovakia:

Czechoslovak Academy of Sciences, Institute of Experimental Botany, Collection of Cultures of Autotrophic Organisms, Praha (Acad. S. Prát); bacteria-free cultures, all fresh-water groups (Pringsheim 1928, Prát 1948, Baslerová et Dvořáková 1962).

Charles University, Chair of Botany, Cryptogamological Laboratory, Praha (Prof. Dr. B. Fott): all fresh-water groups (Fott et Truncová 1964, Fott 1965).

Czechoslovak Academy of Sciences, Institute of Microbiology, Laboratory of Algology, Třeboň (Dr. J. Komárek): *Cyanophyceae, Chlorophyceae* (unpublished).

France:

Muséum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris (Prof. Dr. P. Bourrelly): all fresh-water groups (Bourrelly 1948, 1953).

Centre de Recherches Hydrobiologiques, Gif-sur-Yvette (Dr. R. Pourriot): all groups (Wuthrich 1965).

Germany:

Universität Göttingen, Pflanzenphysiologisches Institut, Göttingen, B.R.D. (Dr. W. Koch): all groups (Koch 1964).

Ernst-Moritz-Arndt Universität, Botanisches Institut, Greifswald, D.D.R. (Prof. Dr. H. Borriss): all groups (Borriss et Jeschke 1964).

Great Britain:

University of Cambridge, The Culture Collection of Algae and Protozoa, Cambridge (Prof. Dr. E. A. George): all groups (Pringsheim 1951, George 1958, 1966, 1968).

Japan:

University of Tokyo, Institute of Applied Microbiology, The Algal Collection, Tokyo (Prof. Dr. A. Watanabe): all groups (Watanabe 1960).

Soviet Union:

Academy of Sciences USSR, Institute of Botany, Leningrad (Dr. V. M. Andrejeva): esp.

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* Proposal received before deadline; previous publication in Taxon not feasible for technical reasons.

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Chlorella-strains (unpublished).

Institute of Biology, University of Leningrad (Dr. B. V. Gromov): all groups (Gromov 1965).

U.S.A.:

Indiana University, Culture Collection of Algae, Bloomington, Indiana (Prof. Dr. R. C. Starr): all groups (Starr 1960, 1964, 1966).

Kaiser Foundation Research Institute, Laboratory of Comparative Biology, Culture Collection, Richmond, Calif., later Bethesda, Maryland (Prof. Dr. M. B. Allen): all groups (Allen 1963).

Most of the collections have special methods of strain registration, and some of the strains are classified in various collections under different numbers.

If the identity of strains is pointed out, it is often necessary to refer in the new lists to the designation which is common in other collections, either by using a note (from Prague, in Algensammlung Paris No. 87, material from Emerson, from Delft as *Chlorella miniata*, etc.), or by referring to the number of these collections (see Starr 1964, Fott 1965, etc.). There are only two collections which maintain more or less conforming numbering of the strains: The Culture Collection of Algae and Protozoa from the University of Cambridge (Prof. Dr George) and Sammlung von Algenkulturen, from the University of Göttingen (Dr Koch), both founded by Prof. Dr E. G. Pringsheim. Nevertheless, they also contain some discrepancies, and the uniform numeration is not quite reliable. Some examples:

1. *Chlorella ellipsoidea* Gern.:
   George 1966, p. 22 (Cambridge): 211/1e, isol. Gaffron, used by Tamiya as A 002;
   Koch 1964, p. 411 (Göttingen): 211-1e, isol. Gaffron, ? Tamiya A 001.
2. Strain 202/7e (202-7e respectively):
   George 1966, p. 13 (Cambridge): *Ankistrodesmus braunii* Brunnthaler, isol. George 1953, England;
   Koch 1964, p. 410 (Göttingen): *Ankistrodesmus* aff. *braunii*, isol. R. A. Lewin, Lourdes, Frankreich 1962.
3. As to *Chlorella variegata* Beij., there are mutually corresponding references in the chief collections:

Cambridge (George 1958)	Göttingen (Koch 1964)	Bloomington (Starr 1964)
211/10a isol. Beijerinck Meyer No. 20 Chodat No. 21	211-10a isol. Beijerinck Meyer No. 20 Chodat No. 21	28 isol. Beijerinck Camb. 211/10a
211/10b isol. Beijerinck Meyer No. 21	211-10b isol. Beijerinck Meyer No. 21	255 isol. Beijerinck Camb. 211/10b
211/10c isol. Beijerinck Meyer No. 22	211-10c isol. Beijerinck Meyer No. 22	256 isol. Beijerinck Camb. 211/10c

However, Shihira et Krauss (1965) report in their study of the genus *Chlorella* (p. 41) these mutually corresponding strains (under the name of *Chlorella protothecoides* var. *communis*):

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Type culture: Indiana No. 28 = Cambridge 211/10c, isol. Beijerinck.
Identical strains: Indiana No. 255 = Cambridge 211/10a.
Indiana No. 256 = Cambridge 211/10b.
("Indiana" = Starr's collection in Bloomington).
Moreover, Fott et Nováková (1968) found during a taxonomical revision of the genus *Chlorella* that the strain 211/10a from Cambridge is actually *Chlorella lutecoviridis* Chod., the strain 211-10a from Göttingen *Chlorella protothecoides* Krüger. (Both authors identified the following two strains, 211/10b and 211/10c, as *Chlorella protothecoides* Krüger).

4. Fott et Nováková (1968) give several examples in their monographic study of the genus *Chlorella* of strains identified by the same numbers in the collections of Cambridge and of Göttingen but which are not identical with regard to taxonomy (neither morphologically nor physiologically; comp. also Kessler 1967):
Chl. pyrenoidosa Chick, strain (Emerson) 211-8c (211/8c resp.)
in Cambridge = *Chl. vulgaris* Beij. var. *vulgaris*
in Göttingen (from Soeder) = *Chl. fusca* Shih. et Krauss var. *vacuolata* Shih. et Krauss
Chl. pyrenoidosa Chick, strain (Rohde 1622a) 211-8e (211/8e resp.)
in Cambridge = *Chl. homosphaera* Skuja
in Göttingen (from Kessler) = *Chl. fusca* Shih. et Krauss var. *vacuolata* Shih. et Krauss
Chl. ellipsoidea Gern., strain (Pringsheim) 211-1a (211/1a resp.)
in Cambridge (from Prát) = *Chl. saccharophila* (Krüg.) Mig. var. *ellipsoidea* (Gern.) Fott et Nováková
in Göttingen = *Chl. saccharophila* (Krüg.) Mig. var. *saccharophila*
Chl. ellipsoidea Gern., strain (Gaffron) 211-1e (211/1e resp.)
in Cambridge = *Chl. vulgaris* Beij. var. *vulgaris*
in Göttingen (= Tamiya A 002) = *Chl. saccharophila* (Krüg.) Mig. var. *saccharophila*

There exist also some other sources of important errors in the designation of algal strains which hinder the comparison of results of experimental studies made on the same organisms. This is due to the unregisterable increase of newly isolated strains, some of which are taken as model organisms for various laboratory experiments. There are also non-uniform and incomplete quotations of strains in many experimental works (cf. Lhotsky 1968). In such cases, it is often impossible to identify the strains. Several examples:
1. Galloway et Krauss (1963) report their use of the species *Chlorella vulgaris*, "Pringsheim's strain, isolated by Emerson". The strain, designated as it is, is entirely unidentifiable. In the lists from the chief world collections of algal strains, there are only the following strains of *Chlorella vulgaris* which are connected with the name of Pringsheim and Emerson:

Cambridge (George 1966)	Göttingen (Koch 1964)	Bloomington (Starr 1964)
211/11a isol. Pringsheim Meyer No. 1	211-11a isol. Pringsheim Meyer No. 1	29 isol. Pringsheim Camb. 211/11a
211/11c isol. Pringsheim as C. pyrenoidosa Meyer No. 3	211-11c isol. Pringsheim Meyer No. 3	260 isol. Pringsheim Camb. 211/11c
211/11f isol. Pringsheim 1929 England	211-11f isol. Pringsheim Fundort: Dorking 1939	

Cambridge (George 1966)	Göttingen (Koch 1964)	Bloomington (Starr 1964)
211/11h isol. Pratt received from Emerson 1946		
211/11n isol. Emerson received from Finkle 1950, may be the same as 211/8h (= Emerson No. 3)	211-11n isol. Emerson	
		397 from Emerson Nov. 1953 Craig and Trelease strain
		398 from Emerson Nov. 1953 Pratt strain

It is not clear from the citation of Galloway et Krauss whether it is a question of some of the strains mentioned above, or whether another isolate is meant which has not been published up to now.

2. The well-known book edited by Burlew (1953), which has served as a basic manual for the investigation of the production of algae in cultures until now, and which has appeared in several editions, contains a series of experimental studies written by various authors. A number of strains were used in the described experiments, but only a very small percentage of them can be identified precisely. Thus, e.g.,

Myers (pp. 31–36 and 37–54) reports *"Chlorella pyrenoidosa* (Emerson strain), *C. vulgaris* (Emerson strain), *C. vulgaris* (Trelease or Columbia strain), *C. vulgaris* (Wann or Cornell strain)",

Wassink, Kok and van Oorschot (p. 55–62) report *"Chlorella vulgaris* (Strain 'Botanie')" and *"Chlorella* strain 'A' ",

Kok (p. 63–75): *"Chlorella pyrenoidosa* (Emerson strain)",

Tamiya et al. (p. 76–84): *"Chlorella ellipsoidea"*; etc.

The physiological or productional features of *"Chlorella pyrenoidosa"*, *"Scenedesmus obliquus"*, etc., are often quoted in this book. However, it should be pointed out that most of the isolated strains are not determined correctly (comp. Fott et Nováková 1968, who consider *Chlorella vulgaris* and *C. pyrenoidosa* as identical from the morphological as well as the physiological point of view, etc.). Moreover, from later works (Shihira et Krauss 1965, Fott et Nováková 1968) it appears that the different species can be characterized morphologically and physiologically only by their qualitative differences (they are very often in correlation). Contrarily, every species has a great number of small clonal (steady or unsteady) quantitative deviations in the features (exp. in the physiological ones) which can be isolated as distinct lines. Therefore, it is to be regretted that the data from the previous works concerning the physiological characteristics of some species are problematic.

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It is, certainly, impossible to prevent some errors in the citations or a mix-up of the strains and of their designation (neither incorrect determinations nor different conceptions of the species in taxonomy can be avoided). Nevertheless, precautions must be taken to prevent such errors as much a possible. This had necessitated an elaboration of the Code of Botanical Nomenclature which, despite its imperfections, presents indispensable conditions for taxonomic work. To obtain an up-to-date survey of cultivated algal material and to prevent any mistakes in both the cultivation and the publication of further isolates, it is necessary to establish a precise system of designating algal strains.

For these reasons, a uniform designation of cultivated algal strains is proposed: it should at least partly enable a clear and uniform registration of the great number of cultivated strains which have not been properly surveyed up to now. The aim of this study is to prevent confusion in the designation of algal strains cultivated in the future and to minimize error as much as possible in the designation of old strains (when existing errors cannot be immediately eliminated).

The problems posed by the proposal are: (a) how should the newly isolated strains be uniformly designated, and (b) how should the old, much-published isolates of troublesome identification be recognized. In the second group it is necessary to maintain the existing stage and clarify all discrepancies as much as possible.

The submitted proposal was discussed in detail and accepted by the plenary session of the Algological Section of the Czechoslovak Botanical Society (headed by Prof. Dr Fott). The new algal isolates studied in Czechoslovakia have already been designated according to the proposed method. The strains mentioned in the lists of the collections of Charles University in Prague (Fott 1965) and partly of Indiana University of Bloomington (Starr 1966) are to be published in this way, in parallel order to their former designations. The same method was used for the designation of some strains which will be published in the monographic and taxonomic studies of several chlorococcal genera (Fott et Nováková 1968, Hindák 1968, Komárková-Legnerová 1968, Sulek 1968, etc.). An analogous designation of strains is used, for instance, by van den Hoek (in Starr 1966), and the list of strains from the Cambridge collection (George 1966) also contains the data necessary for such a designation.

Designation of the newly isolated strains

1. Every strain is to be designated obligatorily with a triple symbol comprising the isolator's name, the year in which the isolation was accomplished, and the serial number of the isolate fixed by the isolator (numerical symbol). It is recommended to use simple numbers (e.g. according to the succession in which the strains have been isolated in the course of a year).

Example: *Chlorella zofingiensis* Dönz strain Czygan 1963/105.

The isolator is advised to supply the symbol for each strain immediately upon isolation (at the latest in the first valid publication of the strain). This designation should be required obligatory in all publications (especially in lists of strains and in experimental works of taxonomic, physiological, genetic or biochemical character). The strain designation (in our case "Czygan 1963/105") must be maintained for the given strain and must not be changed under any circumstances (including taxonomic revisions).

The designation of a strain in the manner described is valid from the moment when the strain has been designated by its isolator. No new strain should be turned

over to anyone for experiments, publication, or completion of collections until it has been supplied with the proper designation.

There are arguments for the use of the isolator's name in strain designation: (i) it has been frequently used in the literature up to now (strain "Emerson 3", "Sorokin's strain Tx-71105", "van Niels' strain", "Gaffron's strain D-3", etc.); (ii) the importance of mentioning the isolator's name is unquestionable, in particular with regard to older, "classical" strains and if the isolation was performed for a certain purpose; (iii) the names of isolators are commonly known from the algological literature, e.g. in opposition to the noncomittal abbreviations of localities, etc.; (iv) the name of the isolator is one of the few data which cannot be changed in the course of time.

The year in the symbol must designate the year in which the isolation was performed, not the year of publication. It is useful to indicate this, because it gives the time-period during which the strain was cultivated under laboratory conditions (on agar soil, etc.).

It is further recommended to mention, in addition, the name of the alga (at least a provisional one without species designation, e.g. "*Chlorella* sp.") used in the experimental works. However, it is recommended not to use in any case only the binomial of the taxon for the designation of the experimental strain, since this is subject to nomenclatural changes during taxonomic revisions, monographic elaborations, etc. Most of the strains are not determined definitely, and sometimes it is impossible to avoid incorrect determinations. The comparison of the names of different species of the genus *Chlorella* in the lists of the main algal world collections (George 1958, 1966, Koch 1964, Starr 1964) and in the first monographical studies of the same genus, worked out in the last few years with regard to the strains from the mentioned collections (Shihira et Krauss 1965, Fott et Nováková 1968) illustrates this quite well. E.g. Sorokin's thermophilic strain Tx-71105, assigned originally as "*Chlorella* sp." (Sorokin et Myers 1953) has been recorded in the lists of collections (Koch 1964, Starr 1964, Borriss et Jeschke 1964) under the name "*Chlorella pyrenoidosa* Chick"; Shihira et Krauss (1965) use the name "*Chlorella sorokiniana* sp. nova", Fott et Nováková (1968) "*Chlorella vulgaris* Beij. var. *vulgaris*". Much greater confusion arises if the generic name is changed; this is far from being a single case. So, e.g., *Chlorogloea fritschii* Mitra strain LB 1411/1 (in Cambridge; George 1958, 1966) = B 1411-1 (in Göttingen; Koch 1964) is actually *Nostoc fritschii* (comp. Schwabe et Al Ayouty 1966); the strain LB 1415/1 (in Cambridge: George 1958, 1966), designated as *Cylindrospermum* sp., belongs to the genus *Anabaena;* Komárková-Legnerová (1968) re-classified many strains of *Ankistrodesmus* to the genus *Monoraphidium;* etc.

Neither is a single numerical symbol suitable (e.g. "NRRL-YB 4330" according to Cooke, in Starr 1966), since it is rather difficult to retain it in mind; besides, it may lead to many errors. If only simple numbers were used, it would not be possible to avoid duplicate designations. The collection of the Institute of Applied Microbiology in Tokyo (Watanabe 1960), e.g., is divided according to the chief taxonomic groups, and the strains are numbered independently in every group (from 1 to...). The strains are designated analogously within the range of the species (strains IAM 1 and IAM 2 in *Scenedesmus acutus,* IAM 1 and IAM 2 in *Scenedesmus nanus,* etc.). If the strains identified in this manner are revised taxonomically and their specific or generic designations are changed, confusion may arise, and the re-classified strains should be designated de novo.

The name of the initial collection completed by its number, e.g. "Cambridge

211-14" may cause errors if the strain is transferred to other collections. Moreover, there already exist numerous discrepancies among the strains designated in various collections by the same number (Kessler 1967, Fott et Nováková 1968) and neither in future will it be possible to avoid such confusions. The proposed method, however, allows (in the case of discrepancies) to state conveniently the new symbol, or its part in the strain whose identification with the initial strain is no longer possible.

2. It is recommended to indicate in all experimental works, after the uniform designation of the strain, the name of the collection (or the author's name) from which (or from whom) the strain was obtained.

Example: *Chlorella zofingiensis* Dönz strain Czygan 1963/105, from Cambridge.

3. If two or more parallel strains of the same species are isolated from the same locality, small letters following the serial numerical symbol should indicate these isolates.

Examples: Czygan 1963/105a, Czygan 1963/105b, etc.

4. If parallel clones with various genetic qualities (mutants, male and female clones, etc.) are obtained, it is recommended to complete such strains by any appropriate remarks according to the view-point of the author. This mark should follow the serial numerical symbol.

Example: Czygan 1963/105-0.2, etc.

Designation of published strains

It is recommended to establish a uniform designation of all strains isolated until now and those in all collections (regardless of their specific numeration, which can easily be completed by the uniform symbol). But we can only approach complete uniformity, since in many cases neither the year of the isolation nor the name of the isolator is known. (George 1966 in the list of strains from Cambridge collection closely approaches the proposed designation, mentioning regularly the names of isolators and the year of isolation.) For this reason a proposal of a standard designation for most of the previously published algal strains was elaborated. The list of examples (the genera *Chlorella, Chlorococcum, Scenedesmus* and *Ankistrodesmus* × *Quadrigula*) will be published in the course of 1969; this proposal, completed and corrected by the authorized commission of the Botanical Congress (see below), should have the character of a "List of conserved designations" and it should be published according to the following criteria:

1. In strains designated in a certain, commonly used way, the name of the isolator and the accepted symbol should be established as the proper designation.

Examples: *Chlorella pyrenoidosa* Chick strain Sorokin/Tx-71105, *Chlorella ellipsoidea* Gern. strain Tamiya/105, *Scenedesmus obliquus* (Turp.) Kürz. strain Gaffron/D 3, etc.

2. For strains whose isolator is known, the designation should contain the isolator's name (together with the year of the isolation, if this is known), the abbreviation of the collection (the name of the place where the isolate was kept originally), and the number of the corresponding collection. If the strain is kept only in one collection, this designation is unambiguous. If the strain is maintained in several collections and if it is possible to prove the identity of these parallel strains, the earliest symbol (the earliest published list of cultures) should be taken as the basis.

Examples: *Chlorella pyrenoidosa* Chick strains Pringsheim/Camb. 211-8a, Emerson 1923/ Camb. 211-8b, Lewin/Bloom. 343, etc.

3. When the name of the isolator is unknown, the designation should contain the location of the collection and the corresponding symbol.

Examples: *Chlorella pyrenoidosa* Chick strains Greifswald/5, Cambridge/211-8p, etc.

If in a collection a certain system has been followed with regard to the numbering and registration of strains, *no changes* are necessary. However, the strain identifications (e.g. in published lists) must be completed by a uniform symbol, in parallel order to the home numbering.

The proposal for a uniform designation has been presented to the phycological and the nomenclatural sections, to be discussed at the future Botanical Congress. If it is accepted (either in this form or modified), we will propose that it be published for internal use by algologists and inserted as a special paragraph in the International Code of Botanical Nomenclature.

Proposal 284 [1]

a. Insert the respective rule as "Appendix IV, Uniform designation of cultivated algal strains" into the International Code of Botanical Nomenclature.

b. Proposal for the text of the respective paragraphs:

Art. AS. 1: Beginning January 1, 1969, cultivated algal strains must be provided uniformly with the name of the isolator, the year of isolation, and the number assigned by the isolator. This designation must be established immediately after the isolation of the strain (into a monospecific culture) and must not be changed later. It must accompany the internal numeration in the collections of strains.
Example: *Chlorella zofingiensis* Dönz strain Czygan 1963/105 (i.e. the 105th strain isolated by Czygan in 1963).

Rec. AS. 1a: The enumeration of characteristics of the strains used in experimental works should contain, in addition to the uniform designation of the strain, the name of the collection where the strain originated.

Example: *Chlorella zofingiensis* Dönz strain Czygan 1963/105, from Cambridge.

Rec. AS. 1b: Parallel strains of the same species from the same locality should be identified by small letters following the designation.

Example: *Chlorella zofingiensis* Dönz strains Czygan 1963/105a, Czygan 1963/105b, etc.

Rec. AS. 1c: Clones with a changed genotype obtained from one strain, are to be provided with any conveniable remarks, placed after the designation.

Example: *Chlorella zofingiensis* Dönz strain Czygan 1963/105-0.2, etc.

Art. AS. 2: Algal strains cited in any publication must be provided with fixed designations, regardless of occasional changes in their taxonomic value or name.

Art. AS. 3: Strains isolated before December 31, 1968, are to be uniformly provided (a) with the name of the isolator and the accepted symbol (e.g., abbreviation of the collection

[1] Supporting and critical statements by V. M. Andrejeva, E. A. George, B. V. Gromov, E. Kessler, W. Koch, S. Prát, R. C. Starr, A. Watanabe, P. Bourrelly and R. Pourriot have been received. These texts will be sent to interested parties upon request by the author of this proposal [Ed.].

and its number), or (b) with the name of the collection and its number, if the isolator is unknown. A list of obligatory and conserved designations of these strains is included.*

Examples: *Chlorella pyrenoidosa* strains Pringsheim/Camb. 211-8a, Emerson 1923/Camb. 211-8b, Sorokin/Tx-71105, Greifswald/15, etc.

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(GEORGE E. A.) Anonymous (1966) — Culture Collection of Algae and Protozoa. List of strains. Bot. School, Cambridge, 67 pp.
STARR R. C. (1966) — Culture collection of Algae. Additions to the collection July 1, 1963–July 1, 1966. Dept. Bot., Indiana Univ., 8 pp.

* If this proposal is accepted, the proposer will submit a list of symbols to be conserved to the appropriate committee.

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