CRITERIA FOR THE IMPROVEMENT OF THE
CLASSIFICATION OF ACTINOMYCETES*

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1. Characteristics and Reactions
Useful in Classification

The elements accumulated during the last few years which may be most useful for the improvement of the classification of Actinomycetes, are in our opinion the following:

- a. Knowledge of the microscopic structure and particularly the structure of sporophores. Contributions in this field have been made by Krassilnikov (13), by Burkholder and coll. (7), by Hesseltine and coll. (11) and by Pridham and coll. (18).
- b. A knowledge of the shapes of the spores and their appendages under the electron microscope. In this connection we note the works of Kriss (14), Küster (10, 15) and those of Baldacci and coll. (4, 5, 6).
- c. The choice of those morphological characters which are less subject to variation or do not vary at all in relation to the use of various cultural substrates. Contributions in this field have been made by Baldacci and coll. (2, 3), by Flaig and Kutzner (9), by Kutzner (16), and by Hesseltine, Benedict, Pridham (11).
- d. Production of catabolic products and in particular antibiotics. Contributions in this field are too numerous to be mentioned (Waksman 19, 20).

The problem lies in the method of utilization and the setting in order of these elements for the purpose of a rearrangement of the classification of Actinomycetes.

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Solutions of this problem have been suggested by single investigators, but these solutions are generally based on results of their own work. Thus several research workers have created new genera such as: Microbispora by Nonomura and Ohara (17), Streptosporangium and Actinoplanes by Couch (8), Thermomonospora, Thermopolyspora, Thermoactinomyces, Pseudonocardia by Henssen (12). Others have preferred to form series or groups or sections rather than genera, as Baldacci and coll. (2,3), Flaig and Kutzner (9), Pridham and coll. (18).

On the other hand the excessive multiplication of species has been principally the work of those who have devoted themselves to the examination of catabolic products such as pigments and above all antibiotics (Baldacci, 1).

A brief summing up of the situation shows the absence of a clear and systematic method of classification for this group of microorganisms. And to this must be added the fact that according to some investigators Actinomycetes should be considered as bacteria whilst according to others they are fungi. No definite view can yet be expressed on this matter as there are no adequate reasons in support of either one or the other of these theories.

2. Choice of Media and Their Standardization

The choice of media for classification purposes must satisfy two requirements:

- A. In the first place media must be prepared which are suitable for comparison with the diagnosis made by earlier research workers, that is to say we must in each case use media that have already been used by our predecessors. This consideration is put forward out of respect for the researches made by others and also because it is expedient to utilize to the utmost all preceeding nomenclature. We know with absolute precision, because we have taken the trouble to read

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it up, that for example, the diagnoses of Actinomyces albus, Actinomyces sulphureus, Actinomyces Bostroemi, Actinomyces Madurae, made by the respective European investigators who were the first to study these Actinomycetes, leaves no doubt about the possibility of their re-identification. We regret that this criterion, which we have faithfully followed has not been duly appreciated by English-speaking research workers, and that these species are generally almost completely ignored by them.

- B. The standardization of these substrates which may be effected today thanks to the supply of all sorts of chemical substances, must be the result of work done at the "round table". The choice of substrates must be subject to the condition of the characters that are to be utilized for the classification key.

3. The Choice and Hierarchy of Characters for Application in a Classification Key

Among the reasons put forward to explain the difficulty of defining the species among the Actinomycetes is the necessity of introducing certain characters not used by botanists. The introduction of new characters in a classification should be made with due respect for the definition of the concept of the species which is nothing more nor less than a concept of grouping. Every time a scientist indicates several objects with the same name, he asserts not only that they resemble each other but also that they resemble each other in some thing; that is to say that there are determining characteristics common to all which can be enumerated and designated separately.

It is evident that the choice of new characters to be utilized presupposes that they are definable and countable, and they should be easily recognizable so that there may be no difficulty in their recognition and designation and no fear of errors.

They should be constant, that is to say independent at the highest possible level of external or foreign factors, or at least they should remain constant under conditions easily reproducible by every investigator.

I do not know how many so called biochemical character-

istics used in the classification of the Actinomycetes have been formed by taking into account these requirements. It seems rather that they are the work of specialists in other branches of science rather than that of systematic workers. It would seem legitimate to ask oneself if the failure of classification be not rather the consequence of an erroneous choice.

The choice of characters presupposes not only recognizability and countability but also a criterion of their hierarchy, because this is a specific requirement of any classification system. That is to say the choice of characters presupposes the possibility of giving them a suitable hierarchical position, at the various levels of grouping. For this reason the formation of genera based upon obsolete characters, for example, the creation of the genera of Actinomycetes for their resistance to a high temperature, seems to be arbitrary.

It is easy to see than an important pre-existing attribute does not exist a priori in the characters to be utilized.

The choice of hierarchy or succession obeys another general principle which is the foundation of every scientific system whether it be explanatory or classifying. That is the intrinsic possibility of the development of the system. As Planck said in a celebrated passage "As long as man persisted in dividing all natural forces into friendly or hostile forms, plants into poisonous and edible, animals into dangerous and harmless, he never attained true science."

Have not many microbiologists perhaps fallen into the same error by claiming that the Actinomycetes should be grouped together as pathogenic and nonpathogenic (for man), as useful (because they produce antibiotics) or useless (because they don't)?

In scientific language, and implicitly in a system of classification, every character should be chosen and defined in an univocal manner; but this choice and this definition must not have reference to anything that is outside the system that it is desired to construct, as for example, its advantageousness or disadvantageousness for man, but to something that is in the system itself, in the intrinsic reasons of the system. One must be careful to arrange the succession of characters, which have been collected and defined one by one, in such a way as to facilitate the work of distinguishing and forming the species.

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On the basis of what we have set out also in paragraph 1, we propose:

- a. Confirmation and new formation of genera utilizing the characteristics of the microscopic structures of the sporophores.

The following genera are cited as examples:

Micromonospora
Microbispora
Streptosporangium
Actinoplanes
Streptomyces (or Actinomyces)

For the Actinomycetes with verticillate sporophores, although only a small number has been studied, we propose the genus Streptovercillium [genus that groups together the sections Monovercillus, Monovercillus-spira, Bivercillus, Bivercillus-spira of Pridham and coll. (18)].

- b. Confirmation and new formation of species utilizing the morphological characters of the vegetative and aerial mycelium and of the shape of the spores under the electron microscope. These species should replace the present series or sections or groups. This proposal modifies our previous scheme. (Baldacci and coll. 2,3).
- c. Grouping on the level of varieties or clones the descriptions of species that utilize the characters that are biochemical, ecological, producing antibiotics, etc.

The nomenclature of the genera, species and varieties should be a work of revision at the "round table" and should follow the rules of The International Code of Nomenclature of Bacteria and Viruses and the International Rules of Botanical Nomenclature.

In particular we wish to draw attention to our previous discussion of the subject [Baldacci and coll. (2)].

4. Conditions of Conservation

Observations on this matter have been set out in our work with collaborators.

5. Creation of a Type Culture Collection

We are in favour of this once the conditions of culture and conservation referred to above have been agreed to.

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