STREPTOMYCES ALBUS (ROSSI-DORIA) WAKSMAN ET HENRICI: TAXONOMIC STUDY OF STRAINS LABELED *STREPTOMYCES ALBUS*[1]

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In streptomycete taxonomy and nomenclature the most important species is *Streptomyces albus* (Rossi-Doria) Waksman et Henrici. It is the type species of the genus. No type strain of this species has yet been designated nor are there any of Rossi-Doria's original cultures extant. The descriptions of this species that appear in a number of publications suggest that one of the strains isolated by Waksman and Curtis or Waksman could be designated as the type strain.

There have existed, since about 1916, two entirely different concepts with regard to the nature of *Actinomyces* (*Streptomyces*) *albus*. One concept centers around strains with the following characteristics: flexuous fruiting bodies, colors of aerial mycelium in tints and shades of olive-buff (yellowish gray or tan); nonchromogenicity (inability to form brown, deep brown, or black diffusible pigments in organic substrata); and marked abundance in nature. The other concept concerns strains that are characterized by coiled or spiralled fruiting bodies with catenulate ovoidal spores; by aerial mycelium colors generally interpreted as cretaceus (chalk-white, often with faint tinges of pink); by nonchromogenicity (inability to form brown, deep brown, or black diffusible pigments in organic substrata); and by their relative rareness in nature.

No type strain of the species was designated, although the collective works of Waksman and Curtis (1916), Waksman (1919), Waksman and Lechevalier (1953), and the material on *Actinomyces albus* and *Streptomyces albus* appearing in the several editions of *Bergey's Manual of Determinative Bacteriology* (1923 through 1957) suggest that one of Waksman's strains might be most representative of the type.

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In an attempt to settle this point, we reviewed the available early literature, made a taxonomic study of some 42 strains, and initiated preliminary investigation of an additional 13 recent acquisitions. All these strains were received with the epithet "*albus*," or as varieties or forms of *albus*. The results of this study are presented, and problems concerned with the concept of *Streptomyces albus* are discussed.

HISTORY

To determine whether any of the prior taxonomic work on strains of Actinomycetes, designated by the epithets *alba* or *albus*, points with certainty to any particular type of streptomycete, we reviewed the most pertinent papers of the early literature. Included were those of Cohn (1875) on *Streptothrix foersteri*; Almquist (1890) on three unnamed streptothrices, subsequently stated by Rossi-Doria to be identical with his *Streptotrix* [sic] *alba*; Gasperini (1889/1890) on *Streptothrix foersteri*, also claimed by Rossi-Doria to be identical with his *Streptotrix* [sic] *alba*; Rossi-Doria (1891) on *Streptotrix* [sic] *alba* and *S. foersteri*; the collective papers of Krainsky (1914), Waksman and Curtis (1916), Waksman (1919), Jensen (1931), Duché (1934), Baldacci (1939), Krasil'nikov (1941, 1949), Waksman and Lechevalier (1953); and the several editions of *Bergey's Manual of Determinative Bacteriology* (1923 through 1957).

Review of the literature published prior to 1916 strongly suggests that Rossi-Doria, who first used the epithet "*alba*" for an Actinomycete, was probably working with strains of streptomycetes now commonly referred to as *Streptomyces griseus*. The fact that he commented on the marked abundance of *Streptotrix* [sic] *alba*, that he recognized the ability of his strains to form concentric rings of aerial mycelium, and that he implied that *S. alba* isolates were characterized by straight to flexuous fruiting bodies,

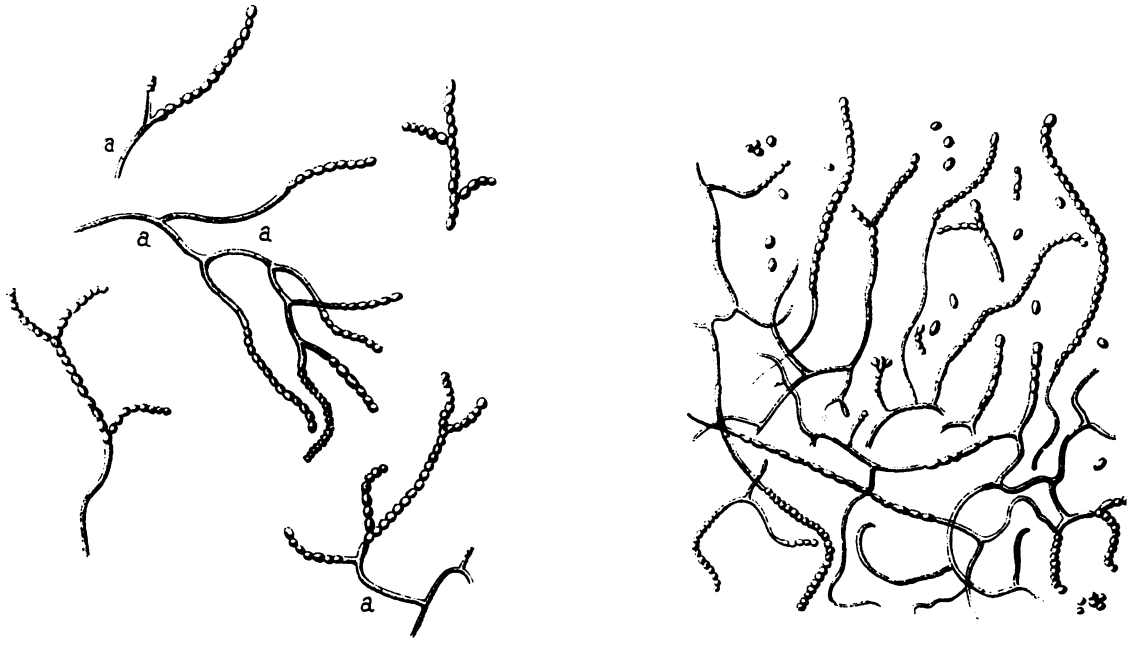

Fig. 1. Illustrations of *Streptothrix foersteri* Cohn reproduced from Gasperini, G., Annales de Micrographie, **2**, 449-473, Plates VI and VII (1889/1890).

all suggest *Streptomyces griseus*. The morphology of Rossi-Doria's isolates is deduced from his general statements and through his reference to Gasperini's work on *Streptothrix foersteri* (Fig. 1). Drechsler (1919) came to this same conclusion, i.e., that Rossi-Doria's *Streptotrix* [sic] *alba* appeared to be identical with Krainsky's *Actinomyces griseus* (Fig. 2). The fact that Rossi-Doria reported white aerial mycelium for *Streptotrix* [sic] *alba* rather than the olive-buff, yellowish gray, or tan colors which are characteristic of common strains of *Streptomyces griseus*, can be explained. The substrata used by Rossi-Doria and other early investigators contained materials that are not too conducive to sporulation and that probably would lead to the formation of white aerial mycelia with any number of different streptomycete types. Also, "white" has been a very loosely interpreted color designation in Actinomycete taxonomy.

In support of these statements, more than half the strains of *albus* we have received from a variety of sources clearly fall in the *S. griseus* group. But developments in streptomycete taxonomy have come about rapidly, and most papers on taxonomy published prior to 1916 have only historical and nomenclatural interest. Had Krainsky given any attention to micromorphology and carefully considered Rossi-Doria's and Gasperini's papers, there now would be fewer questions with regard to *Streptomyces albus*.

Around 1916 there was a marked change in concept with regard to *Actinomyces albus* that has been preserved in publications to the present date. The work of Waksman and Curtis (1916) and Waksman's subsequent revision in 1919 formed the basis for this concept. Data in these papers presumably were used in preparing the description of *Streptomyces albus* in Waksman and Henrici's paper of 1943.

Waksman and Henrici's proposal of the genus *Streptomyces* in 1943 states:

"We have selected as the type species of this newly-named genus, *Streptomyces albus* (Rossi-Doria emend Krainsky) comb. nov. This species was formerly known as *Actinomyces albus* Krainsky and first described as *Streptothrix alba* Rossi-Doria. This is one of the commonest and best known species of the group, and while it may later be subdivided into further species, it is at present as definite as any others. It has been recently studied intensively by Duché (1934) and by Baldacci (1939). It is colorless with white aerial mycelium, forming ovoidal spores in coiled chains on lateral branches of the aerial hyphae. It is proteolytic, liquefying gelatin and peptoni-

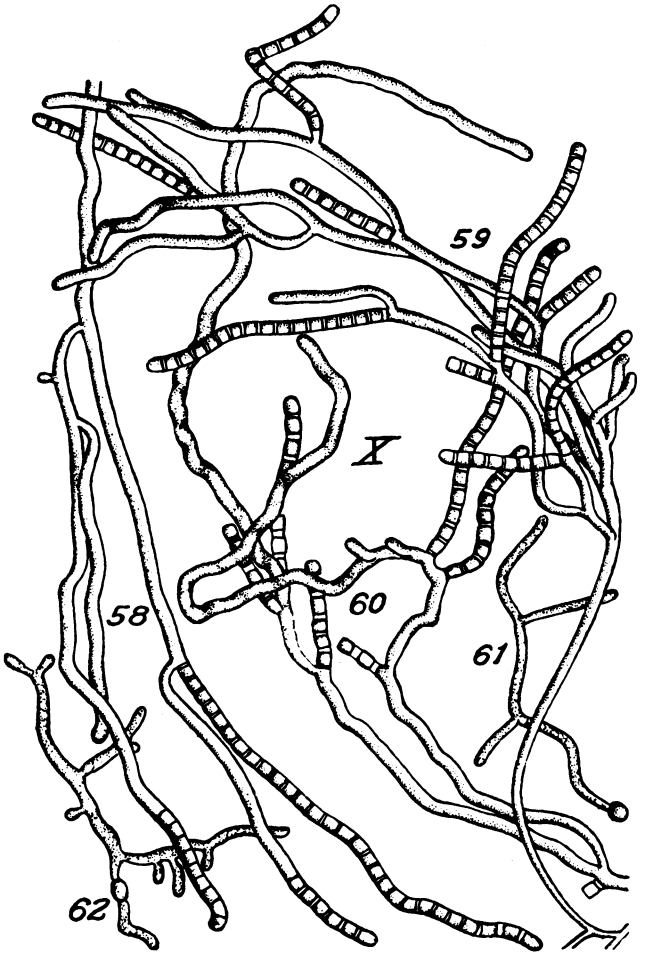

Fig. 2. Illustration of Drechsler's *Actinomyces* X [*Streptothrix alba* Rossi-Doria; *Actinomyces griseus* Krainsky (?)] reproduced from Botanical Gazette, **67,** 147-169, Plate IV (1919).

zing milk with the production of an alkaline reaction in the latter. It does not produce any soluble pigment either on an organic or synthetic medium, but does produce a characteristic earthy or musty odor."

One can easily appreciate the confusion that would result were specialists in the field to recognize the original concept of *Streptotrix* [sic] *alba.* The name *Streptomyces griseus* has become so entrenched in the minds of specialists in the field, and cultures of organisms that fall in the *S. griseus* group now are so readily recognizable, that it would be senseless to change this concept. The most logical and practical solution to this problem is to assess *Streptomyces albus* in terms of the 1916 to 1919 concept. In doing this, however, one must keep in mind that many publications on *Actinomyces albus* or *Streptomyces albus* are concerned with organisms in the *Streptomyces griseus* group. No generalizations on this species should be made unless the particular strains studied are clearly detailed as to their micromorphology, color of sporulating aerial mycelium, and inability to form brown, deep brown, or black diffusible pigments.

MATERIALS AND METHODS

Strains studied. The 55 strains used in this study were obtained from the following sources: Centraalbureau voor Schimmelcultures, Baarn, Netherlands; American Type Culture Collection, Washington, D. C.; Institute of Vegetable

Pathology, University of Milan, Italy; Institute for Biochemistry of Soils, Investigative Institute for Agriculture, Braunschweig-Volkenrode, Germany; Institute of Microbiology, Rutgers University; Charles Pfizer and Company, Inc., Brooklyn, New York; Parke, Davis and Company, Detroit, Michigan; Stine Laboratory, E. I. Du Pont de Nemours and Company, Newark, Delaware; Boots Pure Drug Company, Ltd., Nottingham, England; University of Liege, Belgium; Institute of Applied Microbiology, University of Tokyo, Japan; Colonial Microbiological Institute, Trinidad, British West Indies; and Oswaldo Cruz Institute, Rio de Janeiro, Brazil. We are much indebted to the various specialists who supplied us with their strains. The numbers assigned to these strains by the contributors are listed in the presentation of results.

Methods. The general procedures used in this study have been described elsewhere (Hesseltine, Benedict, and Pridham, 1954; Pridham and Gottlieb, 1948; Pridham et al., 1951, 1957, 1958; Tresner and Danga, 1958; *A Manual of Methods for Pure Culture Study of Bacteria*, 1946; "Methods for use in cooperative studies on criteria for description of the streptomycetes," June 1958, *unpublished*; "Final plan for the international common experiment on characterization of streptomycetes," December 20, 1958, *unpublished*).

Stock cultures and inocula. On receipt, soil cultures were prepared with each strain following the method described by Pridham et al. (1957). The air-dried soil cultures were used in all subsequent work. For inoculating the various media, two wet loopfuls (loop, 3 mm i.d.) containing about 90 mg of soil culture were transferred to 10 ml of tryptone-yeast extract broth (Pridham and Gottlieb, 1948) in test tubes (25 by 150 mm). The tubes were placed on a Gump rotary shaker operating at 200 rev/min and incubated for 48 hr at 28 to 30 C. About 0.2 ml of the resultant culture was added to each agar slant or dish. For dish cultures the inoculum was streaked in a cross-hatch design on the agar.

Determination of spore morphology and nature of spore surface. Spore morphology was determined by examination of Drechsler impression slides of strains that had been cultivated on inorganic salts-starch agar for 14 days at 28 to 30 C. The material on the slides was fixed by immersion in 95% ethanol for 10 sec, stained with 0.02% aqueous methylene blue, and examined under oil immersion at 1,800×. An electron microscope was not available, but data obtained in other laboratories on some strains selected as representative of *S. albus* are included in the results.

Determination of micromorphology. To determine micromorphology, each strain was cultivated on petri dishes containing Czapek's solution agar, or inorganic salts-starch agar (Pridham et al., 1957). Also utilized was the glycerol-asparagine agar recommended for the international common experiment on characterization of streptomycetes. Our interpretation of the directions for preparation of this medium follows.

International glycerol-asparagine agar. L-Asparagine (anhydrous basis), 1.0 g; glycerol, 10.0 g; K_2HPO_4 (anhydrous basis), 1.0 g; distilled water, 1,000 ml; do not adjust pH. The pH of this solution is about 7.3. Add agar, 20.0 g; melt by steaming at 100 C for 15 to 20 min, dispense, and sterilize for 20 min at 121 C. The final pH of the medium after sterilization without agar is 7.8. The final pH of the medium after sterilization with agar and solidification is 7.4 (greenish blue color with bromothymol blue).

After incubation at 28 to 30 C for 14 days, each culture was examined in situ at magnifications ranging from 100× to 800×, and the strains were relegated to the indicated sections described in Pridham, Hesseltine, and Benedict (1958).

Determination of color. Observations of the color of sporulating aerial mycelium, reverse of cultures, and color of diffusible pigments were made on each strain with the dish cultures used for studies of micromorphology after 14 days. Each dish, minus cover, was held at an approximate distance of 24 in. below a 15 watt, white fluorescent lamp. Colors were first recorded using common designations such as yellow-brown, cream-color, etc., and then each was keyed out to its approximate equivalent in Ridgway (1912). The Ridgway color designations later were keyed out to the approximate equivalents in the Maerz and Paul *Dictionary of Color* (1950). Colors of sporulating aerial mycelia were obtained from inorganic salts-starch agar cultures, whereas those of the reverses and diffusible pigments were determined from the glycerol-asparagine dishes. Cultures were relegated to the approximate aerial mycelium color series as outlined in Pridham et al. (1958).

Determination of chromogenicity. In this work,

chromogenicity is defined as the production of a brown, deep brown, or black diffusible pigment after 4 days of incubation at 28 to 30 C on the peptone agar recommended for the international common experiment on characterization of streptomycetes. Our interpretation of the directions for preparation is given below:

International peptone agar. Yeast extract (Difco), 1.0 g; tryptone (Difco), 1.0 g; sodium chloride, 8.5 g; distilled water, 1,000 ml. Adjust pH to 7.0 with sodium hydroxide, if necessary. Add agar, 17.0 g. Melt by steaming at 100 C for 15 to 20 min, dispense in test tubes, sterilize for 20 min at 121 C, and allow medium to solidify as slants.

Although this medium was recommended in the instructions for the international common experiment for determination of melanoid pigment production by streptomycetes, it is not considered the best for this purpose. Cultures forming a greenish brown to brown to black diffusible pigment after 4 days were recorded as positive. Those forming no diffusible pigment, or yellow or orange diffusible pigments, were recorded as negative.

Hydrogen sulfide production. The procedure to test the capacity for forming hydrogen sulfide recommended by Pridham, Hall, and Shekleton (1951) was modified in accordance with the work of Tresner and Danga (1958). Peptone-iron agar (Difco) was supplemented with 0.1% yeast extract (Difco) and cultures were examined after 24 hr incubation at 28 to 30 C, and again at 10 days.

RESULTS

Our examination of the 55 strains labeled as *albus*, or as varieties or forms of *albus*, indicates that the characteristics of only 17 of these conform to those cited in Waksman and Henrici's 1943 paper. Of these, only about 10 appear to have come from different sources, and histories of some of these strains are still incomplete. It is entirely possible that all these may represent as few as 5 original isolates. The histories of the 17 strains, determined thus far, are presented in Table 1. Thirty-four of the strains are considered incorrectly identified. Four of the 55 strains formed very sparse to no aerial mycelium and spores could not be demonstrated. Studies are underway to determine whether any of these are related to *S. albus*. No further consideration will be given to the 34 incorrectly identified strains and the 4 nonsporulating ones. Data are presented principally on the 17 strains whose characteristics conform most closely to those cited by Waksman and Henrici.

Characteristics of liquid shaken cultures. Cultures of the 17 selected strains grown in 48-hr shaken tubes were essentially identical. Growth was abundant, flaky, very fine, opalescent-white, and in every instance so heavy that the cultures appeared viscous. No diffusible pigments were noted.

Spore morphology and surface. Examination of the literature, and our results, confirms that *Streptomyces albus* forms elongated, ovoid spores with smooth surfaces (Fig. 3). These spores (unstained preparations) measure approximately 1.25 by 1.75 μ. This information is presented in Table 2.

Micromorphology. From observations of the petri dish cultures it was possible to place the strains studied into four of the morphological sections outlined in Pridham et al. (1958):

Section *Rectus-Flexibilis*	31 strains.
Section *Spira*	19 strains.
Section *Biverticillus*	1 strain.
Section Unknown	4 strains.

The typical morphology of the fruiting bodies of the strains selected as representative of *Streptomyces albus* is illustrated in Fig. 4. The organism forms small, compact, coiled chains of spores. The fruiting bodies occur as relatively short branches on rather long sterile hyphae. They occur singly, oppositely branched, and sometimes in verticils which are difficult to detect. The verticillate aspect of these strains is quite different from that of forms that occur in the genus *Streptoverticillium* Baldacci.

Color of sporulating aerial mycelium. Colors noted after 14 days of growth on inorganic salts-starch agar of the 17 strains of *S. albus* are presented in Table 3. The general color of the aerial mycelium can best be described as pale pinkish cretaceus. The color of the aerial mycelium of these cultures approaches pure white more nearly than do any other streptomycetes we have seen.

Color of reverse of cultures. Colors of the reverse side of 14-day glycerol-asparagine agar cultures of the 17 strains are presented in Table 4. Although the colors of the aerial mycelium are quite similar, some differences are noted from strain to strain with respect to colors of the reverse. These ranged from a pale cream color to brown.

Chromogenicity. Only 1 of the 55 strains ex-

TABLE 1

Histories of strains of Streptomyces albus that conform most closely with the description of Waksman and Henrici (1943)

Designation Used in this Paper	History Received at NRRL from
618-1	American Type Culture Collection (ATCC), as ATCC 618; received by ATCC from A. J. Kluyver, Delft, Netherlands in 1926.
618-2	R. Gordon, Rutgers University, as ATCC 618.
618-3	T. Yamaguchi, Institute of Applied Microbiology, University of Tokyo, Japan, as ATCC 618.
618-4	H. J. Kutzner, Institute of Microbiology. Rutgers University (IMRU), as FAL H78; received by Kutzner from S. A. Waksman as ATCC 618.
3004-1	S. A. Waksman, IMRU, as No. 3004; received by Waksman from the Pribram Collection, originally the Kral Collection, in Vienna carrying the label that it was named or isolated by Berestnew.
3004-2	ATCC in 1956, as ATCC 3004; received by ATCC from S. A. Waksman in 1944.
3004-3	ATCC in 1959, as ATCC 3004; received by ATCC from S. A. Waksman in 1944.
C.B.S.	Centraalbureau voor Schimmelcultures (CBS), Baarn, Netherlands, as C.B.S. strain; received by CBS from Schmid-Kunz, who isolated the strain from dental caries.
F/3-1	E. Baldacci, Istituto Patologia Vegetale, Universita di Milano, Italy (IVP), as strain 82x; isolated in 1956–1957 from diseased bees or near beehives.
F/3-2	E. Baldacci, IVP, as No. 1; isolated from diseased bees or near bee hives and assigned strain number F/3 and later 82x by Baldacci.
$C_{13}R_5$-1	CBS, as Pollacci $C_{13}R_5$ strain; received by CBS from P. Redaelli, Institute of Pathological Anatomy, University of Pavia, Italy, as *Actinodiscomyces bovis* Ronchi strain; presumably first isolated by Cortese from a case of human actinomycosis and designated as *Act. albus n. varietas* for study of its porphyrine content.
$C_{13}R_5$-2	E. Baldacci, IVP, as strain $C_{13}R_5$ strain 849.
F/2	E. Baldacci, IVP, as strain 52x; isolated in 1956–1957 from diseased bees or near beehives.
A/7	E. Baldacci, IVP, as strain 79x; isolated in 1956–1957 from diseased bees or near beehives.
298x	E. Baldacci, IVP, as strain 298x; isolated from diseased bees or near beehives.
299x	E. Baldacci, IVP, as strain 299x; isolated from diseased bees or near beehives.
FAL H123	H. J. Kutzner, IMRU, as strain FAL H123; received by Kutzner as *Actinomyces albus* from Agricultural Chemical Institute, Tech. Hochschule, Munich.

TABLE 1—*Concluded*

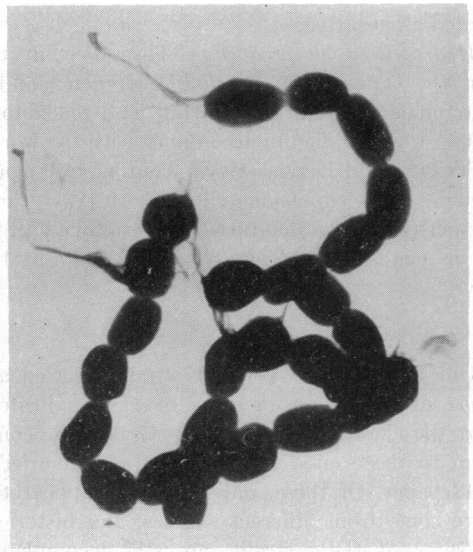

Fig. 3. Morphology and nature of spore surfaces of *Streptomyces albus* F/3-2 (Baldacci No. 1 strain). Magnification, 17340×. Electron microscopy by N. Coy and W. Trejo, Squibb Institute for Medical Research, New Brunswick, New Jersey.

amined formed a brown to black diffusible pigment when cultured on the international peptone agar slants. It was not one of those selected as representative of *Streptomyces albus*.

Production of hydrogen sulfide. Only 1 of the

TABLE 2

Morphology and nature of spore surfaces of strains of Streptomyces albus

Designation Used in this Paper	Spore Morphology[a]	Nature of Spore Surface
618-1	Elongated-ovoid	Smooth-walled[b]
618-2	Elongated-ovoid	
618-3		
618-4	Elongated-ovoid	Smooth-walled[c]
3004-1	Elongated-ovoid	
3004-2	Elongated-ovoid	
3004-3		
C.B.S.	Elongated-ovoid	
F/3-1	Elongated-ovoid	
F/3-2	Elongated-ovoid	Smooth-walled[d]
$C_{13}R_5$-1	Elongated-ovoid	
$C_{13}R_5$-2		
F/2	Elongated-ovoid	
A/7	Elongated-ovoid	
298x	Elongated-ovoid	
299x	Elongated-ovoid	
FAL H123	Elongated-ovoid	Smooth-walled[c]

[a] Our data obtained from examination of Drechsler impression slides. Examination of unstained preparations indicates that the spores measure approximately 1.25 by 1.75 μ.

[b] We are indebted to Dr. K. L. Jones, Department of Botany, University of Michigan, Ann Arbor, for this datum.

[c] Data taken from Kutzner (1956).

[d] We are indebted to Dr. N. Coy and Mr. W. Trejo, Squibb Institute for Medical Research, New Brunswick, New Jersey, for this datum.

55 strains formed hydrogen sulfide with peptone-iron agar supplemented with 0.1% yeast extract. The test results appear to correlate positively with those of the test for chromogenicity, despite the fact that at least two different metabolic products are being measured, i.e., melanin pigment and hydrogen sulfide. It is not definitely known whether this correlation would hold true if a large number of chromogenic strains were tested for ability to form hydrogen sulfide. The results of our general characterization program of many types of streptomycetes suggest that there may be a few exceptions.

Ability to utilize sucrose in Czapek's solution agar. When the 55 strains labeled *albus* were cultured on Czapek's solution agar for 14 days at 28 to 30 C, some strains grew well, and others poorly. The 17 selected strains of *S. albus* grew poorly.

DISCUSSION

The results of this study have given us a clearer picture of *Streptomyces albus*, provided one accepts the 1943 description of the species by Waksman and Henrici. With this description as a basis, it was relatively easy to select strains of the species. Studies of the physiological characteristics of the 17 strains, selected as most representative, should allow the selection and designation of a suitable neotype strain.

Since about 1916, two entirely different concepts of *Streptomyces albus* have existed, one of

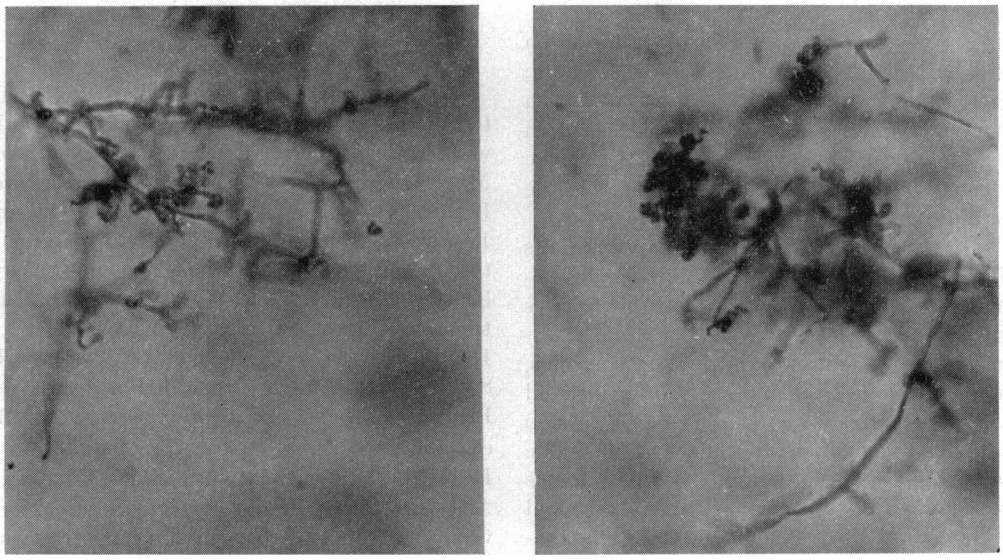

Fig. 4. Micromorphology of *Streptomyces albus* F/3-2 (Baldacci No. 1 strain). Magnification, 800×; 14-day cultures on inorganic salts-starch agar at 28 to 30 C.

TABLE 3

Colors of sporulating aerial mycelium of strains of Streptomyces albus grown for 14 days at 28 to 30 C on inorganic salts-starch agar

Designation Used in this Paper	Common Color Name	Ridgway Designation[a]	Maerz and Paul Designation[a]
618-1	Cretaceus (chalk-white)	—[b]	—
618-2	Pale mealy-gray to off-white	—	—
618-3	Cretaceus to off-white to very pale olive-buff	—	—
618–4	Pale buff	Pale Pinkish Buff XXIX[c]	Ivory 10B2
3004-1	Off-white	—	—
3004-2	Off-white	—	—
3004-3	Cretaceus	—	—
$C_{13}R_5$-1	Pale pinkish buff	Pale Pinkish Buff XXIX	Ivory 10B2
$C_{13}R_5$-2	Off-white	—	—
C.B.S.	Pale pinkish buff	Pale Pinkish Buff XXIX	Ivory 10B2
F/3-1	Pale buff white	—	—
F/3-2	Cretaceus to pale pinkish buff	Pale Pinkish Buff XXIX	Ivory 10B2
F/2	Pinkish cretaceus	—	—
A/7	Pinkish cretaceus	—	—
298x	Pale pinkish buff	—	—
299x	Pinkish cretaceus	—	—
FAL H123	Pale pinkish white	Pale Pinkish Buff XXIX	Ivory 10B2

[a] The Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) color names (Kelly and Judd, 1955) for the Ridgway and Maerz and Paul designations are, "73. pale orange yellow," and "89. pale yellow," respectively.

[b] Dash indicates that no color tabs, other than "white" were equivalent to the color observed.

[c] The Ridgway designation represents the closest approximation that could be obtained. All colors might more precisely be designated as "between the white tab and the Pale Pinkish Buff tab."

which centers around cultures now considered as members of the *S. griseus* group. The other includes a group that form coiled fruiting bodies with catenulate, elongated, ovoidal, smooth-walled spores and cretaceus (chalk-white, often tinged with pink) sporulating aerial mycelium; are nonchromogenic; cannot form hydrogen sulfide; and grow poorly on Czapek's solution agar. Preliminary evidence suggests that there are some physiological differences among the 17 strains of this group that we have acquired.

The fact that there have been two concepts with regard to *S. albus* suggests a careful re-examination of the synonymy of this species should be made.

In our taxonomic work on streptomycetes, we recently adopted the practice of using distilled water in preparing all of our media. This step was taken to eliminate the effect of inorganic salts of unknown composition. If this practice were adopted by other laboratories, it should tend to reduce the possibilities for interlaboratory differences in results of various tests. Some differences in results now noted could be attributed to variation in composition of tap water obtained from widely differing sources.

ACKNOWLEDGMENT

We are indebted to Miss Collette Foley for technical assistance with certain portions of the work reported here; to Dr. Charles Drechsler, Mycologist, Vegetable and Ornamental Research Branch, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Plant Industry Station, Beltsville, Maryland, and to the Botanical Gazette for permission to reproduce the material shown in Fig. 2; to Dr. N. Coy and Mr. William H. Trejo, The Squibb Institute for Medical Research, New Brunswick, New Jersey, for preparation of the electron micrograph illustrated in Fig. 3; and to Dean R. E. Buchanan, Iowa State University, Ames, Iowa, and Professor David Gottlieb, University of Illinois, Urbana, Illinois, for reviewing the manuscript during its preparation.

TABLE 4

Colors of reverse of strains of Streptomyces albus grown for 14 days at 28 to 30 C on international glycerol-asparagine agar

Designation Used in this Paper	Common Color Name[a]	Ridgway Designation[a,c]	Maerz and Paul Designation[b,c]
618-1	Pale orange-brown	Pale Ochraceous-Buff XV	(No name) 9C4
618-2	Orange-brown to olive-brown	Tawny-Olive XXIX to Saccardo's Umber XXIX	Hazel 13J9 to Acorn 15E7
618-3	Orange-brown to pale olive-yellow-brown	Chamois XXX to Warm Buff XV to Buckthorn Brown XV	Raffia 11E5 to Nankeen 10F3 to Chipmunk 13L9
618-4	Light brown	Tawny-Olive XXIX	Hazel 13J9
3004-1	Pale cream to pale olive	Light Buff XV to Deep Olive-Buff XL	Ivory 10B2 to (no name) 12C2
3004-2	Dull cream to pale orange-brown	Cream Color XVI to Pale Ochraceous-Buff XV	Straw 10F2 to Polar Bear 9B2
3004-3	Light orange-brown	Cream Buff XXX	(No name) 10E3
$C_{13}R_5$-1	Pale yellow-brown	Naples Yellow XVI	Nankeen 10F3
$C_{13}R_5$-2	Light olive-brown	Buckthorn Brown XV to Dresden Brown XV	Chipmunk 13L9 to Olive Brown 15H7
C.B.S.	Pale cream to dull cream	Light Buff XV to Cream Color XVI	Ivory 10B2 to Straw 10F2
F/3-1	Pale brown	Buckthorn Brown XV	Chipmunk 13L9
F/3-2	Pale orange-yellow-brown to olive-brown to pinkish-buff	Buckthorn Brown XV to Tawny-Olive XXIX to Light Ochraceous-Buff XV	Chipmunk 13L9 to Hazel 13J9 to (no name) 10D4
F/2	Dark brownish-yellow	Warm Buff XV	Nankeen 10F3
A/7	Olive-brown	Warm Buff XV	Nankeen 10F3
298x	Pale olive-brown	Cinnamon-Buff XXIX	Toltec 11B7
299x	Pale olive-brown	Cinnamon-Buff XXIX to Tawny-Olive XXIX	Toltec 11B7 to Hazel 13J9
FAL H123	Pale olive-yellow	Pinkish Buff XXIX	Vanilla 10C3

[a] Results presented are those obtained by two different individuals and reflect individual differences in color interpretation.

[b] The Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) color names (Kelly and Judd, 1955) for the Ridgway and Maerz and Paul designations are given below:

28. light yellowish pink
29. moderate yellowish pink
57. light brown
71. moderate orange yellow
73. pale orange yellow
74. strong yellowish brown
76. light yellowish brown
77. moderate yellowish brown
80. grayish yellowish brown
86. light yellow
87. moderate yellow
89. pale yellow
90. grayish yellow
94. light olive brown
95. moderate olive brown

Note the broader range of colors as compared with those of table 3.

[c] Results presented are those obtained by two different individuals, keying out together, the color tabs in Ridgway indicated in second column. When working together, there was a considerably greater degree of agreement on color interpretation.

SUMMARY

A review of the literature and a taxonomic study of a number of strains of *Streptomyces albus* have been made. The results indicate that two entirely different concepts regarding *Streptomyces albus* have existed since 1916.

The earlier concept suggests recognition of some member of the *Streptomyces griseus* group

as the neotype of *Streptomyces albus sensu* Rossi-Doria and other investigators.

The other concept centers around streptomycetes that possess these characteristics: coiled fruiting bodies with catenulate, elongated, ovoidal, smooth-walled spores; a cretaceus (chalk-white often tinged with pink) sporulating aerial mycelium; nonchromogenicity; inability to form hydrogen sulfide; and poor growth on Czapek's solution agar.

We believe that the second concept of *Streptomyces albus* should be accepted. This proposal is made to prevent the obvious confusion that would ensue were the original concept for *S. albus* recognized. In our opinion acceptance of the newer concept will impart a greater degree of stability to streptomycete taxonomy and nomenclature. We recognize that much of the earlier literature concerning *S. albus* refers to streptomycetes that now would be placed in the *S. griseus* group, that many strains now available and labeled with the epithet *albus* are strains that would be placed in the *S. griseus* group, and that the synonymy of *S. albus* should be carefully examined. Specialists who must refer to the literature on *S. albus* should be aware of these facts.

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