Cooperative Description of Type Strains of *Streptomyces*

V. Additional Descriptions¹

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This is the final major publication of a series describing the type or suggested neotype strains for a total of more than 450 species of actinomycetes. Type strains or suggested neotype strains for species previously placed in the genera *Streptomyces*, *Actinomyces* sensu Krasil'nikov, or *Streptovercillum* have been obtained from original authors, culture collections, or other reliable sources for redescription by currently acceptable criteria and methods. More than 40 collaborating laboratories representing 18 nations have cooperated in establishing methods and criteria, in locating authentic type strains, and especially in laboratory studies required for the emendations to descriptions. Specimens of the redescribed type strains or suggested neotypes are deposited in the American Type Culture Collection, the Centraalbureau voor Schimmelcultures, the U.S.S.R. Research Institute for Antibiotics, and the Institute for Fermentation, Osaka, Japan. This report adds descriptions for 158 additional species, completing the major work of the project. Additional type strains will be studied, described, and deposited in collections as they become available.

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INTRODUCTION

This is the final major report of a series related to the comprehensive international effort to clarify taxonomy at the species level within the genus *Streptomyces* Waksman and Henrici (1943) and the two closely related genera *Streptovercillium* Baldacci (1958) and *Chainia* Thirumalachar (1955). Descriptions of type strains published here and in three previous reports represent the collaborative work of more than 40 specialists from 18 nations. The cooperative study is known as the International Streptomyces Project (ISP). The rationale, scope, extensive background preparation, and general plan are explained in the first paper of the series (62); descriptive criteria and methods for the ISP characterizations of type strains were published earlier (171).

For each species, a freeze-dried specimen of the type or suggested neotype strain, identified only by a code number, was sent to each of three independent laboratories for study by ISP methods. The data obtained by the three collaborators and reported to E. B. Shirling, Ohio Wesleyan University, were used to prepare standardized emendations to the original descriptions for the species. The collaborators who studied each type strain are to be regarded as the authors for the emendation. They are listed as cooperating groups at the beginning of each report and are identified by group number in each description. Earlier descriptions for each strain, including the descriptions ascribed to the author who first named the species, are cited wherever possible to complete the characterization.

Parts II, III, and IV of the series (172–174) include illustrated descriptions for 300 type or suggested neotype strains. Part II (172, p. 73–79) should be consulted for analysis of a typical entry and guidance in interpretation of the abbreviated descriptions. This report (Part V of the series) includes 158 additional descriptions and completes the study of strains available to the ISP through the year 1970.

Altogether, more than 1,000 species have been named in the genera *Streptomyces*, *Actinomyces* sensu Krasil'nikov, *Streptovercillium*, and *Chainia*, but only about half this number will be available for the ISP study. Type strains for many species are no longer extant, and the original descriptions seem inadequate for selection of suitable neotypes. For some species of industrial importance, type strains are not presently available because patents have not been issued or because distribution is restricted for other reasons. In other instances, new names have been used in patent applications or patents subsequently abandoned. Type strains were not kept, and there is no

incentive to establish neotypes. Names have been used in the antibiotic and biochemical literature and in other reports with no description of the organism other than the mention of a metabolic product, and the type strains have not been designated or deposited in a culture collection. Again, there is little prospect for finding the type or establishing a neotype strain for a name receiving only incidental mention in the literature.

The foregoing examples illustrate the impossibility of obtaining suitable specimens for many named species placed in the genus *Streptomyces* or related genera. On the other hand, the ISP reports do include all of the type or suggested neotype specimens available to us from reliable sources. Thus we have included suggested type or neotype strains for "species" whose names have never been validly published or which are not legitimate according to the International Code of Nomenclature of Bacteria. We have also included in our publications the ISP descriptions for microorganisms named as species of *Streptomyces* (*Actinomyces*), *Streptovercillium*, or *Chainia*, even though the ISP studies suggest that they are not properly placed in any of these genera. We hope inclusion of the ISP characterizations of these "misplaced" bacteria, together with simultaneous deposition of type strains in the world's culture collections, will result in additional studies and assignment to the correct genus.

Finally, we emphasize that publication of the ISP characterization is intended only to add standardized descriptive criteria as emendations to whatever previous characterizations existed. Inclusion of a strain or a named species in our studies and reports does not constitute valid publication, elevation of a name to legitimate status, or ipso facto evidence that a strain has been properly named or classified. The ISP effort is limited to obtaining suitable type specimens, characterizing them by standardized methods and criteria, and depositing them in four major culture collections where they will be maintained for future reference and study. The bulk of this work is completed with this report, but additional ISP descriptions will be published from time to time as type specimens for other species become available.

Investigators working with streptomycetes are urged to avail themselves of the type strains now documented in these reports and deposited for easy access in the American Type Culture Collection, the Centraalbureau voor Schimmelcultures, the U.S.S.R. Research Institute for Antibiotics, and the Institute for Fermentation, Osaka, Japan. The corresponding culture collection numbers for the ISP strains are listed in Table 1 (p. 376–386). Failure to use the type strain as one base for

reference in future research involving a named species may contribute to the confusion already existing in the literature!

Streptomyces acidoresistans nom. nud. See Hütter (80). Type strain: IMRU 3049. ISP 5540 from S. A. Waksman as IMRU 3049. ISP description by Group F-1.

Spore-chain morphology: Section *Rectiflexibiles*. Mature spore chains generally have more than 10 spores per chain (Fig. 1). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 2).

Color of colony: Aerial mass color in the yellow color series (2ba or 2db, pale yellow, or 1cb, pale yellowish green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; immature or poorly developed aerial mycelium is white.

Reverse side of colony: No distinctive pigments (light olive brown or yellowish brown to orange yellow on yeast-malt agar; light yellow to grayish or greenish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, D-fructose, and rhamnose are utilized for growth. Reports vary on the utilization of D-mannitol. A trace of growth slightly greater than that on the carbon-free control is reported for L-arabinose, sucrose, *i*-inositol, and raffinose; utilization of these carbon sources is doubtful.

Streptomyces alanosinicus Thiemann and Beretta. Description: Thiemann and Beretta (182). Type strain: Lepetit S.p.A. V/119 = ATCC 15710 (182). ISP 5606 from E. F. Lessel, ATCC, as ATCC 15710. ISP description by Group F-6.

Spore-chain morphology: Section *Spirales* (Fig. 3). Mature spore chains are generally long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar, but sporulating aerial mycelium is thin or absent on glycerol-asparagine agar. Spore surface: Spiny (Fig. 4).

Color of colony: Aerial mass color in the Red color series (4ec, grayish yellowish pink, or 3ca, pale orange yellow) on yeast-malt agar, oatmeal agar, and salts-starch agar. Sporulating aerial mycelium is thin or absent on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (moderate reddish brown to strong brown on

yeast-malt agar; pale grayish yellow to light yellowish brown or olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but reaction may be delayed or weak in tyrosine agar. No pigment is found in the medium in salts-starch agar or glycerol-asparagine agar. Some yellow pigment may or may not be seen in yeast-malt agar and oatmeal agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and raffinose are utilized for growth. Reports vary on utilization of sucrose; no growth or only a trace of growth with rhamnose.

Streptomyces albaduncus Tsukiura, Okanishi, Ohmori, Koshiyama, Miyama, Miyaki, Kitazima, and Kawaguchi. Description: Tsukiura et al. (190). Type strain: Bristol-Banyu Research Institute 13246 (190) = ATCC 14698 (E. F. Lessel, personal communication, Sept. 1967). ISP 5478 from E. F. Lessel, ATCC, as ATCC 14698. ISP description by Group E-2.

Spore-chain morphology: Section *Retinaculiperti* to *Spirales*. Short spore chains are flexuous or form hooks, loops, and incomplete or imperfect spirals (Fig. 5). True spirals are not reported. Mature spore chains generally contain more than 10 spores per chain but are shorter than those found in typical RA cultures. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny with numerous long spines (Fig. 6).

Color of colony: Aerial mass color in the White or Yellow or Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. The nearest matching color tab in the Yellow color series is 2ba, pale yellow, and in the Gray color series is d, light gray, 2fe, medium gray, or 3fe, light brownish gray.

Reverse side of colony: No distinctive pigments (grayish yellow to yellowish brown, olive brown, or strong brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Yellow pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth with sucrose or raffinose.

FIG. 1. *S. acidoresistans*. RF spore chains on glycerol-asparagine agar, 14 days. $\times 960$.

FIG. 2. *S. acidoresistans*. Smooth spores. (a) Electron micrograph from 21-day-old culture on salts-starch agar. (b) Scanning electron micrograph from same preparation.

FIG. 3. *S. alanosinicus*. Spiral spore chains on salts-starch agar, 14 days. $\times 800$.

FIG. 4. *S. alanosinicus*. Spiny spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 5. *S. albaduncus*. (a) Hooks on oatmeal agar, 14 days. $\times 500$. (b) Imperfect spirals suggesting RA morphology on yeast-malt agar, 7 days. $\times 300$.

FIG. 6. *S. albaduncus*. (a) Spiny spores with numerous, long, curved spines; electron micrograph from 14-day-old culture on salts-starch agar. (b) Both smooth and spiny spores on same chain. Electron micrograph from 14-day-old culture on oatmeal agar.

Streptomyces albolongus Tsukiura, Okanishi, Koshiyama, Ohmori, Miyaki, and Kawaguchi. Description: Tsukiura et al. (189). Type strain: Bristol-Banyu Research Institute 304R7 (189). ISP 5570 from H. Tsukiura, Bristol-Banyu Research Institute as 304R7. ISP description by Group F-3.

Spore-chain morphology: Section *Rectiflexibiles*. Long, straight or slightly flexuous spore chains usually contain more than 50 spores per chain (Fig. 7). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 8).

Special morphological characteristics: One observer reports lateral spore-like bodies borne singly on the substrate hyphae (Fig. 9).

Color of colony: Aerial mass color in the White color series on yeast-malt agar and salts-starch agar; White or Yellow color series (2ba, pale yellow) on oatmeal agar and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (grayish yellow, orange yellow, or yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, and D-xylose are utilized for growth. Only a trace of growth is found on *D*-inositol, D-mannitol, fructose, rhamnose, sucrose, or raffinose.

Actinomyces alborubidus Kudrina. Description: Kudrina, in Gauze et al. (55, p. 109-111). Type strain is no longer extant (Preobrazhenskaya, personal communication, August 1965; INA 6476/62 suggested as a potential neotype by G. F. Gauze, personal communication, March 1967). ISP 5465 from G. F. Gauze as INA 6476/62. ISP description by Group E-4.

Spore-chain morphology: Section *Rectiflexibiles* or *Spirales*. True spirals are usually not evident. Short chains are crooked and may have terminal loops or hooks of small diameter (Fig. 10). Mature spore chains are short to moderately long, usually with more than 10 spores per chain on yeast-malt agar, oatmeal agar, and salts-starch agar; chains may be shorter or absent on glycerol-asparagine agar. Spore surface: Smooth (Fig. 11).

Special morphological characteristics: Globose bodies are reported on oatmeal agar in 20 days.

Color of colony: Aerial mycelium may be poorly developed. When adequate aerial mycelium is produced, it is in the White color series

on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; Red color series (5cb, grayish yellowish pink) on oatmeal agar.

Reverse side of colony: No distinctive pigments (colorless to light grayish yellow or yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar). One observer reports orange pigment on the reverse side of the colony on yeast-malt agar in 21 days.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, and D-xylose are utilized for growth. Reports vary on the utilization of D-mannitol, D-fructose, and rhamnose. No growth or only a trace of growth with sucrose, *D*-inositol, and raffinose. Note: This suggested neotype differs from the original description (55) in failure to produce significant amounts of orange to grayish brownish red pigment in the substrate mycelium and its inability to utilize sucrose.

Streptomyces albulus (Routien in Rao, Marsh, and Garretson. German Pat. 1 052 065, August 20, 1959). Description: Rao et al. (156). The name only, without description, appears in Rao and Cullen (154); a footnote ascribes the characterization to J. B. Routien, Chas. Pfizer Co., Inc., but cites no publication. Type strain: ATCC 12757 (German Pat. 1 052 065 [156]). ISP 5492 from E. F. Lessel, ATCC, as ATCC 12757. ISP description by Group E-6.

Spore-chain morphology: Section *Spirales* (Fig. 12). Mature spore chains are moderately long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 13).

Color of colony: Aerial mass color in the Gray color series (5fe, light grayish reddish brown; 4li, brownish gray; 4ig, light grayish brown) on yeast-malt agar and oatmeal agar; Gray or Red color series on salts-starch agar and glycerol-asparagine agar. (Nearest tab in the Red color series is 5dc, grayish yellowish pink.)

Reverse side of colony: No distinctive pigments (pale or grayish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *D*-inositol, D-mannitol, and D-fructose are utilized for growth.

No growth or only a trace of growth with L-arabinose, D-xylose, rhamnose, sucrose, or raffinose.

Streptomyces alni (Woronin) Fiuczek. Descriptions: Not seen. According to Index Bergeyana (28), the following references establish the name and may contain early descriptions: *Schinzia alni* Woronin 1866, 10 (216); *Frankia subtilis* (Woronin) Brunchorst 1886, 174 (27); *Actinomyces* (sic) *alni* Peklo 1910, 505 (144); *Streptomyces alni* (Woronin) Fiuczek 1959, 283 (49). Type strain: CBS 100.41 = strain von Plotho, suggested neotype. ISP 5557 from G. A. de Vries, CBS, as CBS 100.41 strain von Plotho. ISP description by Group F-1.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 14). Mature spore chains are generally poorly developed, but straight or flexuous chains of 10 to 50 or more spores per chain can be found on yeast-malt agar and sometimes on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 15). Coremia formation is reported on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, and one of three observers reports fragmentation of the substrate mycelium on glycerol-asparagine agar in 14 days.

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray) on yeast-malt agar, oatmeal agar, and salts-starch agar when mature sporulating aerial mycelium is formed. Aerial mycelium is often poorly developed on these media or on glycerol-asparagine agar, and the aerial surface may appear to be in the White color series or Yellow color series (1dc, pale yellow green).

Reverse side of colony: No distinctive pigments (yellowish brown to strong brown on yeast-malt agar and glycerol-asparagine agar; light grayish yellow or pale yellow on oatmeal agar and salts-starch agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar in 14 to 21 days. This pigment is not pH sensitive.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth. Utilization of *i*-inositol, rhamnose, sucrose, or raffinose is doubtful.

Streptomyces anandii Batra and Bajaj. Description: Batra and Bajaj (14). Type strain: ITCC 1233 (14) = ATCC 19388 (S. K. Batra, personal communication, February 1968). ISP 5535 from E. F. Lessel, ATCC, as ATCC 19388. ISP description by Group E-5.

Spore-chain morphology: Section *Spirales* (Fig. 16), but open loops and flexuous chains are also seen. Mature spore chains are moderately long with 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 17).

Special morphological characteristics: One of three observers found globose bodies (Fig. 18) in the aerial mycelium on yeast-malt agar, and coremia formation on oatmeal agar and salts-starch agar.

Color of colony: Aerial mass color in the White or Gray (2dc, yellowish gray, or 3ge, light grayish yellowish brown color series) on yeast-malt agar and glycerol-asparagine agar; Gray or Red color series (2dc, yellowish gray, to 4ec or 5cb, grayish yellowish pink) on oatmeal agar and salts-starch agar.

Reverse side of colony: No distinctive pigments (pale or grayish yellow to olive brown or strong brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, tryptone-yeast broth, and Gauze medium no. 2. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, sucrose, and raffinose are utilized for growth. No growth or only a trace of growth with rhamnose.

Chainia antibiotica Thirumalachar 1955. See *Streptomyces sclerotialis* Pridham 1970, 44.

Streptomyces anulatus (Beijerinck) Waksman. *Streptomyces annulatus* (sic) (Beijerinck) Waksman 1953. Spelling corrected in Waksman (205). Not *A. annulatus* Wollenweber 1920 (214). Descriptions: *Actinomyces* (*Streptothrix*) *annulatus* (sic) Beijerinck 1912, 4 (16); *Actinomyces annulatus* (sic) Beijerinck 1912, 94 (16); *Actinomyces albus* subsp. *annulatus* (sic) (Beijerinck) Krasil'nikov 1941, 39-40 (100); *Streptomyces annulatus* (sic) (Beijerinck) Waksman (209, p. 40). Type strain: CBS Beijerinck strain of March 1918 (G. A. deVries, CBS, personal communication). (Not IMRU 3307, not ATCC 3307; Hütter [80, p. 229].) ISP 5361 from G. A. deVries, CBS as *A. annulatus*, Beijerinck strain. ISP description by Group D-9.

Spore-chain morphology: Section *Rectiflexibiles* on oatmeal agar, salts-starch agar, and glycerol-asparagine agar (Fig. 19a), but open spirals of two to several turns, hooks, and loops of small diameter, as well as straight and flexuous chains are found on yeast-malt agar. The strain as ob-

FIG. 7. *S. albolongus*. Long, straight RF spore chains on yeast-malt agar, 8 days. $\times 800$.

FIG. 8. *S. albolongus*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 9. *S. albolongus*. Lateral sporelike bodies borne singly on substrate hyphae; seen by one observer on glycerol-asparagine agar, 14 days. $\times 850$.

FIG. 10a, b. *S. alborubidus*. Crooked spore chains with some loops of small diameter on yeast-malt agar. (a) 8 days. $\times 280$. (b) 20 days, $\times 300$.

FIG. 11. *S. alborubidus*. Smooth spores; electron micrograph from 7-day-old culture on oatmeal agar.

FIG. 12. *S. albulus*. Spiral spore chains on oatmeal agar, 7 days. $\times 850$.

FIG. 13. *S. albulus*. Spiny spores from 28-day-old culture on yeast-malt agar.

FIG. 14. *S. alni*. Poorly developed RF aerial mycelium on glycerol-asparagine agar, 14 days. $\times 500$.

FIG. 15. *S. alni*. Smooth spores from 14-day-old culture on oatmeal agar.

served on yeast-malt agar can therefore be placed in section *Spirales* or RA (Fig. 19b). Spore surface: Smooth (Fig. 20).

Color of colony: Aerial mass color in the Yellow or White color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Observers selected color tab 2ba (pale yellow) from the Yellow color series and tab a (white) from the White color series; both yellow and white may be observed on the same medium.

Reverse side of colony: No distinctive pigments (colorless to pale yellow, grayish yellow, or yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment (or only a trace of yellow) is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only trace of growth with *i*-inositol, sucrose, or raffinose.

Streptomyces arduus DeBoer, Dietz, Lummis, and Savage. Description: DeBoer et al. (39). Type strain: NRRL 2817 = UC 2500 (A. Dietz, Upjohn Co., personal communication, October 1963). ISP 5527 from T. G. Pridham, NRRL, as NRRL 2817. ISP description by Group E-5.

Spore-chain morphology: Sporulating aerial mycelium is usually absent or very poorly developed on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Sterile aerial hyphae are straight (Fig. 21) or flexuous (Fig. 22). Coremia may be produced on yeast-malt agar and oatmeal agar in 7 to 14 days. The original description (39) reported that this strain sporulates with difficulty, producing only a few monoverticillate and biverticillate sporophores. Spore surface: Not observed.

Color of colony: Aerial mass color of sporulating aerial mycelium not observed. Sterile hyphae or scant aerial mycelia appear to be white to light gray when produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (pale grayish yellow to light yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but not on tyrosine agar or Gauze medium no. 2. No pigment is found in the medium in oatmeal agar, salts-starch agar, or glycerol-asparagine agar. One observer reports traces of red pigment in yeast-malt agar. This pigment is

not pH-sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, *i*-inositol, and D-fructose are utilized for growth. Reports vary on utilization of L-arabinose. No growth or only trace of growth with D-xylose, D-mannitol, rhamnose, sucrose, and raffinose.

Streptomyces aspergilloides (Rao, Marsh, and Renn. U.S. Pat. 3,328,248. June 27, 1967). Description: Rao et al. (157). Type strain: BA-181314A = ATCC 14808 (157). ISP 5565 from J. Routien, Chas. Pfizer and Co., as BA-181314A = ATCC 14808. ISP description by Group F-2.

Spore-chain morphology: Section *Verticillati*, Umbellate Monoverticillate (biverticillate). (Fig. 23). Mature spore chains are generally 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 24).

Color of colony: Aerial mass color in the Yellow or Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs in the Yellow color series are 2db or 2ba, pale yellow, and 1dc, pale yellow green. Nearest matching tabs in the Gray color series are 2ge, light olive brown, and 2dc, yellowish gray.

Reverse side of colony: No distinctive pigments (pale grayish yellow or pale yellowish green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *i*-inositol, D-mannitol, and D-fructose are utilized for growth. No growth or only trace of growth with L-arabinose, D-xylose, rhamnose, sucrose, or raffinose.

Streptomyces atrofaciens (Ehrlich, Bartz, and Knudsen. U.S. Pat. 3,100,176, August 6, 1963). Description: Ehrlich et al. (45). Type strain: PD 04992 = NRRL 2429 (45). ISP 5475 from Lucia Anderson, Parke Davis & Co., as PD 04992 = NRRL 2429. ISP description by Group E-1.

Spore-chain morphology: Section *Rectiflexibiles*. Long, straight to flexuous chains, often with more than 50 spores per chain, predominate on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar (Fig. 25). Long chains may occasionally produce hooks or loops of wide diameter, suggesting RA morphology. Spore surface: Smooth (Fig. 26).

FIG. 16. *S. anandii*. Spiral spore chains on glycerol-asparagine agar, 21 days. $\times 690$.

FIG. 17. *S. anandii*. Smooth spores. (a) Electron micrograph from 14-day-old culture on oatmeal agar. (b) Scanning electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 18. *S. anandii*. Globose bodies on aerial mycelium of 14-day-old culture on yeast-malt agar. $\times 200$.

FIG. 19. *S. anulatus*. (a) RF spore chains on glycerol-asparagine agar, 14 days. $\times 900$. (b) Irregular spirals suggesting RA morphology on yeast-malt agar, 10 days. $\times 500$.

FIG. 20. *S. anulatus*. Smooth spores from 28-day-old culture on salts-starch agar.

FIG. 21. *S. arduus*. Straight, sterile aerial hyphae on glycerol-asparagine agar, 21 days. $\times 600$.

FIG. 22. *S. arduus*. Flexuous, sterile aerial hyphae on oatmeal agar, 14 days. $\times 200$.

FIG. 23. *S. aspergilloides*. Umbellate monovercillate (BV) sporophores. (a) On glycerol-asparagine agar, 14 days. $\times 812$. (b) On yeast-malt agar, 14 days. $\times 300$.

FIG. 24. *S. aspergilloides*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

Special morphological characteristics: Knots and interwoven masses of aerial mycelium (Fig. 27) may develop into globose bodies or sclerotia (Fig. 28) on yeast-malt agar, oatmeal agar, and salts-starch agar in 14 to 21 days.

Color of colony: Aerial mass color in the Red color series (5cb, grayish yellowish pink; 3ca, pale orange yellow; 5ca, light yellowish pink) on yeast-malt agar, oatmeal agar, and salts-starch agar; aerial mycelium may be poorly developed (white) or light yellowish pink on glycerol-asparagine agar.

Reverse side of colony: Strong brown to reddish brown on yeast-malt agar; pale yellow, yellowish brown, or medium brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Substrate pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment or only a trace of yellowish brown is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, *i*-inositol, and raffinose are utilized for growth. Utilization of D-xylose and D-fructose is doubtful. No growth or only a trace of growth with D-mannitol, rhamnose, and sucrose.

Streptomyces avellaneus Baldacci and Grein. Description: Baldacci and Grein (10). Type strain: 2758FI (10) = IPV 1830 (E. Baldacci, personal communication, April 1968). ISP 5554 from E. Baldacci, IPV, as 2758FI = IPV 1830. ISP description by Group F-1.

Spore-chain morphology: Section *Rectiflexibiles*. Mature spore chains are moderately long with 10 to 50 or more spores per chain (Fig. 29). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 30).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray; 3fe, light brownish gray; or 5fe, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (strong yellowish brown to dark brown on yeast-malt agar; grayish yellow to orange yellow, light brown or strong brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-fructose, and sucrose are utilized for growth. No growth or only

trace of growth with L-arabinose, D-xylose, *i*-inositol, D-mannitol, rhamnose, or raffinose.

Streptomyces avidinii Stapley, Mata, Miller, Demny, and Woodruff. Description: Stapley et al. (178). Type strain: MA-833 (178). ISP 5526 from H. B. Woodruff, Merck Sharp & Dohme, as MA-833. ISP description by Group E-4.

Spore-chain morphology: Section *Retinaculi-aperti* with many RF spore chains as well as terminal loops or coils of wide diameter (Fig. 31). Mature spore chains are generally long, with 10 to 50 or more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 32).

Color of colony: Aerial mass color in the Red color series (5dc, 5ec, or 5gc, grayish yellowish pink; 5ge, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Note: The original description (178) characterizes this strain as gray in contrast with the pink to lavender aerial mycelium seen on 11 similar strains identified as strains of *S. lavendulae*. The three ISP collaborators agree that ISP 5526 is in the Red color series on ISP media.

Reverse side of colony: No distinctive pigments (colorless or pale yellow to light yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar but not in tyrosine agar. Melanoid pigment may or may not be found in tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and D-fructose are utilized for growth. Utilization of rhamnose and sucrose is doubtful. No growth or only a trace of growth with L-arabinose, D-xylose, *i*-inositol, D-mannitol, or raffinose.

Streptomyces bacillaris (Krasil'nikov) Pridham. Citations (name without description): *Actinomyces bacillaris* Nikitina 1957 according to Kostachev (98) and Krasil'nikov (102, p. 258). *Streptomyces bacillaris* (Krasil'nikov) Pridham 1970, 9 (147). Type strain: INMI 445 = RIA 336 (N. I. Nikitina, personal communication, February 1969) = ATCC 15855 (Pridham, op. cit.). ISP 5598 from V. D. Kuznetsov, RIA, as RIA 336. ISP description by Group F-5.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 33). Mature spore chains are generally long with 10 to more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-

FIG. 25. *S. atrofaciens*. RF spore chains on oatmeal agar. This morphology usually predominates on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but long chains may also form hooks or loops suggesting RA morphology. $\times 900$.

FIG. 26. *S. atrofaciens*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 27. *S. atrofaciens*. Knot-like tangles in aerial hyphae on yeast-malt agar, 21 days. $\times 900$.

FIG. 28. *S. atrofaciens*. Sclerotia-like globules on oatmeal agar, 14 days. $\times 960$.

FIG. 29. *S. avellaneus*. RF morphology on oatmeal agar, 14 days. $\times 600$.

FIG. 30. *S. avellaneus*. Smooth spores; electron micrograph from 10-day-old culture on yeast-malt agar.

FIG. 31. *S. avidinii*; RA morphology. (a) Hooks and loops of wide diameter on oatmeal agar, 20 days. $\times 300$. (b) Terminal coils on salts-starch agar, 7 days. $\times 280$.

FIG. 32. *S. avidinii*. Smooth spores; electron micrograph from 7-day-old culture on oatmeal agar.

asparagine agar. Spore surface: Smooth (Fig. 34).

Color of colony: Aerial mass color in the Yellow color series (2ba, 2db, 1ba, pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; some parts of the aerial mycelium on yeast-malt agar may also be in the Gray color series (3ge, light grayish yellowish brown), and white aerial mycelium is also observed.

Reverse side of colony: No distinctive pigments (orange-yellow to yellowish brown on yeast-malt agar; light grayish yellow on oatmeal agar; yellowish or orange yellow on salts-starch agar, or glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not on tyrosine agar. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-mannitol, and D-fructose are utilized for growth. Utilization of D-xylose is doubtful. Only a trace of growth is seen with L-arabinose, *i*-inositol, rhamnose, sucrose or raffinose.

Streptomyces bambergensis (Lindner, Wallhäusser, and Huber. German Pat. [DBP] 1,113,791, March 22, 1962). Description: Lindner et al. (115). Type strain: Farbwerke Hoechst A G. 3263 = ATCC 13879 (115). ISP 5590 from E. Lessel, ATCC, as ATCC 13879. ISP description by Group F-5.

Spore-chain morphology: Section *Retinaculiperti* to *Rectiflexibiles*. Strongly flexuous chains with open or primitive spirals (Fig. 35) and terminal loops or turns (Fig. 36). Mature spore chains are moderately long, usually with more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Hairy (Fig. 37).

Color of colony: Aerial mass color in the Green color series (1½li-ig, light grayish olive or olive gray to 24½ih-li, dark greenish gray or grayish olive green) on yeast-malt agar, oatmeal agar, and salts-starch agar. White, Yellow or Green color series on glycerol-asparagine agar.

Reverse side of colony: strong brown on yeast-malt agar; light yellow on oatmeal agar; light grayish olive to olive brown on salts-starch agar; and yellowish pink, orange yellow, or reddish brown on glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Greenish to reddish pigment is reported in the medium in yeast-malt agar, salts-starch agar, and glycerol-as-

paragine agar. One observer reports no pigments in these media. The pigment, when present, is not pH sensitive.

Carbon utilization: D-Glucose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Reports vary on the utilization of L-arabinose; no growth or only a trace of growth with sucrose and raffinose.

Streptomyces bikiniensis Johnstone and Waksman. Note: The strain previously studied by ISP and reported in our earlier publication (173, p. 300) differs from the original descriptions of Johnstone and Waksman (86, p. 294-295; 87, 317-326) in several characteristics. The strain IMRU 3514 (ISP 5235) used in the earlier study is apparently a strain of *S. griseus* (Krain-sky) Waksman and Henrici 1948 (208). This opinion is in agreement with observations made by R. E. Gordon, at IMRU, who believes a labeling or transfer error occurred before 1952 (personal communication, April 1970). Strain ATCC 11062 and the CBS strain of *S. bikiniensis* Johnstone and Waksman were deposited in these collections by S. A. Waksman prior to 1951 as IMRU 3514. They retained the characteristics originally ascribed to *S. bikiniensis* IMRU 3514 by Johnstone and Waksman (86). ISP 5235 (and the ISP description published in 1968 [173]) has been withdrawn from the ISP studies. The new study reported here is based upon ISP 5581 = ATCC 11062. ISP description by Group F-4.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 38) with long, straight to slightly flexuous spore chains of more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 39).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs are 3ih, dark gray; 2fe, medium gray; 3fe, light brownish gray; 5fe, light grayish reddish brown; and 2dc yellowish gray.

Reverse side of colony: No distinctive pigments (grayish yellow to yellowish brown or olive brown on yeast-malt agar; pale to grayish yellow or light grayish yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction is weak in tyrosine agar. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, and

D-fructose are utilized for growth. Reports vary on utilization of L-arabinose; utilization of D-mannitol, rhamnose, and raffinose is doubtful, and no significant growth is seen with *D*-inositol or sucrose.

Streptomyces bluensis Mason, Dietz, and Hanka. Description: Mason et al. (122). Type strain: Upjohn U-12898 (122) = NRRL 2876 (A. Dietz, Upjohn Co., personal communication, June 1968). ISP 5564 from T. G. Pridham, NRRL, as NRRL 2876. ISP description by Group F-2.

Spore-chain morphology: Section *Spirales*. Spirals may be poorly developed on some media and open loops, imperfect spirals or flexuous spore chains may be common (Fig. 40). Observers do not agree on the best medium for spiral formation. Some spirals are reported by different observers on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore chains are short to long, usually with more than 10 spores per chain. Spore surface: Spiny (Fig. 41).

Color of colony: Aerial mass color in the Blue or White color series on yeast-malt agar; White color series on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tab in the Blue color series is 19dc, pale blue.

Reverse side of colony: No distinctive pigments (light grayish yellow to pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *D*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces caeruleus (Baldacci) Pridham, Hesseltine, and Benedict. Description: *Actinomyces caeruleus* Baldacci 1944, 180-184 (9); *Streptomyces caeruleus* (Baldacci) Pridham et al. 1958, 60 (148). See also *Streptomyces caeruleus* (Baldacci) Waksman (sic) 1961, 184 (206). Type strain: IPV 930 (E. Baldacci, personal communication, November 1963). ISP 5103 from E. Baldacci as IPV 930. ISP description by Group A-7.

Spore-chain morphology: Section *Rectiflexibiles*. Two observers report poor growth or no sporulating aerial mycelium on yeast-malt agar and oatmeal agar. Mature spore chains with more than 10 spores per chain are usually produced on salts-starch agar, glycerol-asparagine agar,

and the medium of Hickey and Tresner (71). The composition of the medium of Hickey and Tresner is as follows: 1% Amidex (dextrin; Corn Products Refining Co., Cincinnati, Ohio), 0.2% N-Z Amine A (enzymatic hydrolysate of casein; Sheffield Chemical, Union, N.J.), 0.1% Difco beef extract, 0.1% Difco yeast extract, 2 mg% $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 2% agar; sterilize at 121 C; dry agar surface before inoculation. Spore surface: Typical spores not observed; atypical spores (Fig. 42) are smooth.

Special morphological characteristics: One observer reports fragmentation of substrate mycelium on Hickey and Tresner agar in 14 days.

Color of colony: Aerial mass color in the Gray color series on salts-starch agar, glycerol-asparagine agar, and Hickey and Tresner agar. One observer also records gray aerial mycelium on yeast-malt agar and oatmeal agar, but sporulating growth on these media may be inadequate for color determination.

Reverse side of colony: A distinct blackish blue to very dark grayish purple pigment is produced on salts-starch agar, glycerol-asparagine agar, and Hickey and Tresner agar. A dark blue violet to blackish pigment may also be seen in yeast-malt agar or glycerol-asparagine agar when adequate growth occurs. Reverse mycelium pigment is a pH indicator, changing from dark violet or blue to deep green with the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments probably are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth; observation may be obscured by dark violet or blue pigments. Brown violet, blue, or blue black pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar, and Hickey and Tresner agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl, or it may be somewhat sensitive to 0.05 N NaOH, changing from violet to very deep green.

Carbon utilization: Growth is generally very poor or absent on Pridham and Gottlieb carbon-utilization medium containing D-glucose or other carbon sources. Carbon utilization cannot be determined accurately on this medium. (One observer notes that traces of growth on sucrose and rhamnose are probably equal to growth on D-glucose, but this observation is of doubtful significance.)

Streptomyces caesi (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. Descriptions: *Actinomyces caesi* Krasil'nikov et al. (104, p. 107); *Streptomyces caesi* (Krasil'nikov et al.) Pridham 1970, 10 (147). Type strain: INMI 118 (147; and N. A. Krasil'nikov, personal communication, December 1966). ISP

FIG. 33. *S. bacillaris*. RF spore chains on glycerol-asparagine agar, 14 days. $\times 970$.

FIG. 34. *S. bacillaris*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 35. *S. bambergiensis*. Irregular primitive spirals on salts-starch agar, 21 days. Scanning electron micrograph $\times 2,500$.

FIG. 36. *S. bambergiensis*. Flexuous chains, hooks, and primitive open spirals on salts-starch agar, 14 days. $\times 970$.

FIG. 37. *S. bambergiensis*. Hairy spores. (a) Electron micrograph from 14-day-old culture; (b) scanning electron micrograph from 21-day-old culture on salts-starch agar.

FIG. 38. *S. bikiniensis*. Long RF spore chains on oatmeal agar, 21 days. $\times 500$.

FIG. 39. *S. bikiniensis*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 40. *S. bluensis*. Irregular spirals and hooks on glycerol-asparagine agar, 14 days. $\times 812$.

FIG. 41. *S. bluensis*. Spiny spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 42. *S. caeruleus*. Atypical spores found on Hickey and Tresner agar, 14 days.

5419 from N. A. Krasil'nikov as INMI 118. ISP description by Group D-8.

Spore-chain morphology: Section *Spirales*; open spirals (Fig. 43) and strongly flexuous chains are common. Spirals are best developed on salts-starch agar. Mature spore chains are moderately long, with 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 44).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray; 3fe, light brownish gray; 3ge, light grayish brown; or 5fe, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Usually purplish pink or grayish reddish pink to dark grayish purple or purplish black on yeast-malt agar, oatmeal agar, and salts-starch agar; pale yellow to yellowish brown or reddish brown or dark purplish gray on glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from reddish violet to blue with the addition of 0.05 N NaOH and from violet to pink with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Red to blue violet pigment (depending on pH) may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes noted for the reverse mycelium pigments.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, and sucrose are utilized for growth. Reports vary on utilization of raffinose.

Streptomyces caespitosus Sugawara and Hata. Description: Sugawara and Hata (180). Type strain: NRRL 2564 (T. G. Pridham, NRRL, personal communication, April 1969). ISP 5603 from T. G. Pridham, NRRL, as NRRL 2564. ISP description by Group F-6.

Spore-chain morphology: Section *Umbellate Monoverticillate* (= *Streptomyces* Section *Verticillati*, biverticillate) (Fig. 45); unbranched whorls and flexuous spore chains not in verticils are also reported. Mature spore chains are generally short, with 3 to 10 or more spores per chain. This morphology is seen on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Flexuous (usually sterile) aerial hyphae are seen on yeast-malt agar. Spore surface: Smooth (Fig. 46).

Color of colony: Aerial mass color in the Yellow

or Green color series when adequate aerial mycelium is produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Nearest matching color tabs in the Yellow color series are 1cb and 1½ec, pale yellow green; and 1ba and 2ba, pale yellow; nearest matching color tabs in the Green color series are 1½ge and 1½ig, light grayish olive.

Reverse side of colony: No distinctive pigments (light olive to strong brown on yeast-malt agar; pale grayish yellow to yellow on oatmeal agar and glycerol-asparagine agar; light olive to orange on salts-starch agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but are weak or absent in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, or glycerol-asparagine agar. Only one of three observers reports green soluble pigment in salts-starch agar; this pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, *i*-inositol, and D-fructose are utilized for growth. Utilization of L-arabinose, D-xylose, sucrose, and D-mannitol is doubtful. No growth or only a trace of growth with rhamnose or raffinose.

Streptomyces canarius Vavra and Dietz. Description: Vavra and Dietz (200). Type strain: UC 2591 = NRRL 2976 (A. Dietz, Upjohn Co., personal communication, January 1968). ISP 5528 from T. G. Pridham, NRRL, as NRRL 2976 = UC 2591. ISP description by Group E-4.

Spore-chain morphology: Section *Spirales* (Fig. 47); straight to flexuous chains are also seen. Mature spore chains are moderately long, with more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 48).

Color of colony: Aerial mass color in the White to Gray color series (b, white, to 2ge, light olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar when adequate sporulating aerial mycelium is produced. Aerial mycelium may be inadequate for color determination on some of these media.

Reverse side of colony: Distinctive greenish yellow to moderate yellow, orange yellow or strong yellowish brown on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow to yellow green

pigment may be found in the medium in oatmeal agar and glycerol-asparagine agar. This pigment is not pH sensitive.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are utilized for growth.

Streptomyces capoamus Gonçalves de Lima, Albert, and Gonçalves de Lima. Description: Gonçalves de Lima et al. (58). Type strain: IAUR 4670-IA-37 (58) = ATCC 19006 = AIC 3122 (V. Gonçalves de Lima, personal communication, May 1969). ISP 5494 from E. F. Lessel, ATCC, as ATCC 19006. ISP description by Group E-3.

Spore-chain morphology: Section *Retinaculiperti* (Fig. 49). Terminal spirals, loops, and hooks may be found on moderately long chains of 10 to 50 spores. Straight to flexuous chains are also common. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar but not on glycerol-asparagine agar. Spore surface: Smooth (Fig. 50).

Color of colony: Aerial mass color in the Gray or Red color series on yeast-malt agar and salts-starch agar; Red color series on oatmeal agar. Aerial mycelium is poorly developed or absent on glycerol-asparagine agar. Nearest matching color tabs from the Gray color series are e, medium gray, and 5 fe, light grayish reddish brown. Nearest matching tabs from the Red color series are 6 ec, grayish yellowish pink, and 7ca, light yellowish pink.

Reverse side of colony: Red; light reddish brown to grayish yellowish pink on yeast-malt agar, oatmeal agar, and salts-starch agar. Reverse mycelium pigment is a pH indicator, changing from red or reddish brown to blue or violet with the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction may be weak in tyrosine agar. Yellow, red, or orange may or may not be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. One of three observers reports a pH-sensitive pigment showing essentially the same reactions noted for the reverse mycelium pigments in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth. Utilization of raffinose is doubtful. No growth or only trace of growth with *i*-inositol, rhamnose, or sucrose.

Streptomyces chrestomyceticus Canevazzi and Scotti. Description: Canevazzi and Scotti (29).

Type strain: The original strain is no longer available from the authors or Farmitalia (G. Canevazzi and T. Scotti, Farmitalia, Milan, personal communication, March 1965). IMRU 3835 was deposited in 1960 as *S. krestomyceticus* (sic) by A. Di Marco, Farmitalia, Milan (R. E. Gordon, personal communication, March 1968). It is believed to be the type strain. ISP 5545 from R. E. Gordon, IMRU, as IMRU 3835. ISP description by Group E-5.

Spore-chain morphology: Section *Spirales* (Fig. 51a). Spirals are often irregular and may become entangled as shown in Fig. 51b. Mature spore chains generally are long with 10 to 50 or often more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 52).

Special morphological characteristics: Moist droplets (hygroscopic droplets) are sometimes found on oatmeal agar (Fig. 53). One observer describes these as similar to sporangia of *Actinosporangium*. Coremia may also be formed on salts-starch agar or glycerol-asparagine agar.

Color of colony: Aerial mass color in the Yellow or White color series on yeast-malt agar and glycerol-asparagine agar; White color series on salts-starch agar; Green or White color series on oatmeal agar. Nearest matching color tabs in the Yellow color series are 1/2ec to 1dc, pale yellow green; 2ba, pale yellow; and 2fb, light yellow. Nearest matching color tab in the Green color series is 1 1/2ge, light grayish olive.

Reverse side of colony: No distinctive pigments (colorless to pale yellow or light yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, tryptone-yeast broth or Gauze Medium No. 2. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-mannitol, and D-fructose are utilized for growth. Utilization of sucrose, D-xylose, *i*-inositol, and raffinose is doubtful. No growth or only trace of growth with rhamnose.

Note: The ISP description of this strain differs from the original description (29) with respect to spiral spore chains versus very short RF chains, Yellow or Green aerial mycelium versus White, and in growth on L-arabinose.

Streptomyces chromogenus sp. Isono, Suzuki, Sawazaki, Nakamura, Kawasaki, Yamashita, Anzai, Serizawa, and Sekiyama. Description: Isono et al. (81). Type strain: IA-887 (Akio

FIG. 43. *S. caesius*. Spiral spore chains on corn meal-salts agar, 7 days. $\times 500$.

FIG. 44. *S. caesius*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 45. *S. caespitosus*. Verticillate sporophores on salts-starch agar, 9 days. $\times 440$.

FIG. 46. *S. caespitosus*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 47. *S. canarius*. Spiral spore chains on oatmeal agar, 20 days. $\times 600$.

FIG. 48. *S. canarius*. Smooth spores; electron micrograph from 10-day-old culture on salts-starch agar.

FIG. 49. *S. capoamus*. RA morphology with terminal coils and loops on yeast-malt agar, 14 days. $\times 590$.

FIG. 50. *S. capoamus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

Seino, personal communication, July 1966). Note: This is not the *Actinomyces chromogenus* or *A. Chromogenes* (sic) of either Gasperini (54) or Krainsky (99). Isono et al. probably intended the designation *Streptomyces chromogenus* sp. (sic) to indicate that strain IA-887 was a chromogenic (melanin-producing) strain of the genus *Streptomyces* (Akio Seino, personal communication, July 1966). See also Index Bergeyana (28, p. 1099). ISP 5384 from Akio Seino as IA-887. ISP description by Group D-4.

Spore-chain morphology: Section *Spirales* or *Rectiflexibiles*: open spirals are found on oatmeal agar (Fig. 54). ISP observers found only RF spore chains on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar. Mature spore chains are generally long, often with more than 50 spores per chain. Spore surface: Smooth; spores with phalangeic shape are common (Fig. 55).

Color of colony: Aerial mass color in the Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Grayish yellow to yellow brown usually becoming orange yellow to strong brown on oatmeal agar and dark brown or very dark brown on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar in 14 to 21 days.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. Pigments (other than melanoids) may be absent from the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, or traces of red pigment may be seen in the medium in yeast-malt agar and salts-starch agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-fructose, and raffinose are utilized for growth. No growth or only trace of growth with D-mannitol, rhamnose, or sucrose.

Streptomyces chryseus (Krasil'nikov, Korenyako, and Nikitina) Pridham. Descriptions: *Actinomyces chryseus* Krasil'nikov et al. 1965 (103; p. 221-224; 227-228); *Streptomyces chryseus* (Krasil'nikov et al.) Pridham 1970, 10 (147). Type strain: 1007B (147). ISP 5420 from N. A. Krasil'nikov as 1007B. ISP description by Group D-8.

Spore-chain morphology: Section *Spirales* on oatmeal agar or salts-starch agar (Fig. 56), but flexuous spore chains suggesting RF morphology may be common on these media and are the predominant morphology on glycerol-asparagine

agar. Sporulating aerial mycelium is poorly developed or absent on yeast-malt agar. Mature spore chains are moderately long, with 10 to 50 or more spores per chain. Spore surface: Smooth (Fig. 57).

Color of colony: Aerial mass color in the Red color series (5ca, light yellowish pink, or 3ca, pale orange yellow) on oatmeal agar, salts-starch agar, and glycerol-asparagine agar in 14 to 21 days. White aerial mycelium may also be seen on these media.

Reverse side of colony: Pale yellow to light yellowish brown or orange yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, and D-fructose are utilized for growth. Reports vary on utilization of D-xylose and *i*-inositol. No growth or only a trace of growth with D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces cirratus Koshiyama, Okanishi, Ohmori, Miyaki, Tsukiura, Matzuzaki, and Kawaguchi. Description: Koshiyama et al. (97). Type strain: Bristol-Banyu Res. Inst. 12090 (97) = ATCC 14699 (E. F. Lessel, 1968). ISP 5479 from E. F. Lessel as ATCC 14699. ISP description by Group E-2.

Spore-chain morphology: Section *Retinaculiperti*. Spore chains often with terminal loops, primitive spirals, or sometimes well-defined coils of several turns (Fig. 58). Mature spore chains are generally long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 59).

Special morphological characteristics: Knots and moist, nestlike tangles may be seen in long aerial hyphae (Fig. 60), or moist droplets may form around terminal coils.

Color of colony: Aerial mass color usually in the Red color series (5dc or 5cb, grayish yellowish pink, or 5ge, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; aerial mycelium sometimes is in the Gray color series (5fe, light grayish reddish brown) on these media.

Reverse side of colony: No distinctive pigments (grayish yellow to light yellowish brown on yeast-malt agar; nearly colorless, pale gray-

FIG. 51. *S. chrestomyceticus*. (a) Spiral spore chains on yeast-malt agar, 14 days. $\times 200$. (b) Irregular spirals and knots on yeast-malt agar, 21 days. $\times 600$.

FIG. 52. *S. chrestomyceticus*. Smooth spores. (a) Electron micrograph from 10-day-old culture on salts-starch agar. (b) Scanning electron micrograph of 21-day-old culture on yeast-malt agar. (c) Carbon repligraph of same preparation.

FIG. 53. *S. chrestomyceticus*. Moist (hygroscopic) droplets on aerial mycelium on oatmeal agar, 14 days. $\times 200$.

FIG. 54. *S. chromogenus*. Spiral spore chains on oatmeal agar, 21 days. $\times 800$. Note that straight and flexuous chains are also present. Spirals were not seen on yeast-malt agar, salts-starch agar, or glycerol-asparagine agar.

FIG. 55. *S. chromogenus*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 56. *S. chryseus*. Open spirals on oatmeal agar, 7 days. $\times 525$.

FIG. 57. *S. chryseus*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

ish yellow or light olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are usually formed in peptone-yeast-iron agar and tryptone-yeast broth but are formed weakly or not at all in tyrosine agar. Yellow pigment is usually found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, and D-fructose are utilized for growth. No growth or only a trace of growth with *i*-inositol, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces coelestis (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. Descriptions: *Actinomyces coelestis* Krasil'nikov et al. 1965 in Krasil'nikov (104, p. 110); *Streptomyces coelestis* (Krasil'nikov et al.) Pridham 1970, 10 (147). Type strain: INMI 20-41 (147; Krasil'nikov, personal communication, December 1966). ISP 5421 from N. A. Krasil'nikov as INMI 21-41. ISP description by Group D-8.

Spore-chain morphology: Section *Spirales*; spirals are best developed on salts-starch agar (Fig. 61) or oatmeal agar. Flexuous chains and imperfect spirals suggesting RA morphology are also common on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Mature spore chains are moderately long with 10 to 50 spores per chain. Spore surface: Smooth (Fig. 62).

Color of colony: Aerial mass color in the Gray color series (3fe, light brownish gray; 2dc, yellowish gray; or 3ge, light grayish yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Dark grayish purple or blackish purple on salts-starch agar and glycerol-asparagine agar; grayish brown to dark brown or reddish black on yeast-malt agar and oatmeal agar. Reverse mycelium pigment is a pH indicator, changing from reddish violet to bluish violet or blue with the addition of 0.05 N NaOH and from bluish violet to reddish violet, brown, or red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Red, violet, or blue pigment, depending on pH, may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but pigment is not always found in these media. This pigment is pH sensitive, showing essentially the same changes noted for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose,

D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of sucrose or raffinose is doubtful.

Streptomyces colombiensis Pridham, Hessel-tine, and Benedict. Descriptions: British Pat. 18236, 1949; mentioned as new species, without description (nom. nud.) in Wood, Hill and Hendlin (215). Pridham et al. (148, p. 76). Type strain: Merck, Sharp & Dohme MA-52 (H. Woodruff, Merck, Sharp & Dohme, personal communication, May 1968) = NRRL B-1990 = ETH 24432 (R. Hütter [80, p. 141, 161]). ISP 5558 from H. B. Woodruff (Merck, Sharpe & Dohme) as MA-52. ISP description by Group F-1.

Spore-chain morphology: Section *Spirales* (Fig. 63). Flexuous spore chains and open loops resembling RA morphology are also present. Mature spore chains are generally long, with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 64, 65, 66).

Color of colony: Aerial mass color in the Red color series (5dc, 5ec, 5cb, 6ec, grayish yellowish pink; or 5ge, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Moderate reddish orange to strong brown on yeast-malt agar; grayish yellow, orange yellow, or yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in tyrosine agar; reports vary on production of melanoid pigments in peptone-yeast-iron agar and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and D-fructose are utilized for growth. No growth or only trace of growth with L-arabinose, D-xylose, *i*-inositol, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces coriofaciens (Schmidt-Thomé, Steigler, Fries, and Weidenmüller. W. German Pat. Appl. 1,128,083, April 19, 1962). Description: Schmidt-Thomé et al. (165). Type strain: ATCC 14155 (165). ISP 5485 from E. F. Lessel, ATCC, as ATCC 14155. ISP description by Group E-2.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 67). Flexuous spore chains generally with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 68).

FIG. 58. *S. cirratus*. RA morphology. (a) Terminal loops and primitive spirals on oatmeal agar, 14 days. $\times 500$. (b) Spirals on glycerol-asparagine agar, 7 days. $\times 300$.

FIG. 59. *S. cirratus*. Smooth spores from 14-day-old culture on oatmeal agar.

FIG. 60. *S. cirratus*. Knots and moist nestlike tangles in aerial hyphae on salts-starch agar, 14 days. $\times 500$.

FIG. 61. *S. coelestis*. Spiral spore chains on salts-starch agar, 7 days. $\times 500$.

FIG. 62. *S. coelestis*. Smooth spores from 14-day-old culture on yeast-malt agar.

FIG. 63. *S. colombiensis*. Spiral spore chains. (a) Oatmeal agar, 14 days; (b) Salts-starch agar, 14 days. $\times 600$.

FIG. 64. *S. colombiensis*. Smooth spores. Transmission electron micrograph from 21-day-old culture on salts-starch agar.

FIG. 65. *S. colombiensis*. Smooth spores. Scanning electron micrograph of sporulating aerial mycelium on oatmeal agar.

FIG. 66. *S. colombiensis*. Detail of same preparation as Fig. 65. Stereoscan microscope.

Color of colony: Aerial mass color in the Yellow color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs are 1½db, pale greenish yellow; 1cb, pale yellowish green; and 1ba, 2ba and 2db, pale yellow.

Reverse side of colony: Olive brown to strong brown on yeast-malt agar; yellow on oatmeal and glycerol-asparagine agar; olive brown on salts-starch agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth, but growth on D-fructose is less than on the other carbon sources supporting growth. No growth or only trace of growth with *i*-inositol, rhamnose, sucrose, or raffinose.

Actinomyces cretaceus (Krüger) Krasil'nikov 1941. Descriptions: *Oospora cretacea* Krüger 1890 (not seen, cited in reference 80); *Actinomyces cretaceus* (Krüger) Krasil'nikov 1941, 35 (100, p. 39). See also: *Actinomyces albus* var. *cretaceus* (Krüger) Wollenweber 1920 (214). Type strain: CBS strain Wollenweber = CBS 137.21 = ETH 13488 (G. A. deVries, personal communication, May 1968). ISP 5561 from G. A. de Vries, CBS, as CBS 137.21. ISP description by Group F-2.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 69). Mature spore chains generally contain 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 70).

Color of colony: Aerial mass color in the Yellow color series (2ba, pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; white aerial mycelium may also be seen on these media.

Reverse side of colony: No distinctive pigments (pale or grayish yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only trace of growth

is seen with L-arabinose, *i*-inositol, sucrose, or raffinose.

Streptomyces cyaneogriseus (Yen) Pridham. Descriptions: *Actinomyces cyaneogriseus* Yen 1956, 75-78 (219); *Streptomyces cyaneogriseus* (Yen) Pridham 1970, 35 (147). Type strain: Not designated by author; CBS 113.60 = Gauze 390 is probably the type strain. ISP 5534 was received from G. A. deVries, CBS, as CBS 113.60; CBS received the strain in 1960 from G. F. Gauze as *A. cyaneogriseus* No. 390. The author for literature citation was not given when the strain was deposited with CBS (G. A. deVries, personal communication, January 1968). ISP description by Group E-5.

Spore-chain morphology: Section *Spirales*. Mature spore chains are often moderately short, with 3 to 10 or more spores per chain. Incomplete spirals (hooks) and spirals of only one to three turns are found at the ends of the short sporophores (Fig. 71 and 72). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. One of three observers reports monovericillate sporophores on these media, but photographs submitted by the three observers do not show verticils. Spore surface: Smooth (Fig. 72).

Special morphological characteristics: One observer reports the formation of moist droplets or subglobose bodies on the aerial mycelium (Fig. 73).

Color of colony: Aerial mass color usually in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; but one of three observers reports aerial mass color in the Green color series (1½ge, light grayish olive) on oatmeal agar and glycerol-asparagine agar, and one observer records both Gray and Red color series (6ec, grayish yellowish pink) for aerial mass color on salts-starch agar.

Reverse side of colony: Blue, dark grayish reddish purple or grayish reddish brown (depending on pH) on yeast-malt agar, oatmeal agar, and salts-starch agar; colorless to pale yellow on glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from grayish pink or red to violet or blue with the addition of 0.05 N NaOH or from violet or blue to grayish pink or red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, tryptone-yeast broth, and Gauze Medium No. 2. Pink to violet or blue pigment is found in the medium in yeast-malt agar and salts-starch agar, but is usually not present in oatmeal agar or glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes found in the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, and rhamnose are utilized for growth. Reports vary on the utilization of sucrose. No growth or only trace of growth with *i*-inositol, D-mannitol, and raffinose.

Streptomyces cyaneus (Krasil'nikov) Waksman. Description: *Actinomyces cyaneus* Krasil'nikov 1941 (100); *Streptomyces cyaneus* (Krasil'nikov) Waksman 1953, 42 (204). Type strain: The original Krasil'nikov strain is not extant; Waksman (206) designated strain IMRU 3761, the Todorovic strain obtained from Kutzner, as the "type strain," and this strain, Kutzner H-112 = IMRU 3761 = SC 3333, is proposed as the neotype strain by Trejo and Bennett (187). ISP 5108 from W. Trejo, Squibb Institute for Medical Research as SC 3333 = IMRU 3761 = Kutzner H-112. ISP description by Group E-1.

Spore-chain morphology: Section *Spirales*. Compact spirals of 2 to 6 turns are common (Fig. 74), but open spirals, imperfect spirals, or flexuous spore chains may also be found. Mature spore chains are moderately long, with 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 75).

Color of colony: Aerial mass color in the Blue or Gray color series on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; and Gray color series on oatmeal agar. Aerial mycelium may be poorly developed and atypical on glycerol-asparagine agar. The most representative color tabs from the Blue color series are 1fe or dc, pale blue, and the most representative color from the Gray color series is tab e, medium gray.

Reverse side of colony: Dark grayish blue to dark grayish purple on yeast-malt agar, oatmeal agar, and salts-starch agar; this pigmentation sometimes fails to develop on glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from violet or purple to blue with the addition of 0.05 N NaOH and from blue to violet or purple with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. Blue or violet pigment is found in the medium in yeast-malt agar, oatmeal agar, and salts-starch agar; it is often not formed in glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes noted for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose,

rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces diastaticus (Krainsky) Waksman and Henrici. Description: *Actinomyces diastaticus* Krainsky 1914, 680-682 (99); Waksman and Curtis 1916, 116-117, 127 (207); Waksman 1919, 110-112 (203). *Streptomyces diastaticus* (Krainsky) Waksman and Henrici 1948, 939 (208). Type strain: not extant. IMRU 3315 = ATCC 3315 (Waksman strain) is included in this study as a potential neotype, but its suitability as a neotype in terms of Krainsky's original description (op. cit.) or Waksman's herbarium specimens is in question Hütter, p. 179, 231 [80]; Pridham, Lyons, and Seckinger [150]. ISP 5496 from E. F. Lessel, ATCC, as ATCC 3315. ISP description by Group E-3.

Spore-chain morphology: Section *Rectiflexibiles* to *Spirales*. Good spirals are not formed on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but highly flexuous or crooked spore chains, some of which suggest irregular spirals, are common on these media (Fig. 76). Hooks, loops, or irregular spirals are of small diameter and are therefore not representative of true RA morphology. Spore chains are often short, with 3 to 10 spores per chain, but longer chains are found. Spore surface: Smooth (Fig. 77).

Color of colony: Sporulating aerial mycelium is often poorly developed on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar so that aerial mass color is difficult to determine. When sporulating aerial mycelium is formed on these media, it may be in the Gray color series (2dc, yellowish gray), or the aerial color may appear to be in the Yellow color series (2ba, pale yellow; 1cb, pale yellowish green).

Reverse side of colony: No distinctive pigments (grayish yellow or pale yellowish green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, sucrose, and D-mannitol are utilized for growth. No growth or only trace of growth with *i*-inositol, rhamnose, and raffinose.

Streptomyces diastatochromogenes (Krainsky) Waksman and Henrici. Descriptions: *Actinomyces diastatochromogenes* Krainsky, 1914 (99); *Actinomyces diastatochromogenus* (sic) Krainsky, in Waksman and Curtis (207; p. 113, 127)

FIG. 67. *S. coriofaciens*. Flexuous spore chains on salts-starch agar, 14 days. $\times 500$.

FIG. 68. *S. coriofaciens*. Smooth spores; electron micrograph from 14-day-old culture on glycerol-asparagine agar.

FIG. 69. *A. cretaceus*. RF spore chains on glycerol-asparagine agar, 14 days. $\times 812$.

FIG. 70. *A. cretaceus*. Smooth spore chains; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 71. *S. cyaneogriseus*. Spirals of one or two turns on short spore chains, salts-starch agar, 20 days. $\times 600$.

FIG. 72. *S. cyaneogriseus*. Smooth spores in spiral chains. (a) Transmission electron micrograph from 10-day-old culture on salts-starch agar. (b) Scanning electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 73. *S. cyaneogriseus*. Moist globular droplets on aerial mycelium on oatmeal agar, 14 days. $\times 200$.

FIG. 74. *S. cyaneus*. Spiral spore chains on oatmeal agar, 14 days. $\times 960$.

FIG. 75. *S. cyaneus*. Spiny spores; electron micrograph from 21-day-old culture on salts-starch agar.

[new isolates, not Krainsky's strain]; *Streptomyces diastatochromogenes* (Krainsky) Waksman and Henrici 1948, 941 (208). See also: Hütter (80, p. 278–281). Type strain: Waksman (206) and Hütter (80) have suggested ATCC 12309 as the neotype. ATCC received the strain from T. Hasegawa, Institute for Fermentation, Osaka, in September 1955 as IFO 3337. ISP 5449 from E. F. Lessel, ATCC, as ATCC 12309 = IFO 3337 = 207. ISP description by Group E-5.

Spore-chain morphology: Section *Spirales* (or *Retinaculiaperti*). Spirals are open with 4 to 6 turns (Fig. 78), and strongly flexuous to straight spore chains are also common. Mature spore chains are moderately long, with 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar, but aerial mycelium may be poorly developed or absent on glycerol-asparagine agar. Spore surface: Smooth (Fig. 79).

Color of colony: Aerial mass color usually in the Gray color series on yeast-malt agar, oatmeal agar, and salts-starch agar; aerial mycelium may be absent on glycerol-asparagine agar, or white aerial mycelium may sometimes be found on this medium, oatmeal agar, and salts-starch agar.

Reverse side of colony: No distinctive pigments (light brown or olive brown on yeast-malt agar; pale yellow or grayish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, tryptone-yeast broth, and Gauze Medium No. 2. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces durhamensis Gordon and Lapa. Description: Gordon and Lapa (59). Type strain: Gordon and Lapa strain 59123 = ATCC 23194 (M. A. Gordon, personal communication, March 1968). ISP 5539 from M. A. Gordon as 59123 = ATCC 23194. ISP description by Group E-6.

Spore-chain morphology: Section *Spirales* (Fig. 80). Mature spore chains generally contain 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny, but smooth spores may also be seen.

Color of colony: Aerial mass color in the Gray or Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs in the Gray color series are 3ge, light grayish yellowish brown;

3fe, light brownish gray; and 2dc, yellowish gray. Nearest tab in the Red color series is 5dc, grayish yellowish pink.

Reverse side of colony: No distinctive pigments (pale or grayish yellow to yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, sucrose, and raffinose are all utilized for growth. No growth or only a trace of growth with rhamnose.

Streptomyces erythraeus (sic) (Waksman) Waksman and Henrici. Descriptions: *Actinomyces* 161, Waksman 1919, 112 (203); *Actinomyces erythreus* (sic) Waksman, in Bergey et al. (22, p. 370); *Streptomyces erythreus* (sic) (Waksman) Waksman and Henrici 1948, 938 (208); *Streptomyces erythraeus* (sic) (according to Waksman [205, p. 766]). Type strain: Waksman (206, p. 204) gives both IMRU 3737 and ATCC 11635 as strain numbers for the type strain of *S. erythraeus*. Both strains were studied by ISP collaborators. Strain ATCC 11635 is presented here as a suggested neotype since IMRU 3737 differed from Waksman's original description in several important characteristics. ISP 5517 from C. E. Higgins, Eli Lilly & Co., as Lilly and Co. M5-12559 = ATCC 11635. ISP description by Group E-4.

Spore-chain morphology: Section *Spirales* or *Retinaculiaperti*. Spore chains are usually short so that imperfect spirals, hooks, or loops of only one turn (Fig. 81), and short, straight to flexuous chains are common. Hooks and loops are usually of small diameter and are not representative of true RA morphology. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but aerial mycelium may be poorly developed on glycerol-asparagine agar. Spore surface: Spiny (Fig. 82).

Color of colony: Aerial mass color in the Red color series (4ec, 5cb, 5dc, grayish yellowish pink; or 3ca, pale orange yellow) on yeast malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. White aerial mycelium may also be seen.

Reverse side of colony: Brown to grayish reddish brown on yeast-malt agar; orange yellow to light yellowish brown or grayish yellow on oatmeal agar and salts-starch agar; yellowish brown to strong brown on glycerol-asparagine agar. Reverse mycelium pigment is usually not a pH indicator, but, when pink pigment is present, it may

be changed to pale yellow with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Pink or yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but pigment is not always present in these media. Pink pigment, when present, becomes colorless with the addition of either 0.05 N HCl or NaOH.

Carbon utilization: D-Glucose, D-fructose, sucrose, raffinose, and D-mannitol are utilized for growth. Reports vary on the utilization of L-arabinose, D-xylose, *i*-inositol, and rhamnose. Significant growth is often observed on control plates of carbon-utilization medium without added carbon source.

Streptomyces erythrogriseus Falcão de Moraes and Dália Maia. Description: Falcão de Moraes and Dália Maia (48). Type strain: The original description (48) is based on two isolates designated 1172 and 1173. ISP 5116 from Falcão de Moraes as 1173. ISP description by Group E-2.

Spore-chain morphology: Section *Spirales* (Fig. 83a), but short spore chains may form imperfect or incomplete spirals or crooked hooks or loops (Fig. 83b). Spirals are most numerous on salts-starch agar after 14 days and are rare on yeast-malt agar and glycerol-asparagine agar. Mature spore chains are generally short, with 3 to 10 or more spores per chain, but long chains with more than 50 spores are also reported. Spore surface: Spiny with short spines (Fig. 84a,b). Smooth spores are also found (Fig. 84c).

Color of colony: Aerial mass color usually in the Gray color series on yeast-malt agar and salts-starch agar; Gray, Red, or White color series on glycerol-asparagine agar. Aerial mycelium suitable for color determination is usually not formed on oatmeal agar, but when present it is in the Gray color series. Nearest matching color tabs in the Gray color series are d, light gray, and 5fe, light grayish reddish brown. Nearest matching tabs in the Red color series are 5ge, light grayish reddish brown, and 5dc, light yellowish pink.

Reverse side of colony: Strong brown on yeast-malt agar; orange yellow to yellowish brown on oatmeal agar and salts-starch agar; reddish orange to reddish brown on glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from yellow to orange with the addition of 0.05 N NaOH and from yellow brown to yellow with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow to orange pigment is sometimes found in the medium in yeast-malt

agar, oatmeal agar, and glycerol-asparagine agar. When this pigment is present, it is pH sensitive, showing the same changes observed in the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth with sucrose and raffinose.

Streptovercillium eurocidicum (Okami, Utahara, Nakamura, and Umezawa) Locci, Baldacci, and Petrolini Baldan. Descriptions: *Streptomyces eurocidicus* Okami, Utahara, Nakamura, and Umezawa 1954, 98–103 (139). *Streptovercillium eurocidicum* (Okami, Utahara, Nakamura, and Umezawa) Locci, Baldacci, and Petrolini Baldan 1969, 36 (116). Type strain: The original description of Okami et al. (op. cit.) includes three strains: 523-A1, 523-G1, and 549-A1. Strain 549-A1 = NIHJ 267 has been selected by Okami for deposition with NRRL as the type strain. (549-A1 = NIHJ 267 = NRRL B-1676, T. G. Pridham, NRRL, personal communication, April 1969; NIHJ 267 = IPV 1996 = KCC-S 0029, Locci, Baldacci, and Petrolini Baldan, 1969, op. cit.). ISP 5604 from T. G. Pridham, NRRL, as NRRL B-1676. ISP description by Group F-6.

Spore-chain morphology: Section *Umbellate Monoverticillate* (= *Streptomyces* Section *Verticillati* biverticillate) (Fig. 85). Mature spore chains contain 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 86).

Color of colony: Aerial mass color in the Yellow color series (1ba or 2ba, pale yellow; 1½db, pale greenish yellow; 1db, pale yellow green; 1½fb, light yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (olive brown to reddish brown on yeast-malt agar; pale grayish yellow to yellowish brown or olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *i*-inositol, and D-fructose are utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, D-mannitol, rhamnose, sucrose, and raffinose.

Streptovercillium fervens (DeBoer, Dietz, Evans, and Michaels) Locci, Baldacci, and Petrolini Baldan. Description: *Streptomyces fervens* DeBoer et al. 1960, 220–226 (38); *Streptovercill-*

FIG. 76. *S. diastaticus*. Flexuous and crooked spore chains, some of which suggest irregular spirals, yeast-malt agar, 14 days. $\times 480$.

FIG. 77. *S. diastaticus*. Smooth spores, electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 78. *S. diastatochromogenes*. Open spirals on salts-starch agar, 21 days. $\times 600$.

FIG. 79. *S. diastatochromogenes*. Smooth spores. Electron micrograph from 10-day-old culture on yeast-malt agar.

FIG. 80. *S. durhamensis*. Tight coils on oatmeal agar, 7 days. $\times 970$.

FIG. 81. *S. erythraeus*. Hooks, loops, and imperfect spirals on yeast-malt agar, 20 days. $\times 300$.

FIG. 82. *S. erythraeus*. Spiny spores; electron micrograph from 24-day-old culture on yeast-malt agar.

FIG. 83. *S. erythrogriseus*. $\times 500$. (a) Spirals on oatmeal agar, 14 days. (b) Short chains forming hooks and incomplete spirals on yeast-malt agar, 14 days.

FIG. 84. *S. erythrogriseus*, electron micrographs from 14-day-old culture, chromium shadowed. (a) Spiny spores from culture on oatmeal agar. (b) Warty spores from culture on yeast-malt agar. (c) Smooth spores from culture on oatmeal agar.

lium fervens (DeBoer et al.) Locci et al. 1969, 23 (116). Type strain: NRRL 2755 (38) = UC 2293 (Dietz, personal communication, August 1963) = IPV 2021 (Locci et al. [116]). ISP 5086 from C. W. Hesseltine, NRRL, as NRRL 2755. ISP description by Group A-7.

Spore-chain morphology: Section not determined. Sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Note: The original descriptions of DeBoer et al. and of Locci et al. (op. cit.) call attention to the limited sporulation; they report verticillate morphology. Spore surface: Smooth (Fig. 87).

Color of colony: The thin aerial mycelium, which generally lacks sporophores and spore chains, is in the Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Two observers report that an appropriate color tab cannot be found in the red color wheel of Tresner and Backus; one observer identifies nonsporulating aerial mycelium color as 7ca, light yellowish pink.

Reverse side of colony: Distinctive red color reported as dark red or eosin red on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is pH sensitive, changing from deep red to reddish brown with the addition of 0.05 N NaOH and from red to violet red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. No pigment other than melanoids is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and *i*-inositol are utilized for growth. A trace of growth is seen on L-arabinose, D-xylose, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose; utilization of these carbon sources is doubtful.

Chainia flava Thirumalachar 1964. See *Streptomyces flaviscleroticus* Pridham 1970.

Streptomyces flaviscleroticus Pridham (*Chainia flava* Thirumalachar). Description: *Chainia flava* Thirumalachar, in Thirumalachar and Sukapure (185). *Streptomyces flaviscleroticus* Pridham 1970, 36 (= *Chainia flava* Thirumalachar). Type strain: ISP 5270 (received from M. J. Thirumalachar as type strain, Thirumalachar, personal communication, October 1964). ISP description by Group F-1.

Spore-chain morphology: Section not determined. Aerial mycelium is poorly developed or absent on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Rare spore chains on yeast-malt agar or on glycerol-

asparagine agar are reported to be straight to flexuous. The original description by Thirumalachar (185) reports irregular spirals. Spore surface: Not determined.

Special morphological characteristics: One of three observers reports "globular sporangia" on yeast-malt agar, oatmeal agar, and salts-starch agar, and sclerotia on yeast-malt agar (Fig. 88). Fragmentation of substrate mycelium into spore-like bodies is also recorded by this observer.

Color of colony: Not determined. Aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: Olive brown to strong brown on yeast-malt agar; greenish yellow on oatmeal agar; grayish yellow, orange yellow, or moderate yellow on salts-starch agar and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of sucrose is doubtful; no growth or only trace of growth with *i*-inositol or raffinose.

Streptomyces flavochromogenes (Krainsky) Waksman and Henrici. Descriptions: *Actinomyces flavochromogenes* Krainsky 1914, 680 and 685 (99); *Streptomyces flavochromogenes* (Krainsky) Waksman and Henrici 1948, 941 (208). Type strain: None designated. IMRU 3671 is suggested as the type (neotype) strain in Waksman 1961, 209 (206). ISP 5541 from S. A. Waksman as IMRU 3671. ISP description by Group F-2.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 89). Straight to flexuous spore chains are short with 3 to 10 or more spores per chain on most media, but long chains are sometimes found. This morphology is seen on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Sporulating aerial mycelium may be thin or absent on yeast-malt agar. Spore surface: Smooth (Fig. 90).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray) on salts-starch agar and glycerol-asparagine agar; thin aerial mycelium may be white on oatmeal agar, and aerial mycelium is usually inadequate for color determination on yeast-malt agar.

Reverse side of colony: No distinctive pigments (pale yellow to greenish yellow or olive brown on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are

formed in peptone-yeast-iron agar and tryptone-yeast broth, but not in tyrosine agar. Yellow or greenish yellow pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, and rhamnose are utilized for growth. Utilization of D-fructose is doubtful, and no growth or only a trace of growth is seen with *i*-inositol, D-mannitol, sucrose, or raffinose.

Streptomyces flavofungini Uri and Békési. Descriptions: Uri and Békési (198); Uri, Sárdy, Békési (199). Type strain: SA-IX-3 (199) = CBS 411.59. ISP 5366 from G. A. deVries as CBS 411.59. ISP description by Group D-11.

Spore-chain morphology: Section *Rectiflexibiles*, but sporulation is poor or absent on most media. Absence of sporulation is also mentioned in the original description for this strain (op. cit.). ISP observers record short to long spore chains on oatmeal agar and salts-starch agar but not on yeast-malt agar or glycerol-asparagine agar. Spore chains may also be seen on carbon-utilization media (Fig. 91). Spore surface: Smooth (Fig. 92).

Color of colony: Aerial mass color in the White or Yellow color series on salts-starch agar. Nearest matching color tab in the Yellow color series is 1cb, pale yellow green.

Reverse side of colony: Yellow to greenish yellow or light olive or light olive brown on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Two of three observers report dark pigments in peptone-yeast-iron agar. No melanoid pigments are seen in tyrosine agar or tryptone-yeast broth. Yellow or pale greenish yellow pigment is sometimes found in the medium in oatmeal agar, salts-starch agar, or glycerol-asparagine agar, or pigment may be absent in these media.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and raffinose are utilized for growth. Utilization of rhamnose is doubtful. No growth or only a trace of growth with sucrose.

Streptomyces fulvissimus (Jensen) Waksman and Henrici. Descriptions: *Actinomyces fulvissimus* Jensen 1930, 66 (84); *Streptomyces fulvissimus* (Jensen) Waksman and Henrici 1948, 946 (208). Type strain: Not extant; NRRL B-1453 (= IMRU 3665 = NCIB 9609 according to personal communications from R. Gordon for S. A. Waksman and T. G. Mitchell, Aberdeen) is suggested as the neotype strain. ISP 5593 from T. G.

Pridham, NRRL, as NRRL B-1453. ISP description by Group F-5.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 93). Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar, but sporulating aerial mycelium may be poorly developed or absent on oatmeal agar. Spore surface: Smooth (Fig. 94).

Color of colony: Aerial mass color in the Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; white aerial mycelium may also be present. Nearest matching color tabs in the Red color series are 3ea, light orange yellow; 5ca and 7ca, light yellowish pink; and 4ea, moderate yellowish pink.

Reverse side of colony: Distinctive reddish orange pigments on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar or tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, *i*-inositol, D-mannitol, D-fructose, and raffinose are utilized for growth. Reports vary on the utilization of D-xylose, and the utilization of sucrose and rhamnose is doubtful.

Streptomyces fungicidicus Okami, Utahara, Nakamura, and Umezawa. Description: Okami et al. (138). Not *Actinomyces fungicidicus* Krasil'nikov. Type strain: The original description (138) is based upon "detailed examination" of three strains. Strains 560-A2 and U-10A are designated *Streptomyces fungicidicus* Group G, and 358-A6 is designated *S. fungicidicus* Group A. Y. Okami, NIHJ, selected 560-A2 = NIHJ 268 as the type strain for *S. fungicidicus* (Y. Okami, personal communication, February 1963). ISP 5020 from Y. Okami as NIHJ 265 = 560-A2. ISP description by Group B-1.

Spore-chain morphology: Section not determined. Sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Spore surface: Not determined.

Color of colony: Aerial mass color not determined. Aerial mycelium is poorly developed or absent on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; some white aerial mycelium may be produced on salts-starch agar.

Reverse side of colony: No distinctive pigments

FIG. 85. *Stv. eurocidicum*. Umbellate monoverticillate (BV) sporophores on oatmeal agar, 9 days. $\times 440$.
 FIG. 86. *Stv. eurocidicum*. Smooth spores. Electron micrograph from 14-day-old culture on oatmeal agar.
 FIG. 87. *S. fervens*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.
 FIG. 88. *S. flaviscleroticus* (*Chainia flava*). Globular bodies or sclerotia on yeast-malt agar, 14 days. (a) $\times 120$; (b) $\times 250$.
 FIG. 89. *S. flavochromogenes*. RF spore chains on soil extract agar, 14 days. $\times 812$.
 FIG. 90. *S. flavochromogenes*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.
 FIG. 91. *S. flavofungini*. RF spore chains on carbon-utilization medium, 15 days. $\times 380$.
 FIG. 92. *S. flavofungini*. Smooth spores; electron micrograph from 20-day-old culture on oatmeal agar.

(light yellow or pale grayish yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, *D*-inositol, D-mannitol, and D-fructose are utilized for growth. Reports vary on utilization of L-arabinose, rhamnose, sucrose and raffinose, but utilization of these carbon sources is doubtful.

Streptomyces galbus Okami and Umezawa. Description: Okami and Umezawa (138). Name and antibiotic production without description in Murase et al. (127). Not *S. galbus* Frommer 1959, 187-206 (51; see reference 173, p. 321). Type strain: Two strain numbers, 1616-Z3 and A61-Z5, are found in the original description by Okami and Umezawa (138). Strain 1616-Z3 is deposited by Okami with ATCC as the type strain = ATCC 14077. ISP 5480 from E. F. Lessel, ATCC, as ATCC 14077. ISP description by Group E-2.

Spore-chain morphology: Section *Spirales* (Fig. 95). Spirals are usually terminal; incomplete spirals or terminal hooks resembling RA morphology may be common. Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. The original description by Okami and Umezawa (op. cit.) describes flexuous chains and incomplete spirals, loops or hooks on other media. Spore surface: Smooth (Fig. 96).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs include 3ig, grayish yellowish brown; 3fe, light brownish gray; 3ih, dark gray; and 4li, brownish gray.

Reverse side of colony: Olive brown to dark brown on yeast-malt agar and glycerol-asparagine agar; grayish yellowish brown to olive brown on oatmeal agar and salts-starch agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction may be weak on tyrosine agar. Yellow to yellow green pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, D-xylose, *D*-inositol, D-mannitol, and D-fructose are utilized for growth. Reports vary on utilization of L-arabinose and raffinose; no growth or only a trace of growth with sucrose or rhamnose.

Streptomyces galilaeus Ettlinger, Corbaz, and Hütter. Description: Ettlinger, Corbaz, and Hütter (47). Type strain: ETH 18822 (47) = ATCC 14969 (E. F. Lessel, personal communication, September 1967). ISP 5481 from E. F. Lessel, ATCC, as ATCC 14969 = ETH 18822. ISP description by Group E-4.

Spore-chain morphology: Section *Spirales*. Open spirals (Fig. 97) with moderately long chains of 10 to 50 or more spores are found on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; shorter flexuous spore chains are usually found on yeast-malt agar. Spore surface: Smooth (Fig. 98).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs for 14- to 21-day-old cultures are 7ih, grayish pink, and 7fe, pale purple. Observers do not agree on the nearest matching color tab from the Gray color series for the aerial mass on salts-starch agar or glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (pale or grayish yellow to yellowish brown or olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Two of three observers note that the yellowish color of the reverse side of the mycelium is changed to yellowish pink or faint pink by the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. When a faint yellow pigment is found, it shows the same color changes noted for the reverse mycelium pigment when 0.05 N NaOH is added.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *D*-inositol, D-fructose, rhamnose, sucrose, and raffinose are utilized for growth. No growth or only a trace of growth with D-mannitol.

Streptomyces galtieri Goret and Joubert. Description: Goret and Joubert (60). Type strain: Goret and Joubert strain AB = CBS 368.49 (60; G. A. deVries, personal communication, August 1966). ISP 5350 from G. A. deVries, CBS, as CBS 368.49 = Goret and Joubert strain AB. ISP description by Group D-8.

Spore-chain morphology: Section *Rectiflexibiles*. Sporulating aerial mycelium is absent or poorly developed on most ISP media; sparse mature spore chains often arise singly and are generally short with 3 to 10 or more spores per chain (Fig. 99). One observer reports no sporulating aerial mycelium on yeast-malt agar, oatmeal

FIG. 93. *S. fulvissimus*. Long RF spore chains. (a) $\times 264$ on glycerol-asparagine agar, 14 days. (b) Scanning electron micrograph, $\times 1,200$, on salts-starch agar, 21 days.

FIG. 94. *S. fulvissimus*. Smooth spores. (a) Transmission electron micrograph. (b) Scanning electron micrograph from 21-day-old culture on salts-starch agar.

FIG. 95. *S. galbus*. Spiral spore chains on oatmeal agar, 14 days. $\times 500$.

FIG. 96. *S. galbus*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 97. *S. galilaeus*. Open spirals on (a) salts-starch agar, (b) glycerol-asparagine agar, 24 days. $\times 600$.

FIG. 98. *S. galilaeus*. Smooth spores; electron micrograph from 7-day-old culture on oatmeal agar.

agar, salts-starch agar, glycerol-asparagine agar, or additional media available in his laboratory. He expresses doubt that this strain belongs to the genus *Streptomyces*. A second observer reports sporulation only on yeast-malt agar. Bodies resembling segmentation spores are seen on the substrate mycelium (Fig. 100). Spore surface: Smooth (Fig. 101).

Color of colony: Aerial mass color in the White color series on yeast-malt agar and sometimes on oatmeal agar.

Reverse side of colony: No distinctive pigments (moderate orange yellow to light yellowish brown on yeast-malt agar; pale yellow to light yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth in 2 to 4 days, but a delayed weak brown discoloration may be seen in peptone-yeast-iron agar and some other media after 7 to 21 days. Although no pigment is usually found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, a trace of yellow or brown may sometimes be detected in yeast-malt agar or glycerol-asparagine agar in 7 to 21 days.

Carbon utilization: D-Glucose and D-fructose are utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, rhamnose, sucrose, raffinose, *i*-inositol, or D-mannitol.

Streptomyces gannmycicus (sic) Hosoya and Soeda. Name is found in: Hosoya (77, p. 130); also Harada and Tanaka (68). Type strain: Kyowa Hakko Kogyo Co. strain 648 40.9. ISP 5572 from O. Makabe, Kyowa Hakko Kogyo Co., Ltd., as 648 40.9. ISP description by Group F-3.

Spore-chain morphology: Section *Spirales* (Fig. 102). Mature spore chains are generally long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 103).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs in the Gray color series are 3ig, grayish yellowish brown, and 3li and 4li, brownish gray. (One observer only reports 1½ge, light grayish olive, from the Green color series on salts-starch agar.)

Reverse side of colony: No distinctive pigments (strong brown or orange yellow on yeast-malt agar; yellow or grayish yellow to orange yellow or olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar,

and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, and raffinose are utilized for growth. Reports vary on utilization of L-arabinose and sucrose.

Streptomyces gedanensis (Scheele and Petruschky 1897 or Löhlein 1909) Waksman. Descriptions: Original descriptions not seen (Scheele and Petruschky, in Petruschky 1909 according to Buchanan et al. 1966, Index Bergeyana, 1105 and Waksman 1953, 86). *Streptomyces gedanensis* (Löhlein) (sic) Waksman (209, p. 86). Type strain: Not extant. Because *S. gedanensis* strain Sara A Scudder No. 24400 = ATCC 4880 = IMRU 3417 = PSA 51 = ETH 16701 (80, p. 260) is widely distributed, it has been studied by ISP as a potential neotype. ISP 5518 from E. F. Lessel, ATCC, as ATCC 4880. ISP description by Group E-4.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 104). Only a few short spore chains, usually with less than 10 spores per chain, can be found after incubation for 21 days on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Aerial mycelium is generally absent on these media. Spore surface: Smooth (Fig. 105).

Color of colony: Aerial mass color not determined (or only a trace of white or pale yellow aerial mycelium) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Yellow, greenish yellow, or yellowish green on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of *i*-inositol is doubtful; no growth or only trace of growth with D-xylose, sucrose, or raffinose.

Streptomyces glomeroaurantiacus (Krasil'nikov and Yuan) Pridham. Descriptions: *Actinomyces glomeroaurantiacus* (Krasil'nikov and Yuan [105, p. 50-52]; Yuan Tsi-chen, dissertation, abstract in Mikrobiologia 31, 1962, p. 188-189; *Streptomyces glomeroaurantiacus* [Krasil'nikov and Yuan] Pridham 1970, 17 [147]). Type strain: INMI 1242 (selected by N. A. Krasil'nikov, personal communication, December 1966). The original description (105) includes INMI 1242 among

a list of representative strains but cites INMI 1464 as the type strain. ISP 5429 from N. A. Krasil'nikov as INMI 1242. ISP description by group D-11.

Spore-chain morphology: Section *Spirales* (Fig. 106), but aerial mycelium is poorly developed and typical spore chains are difficult to find on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Mature spore chains on these media are generally very short or absent. Spore surface: Smooth (Fig. 107).

Special morphological characteristics: Conidia-like spores or fragmentation of the substrate mycelium may be seen on yeast-malt agar and salts-starch agar in 20 days (Fig. 108).

Color of colony: Growth of aerial mycelium is not adequate for determination of aerial mass color on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: Yellowish pink, orange or reddish orange on yeast-malt agar and glycerol-asparagine agar; no distinctive pigments (grayish yellow, orange yellow or yellowish brown) on oatmeal agar and salts-starch agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed on peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. One of three observers records orange to pink or red pigment in the medium in yeast-malt agar, oatmeal agar and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Reports vary from doubtful growth to positive growth with D-xylose, *i*-inositol, sucrose, and raffinose.

Streptomyces graminofaciens Charney, Fisher, Curran, Machlowitz, and Tytell. Description: Charney et al. (31). Type strain: Merck, Sharp & Dohme MA-317 (H. B. Woodruff, Merck, Sharp & Dohme, personal communication, May 1968) = ATCC 12705 (E. Lessel, ATCC, personal communication, March 1968). ISP 5559 from H. B. Woodruff as MA-317. ISP description by Group F-2.

Spore-chain morphology: Section *Spirales*. Open spirals of four or more turns, irregular spirals and hooks, or tight terminal spirals may be found on various media (Fig. 109). Mature spore chains are generally long, sometimes with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Warty (Fig. 110).

Color of colony: Aerial mass color in the Gray or White color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine

agar. Only one of three observers records aerial mycelium in the Red color series (5dc, grayish yellowish pink) on yeast-malt agar in 21 days. Nearest matching color tabs in the Gray color series were d, light gray; 2dc, yellow gray; and 5fe, light grayish reddish brown.

Reverse side of colony: No distinctive pigments (grayish yellow to brown on yeast-malt agar; pale grayish or greenish yellow to light yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces griseoaurantiacus (Krasil'nikov and Yuan) Pridham. Descriptions: *Actinomyces griseoaurantiacus* Krasil'nikov and Yuan (105; p. 41, 52-53); *Streptomyces griseoaurantiacus* (Krasil'nikov and Yuan) Pridham 1970, 17 (147). Type strain: INMI AK-5 (105). ISP 5430 from N. A. Krasil'nikov as INMI AK-5. ISP description by Group D-11.

Spore-chain morphology: Section *Spirales* (Fig. 111a). Hooks, loops, and primitive spirals suggesting RA morphology are very common (Fig. 111b). Mature spore chains have 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 112).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray; 2fe, medium gray; 3fe, light brownish gray; or 5fe, light grayish reddish brown) on yeast-malt agar, oatmeal agar, and salts-starch agar. Gray or Red color series (5dc, grayish yellowish pink) on glycerol-asparagine agar.

Reverse side of colony: Grayish yellow to orange yellow, yellowish pink, or dark reddish orange on yeast-malt agar; yellowish pink or reddish gray to reddish-orange on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar is a pH indicator, changing from orange to red with the addition of 0.05 N HCl and from orange to brown with the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow orange or pinkish red may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-

FIG. 99. *S. galtieri*. Short RF spore chains seen on cornmeal-starch agar, 7 days. $\times 500$.
 FIG. 100. *S. galtieri*. Fragmentation spores in substrate mycelium on oatmeal agar, 21 days.
 FIG. 101. *S. galtieri*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.
 FIG. 102a, b. *S. gannmycicus*. Spiral spore chains on oatmeal agar, 9 days. $\times 800$.
 FIG. 103. *S. gannmycicus*. Spiny spores; electron micrograph from 14-day-old culture on oatmeal agar.
 FIG. 104. *S. gedanensis*. Sparse, erect aerial hyphae on oatmeal agar, 30 days.
 FIG. 105. *S. gedanensis*. Smooth spores. Electron micrograph from 24-day-old culture on oatmeal agar.
 FIG. 106. *S. glomeroaurantiacus*. Spiral spore chains on sparse aerial hyphae. $\times 380$. (a) Salts-starch agar, 17 days. (b) Carbon-utilization medium plus glucose, 15 days.
 FIG. 107. *S. glomeroaurantiacus*. Smooth spores. Electron micrograph from 20-day-old culture on salts-starch agar.
 FIG. 108. *S. glomeroaurantiacus*. Conidia-like spores or fragmentation in substrate mycelium, 20 days. $\times 1,500$.

erol-asparagine agar in 21 days. This pigment, when formed in sufficient quantity, is pH sensitive, showing the same changes observed for reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of raffinose is doubtful. No growth or only a trace of growth with sucrose.

Streptomyces griseochromogenes Fukunaga, Misato, Ishii, and Asakawa. Description: Fukunaga et al. (52). (See also, Nagatsu, Suzuki, and Seino [128] for comparison with other strains.) Type strain: Fukunaga strain 2A 327 (Fukunaga et al., 52) = ATCC 14511 (Lessel and Hatt 1970, 73). ISP 5499 from E. F. Lessel, ATCC, as ATCC 14511. ISP description by Group E-6.

Spore-chain morphology: Section *Spirales* (Fig. 113) to *Retinaculiaperti*. Open loops and hooks as well as well-developed spirals are common. Mature spore chains generally contain 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 114).

Color of colony: Aerial mass color in the Gray color series (2fe, medium gray, or 3ge, light grayish yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; white aerial mycelium may also be seen on young cultures or on 21-day-old cultures on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (grayish yellow to orange yellow on yeast-malt agar; grayish yellow to light olive brown or grayish greenish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, sucrose, and raffinose are utilized for growth. No growth or only a trace of growth with rhamnose.

Streptomyces griseoluteus Umezawa, Hayano, Maeda, Ogata, and Okami. Descriptions: Umezawa et al. (192, p. 111); Umezawa et al. (193, p. 34-40); Okami (136, p. 478-479). Type strain: NIHJ P-37 (136, 192, 193) = IMRU 3729 (Waksman, 206). ISP 5392 from S. A. Waksman as IMRU 3729. ISP description by Group D-11.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 115). Crooked or hooked spore chains may also be seen. Mature spore chains are generally short, sometimes with less than 10 spores per chain. This morphology is seen on yeast-malt

agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 116).

Special morphological characteristics: One observer reports sclerotia-like bodies on the substrate mycelium of salts-starch agar and unusual morphology in the sporulating aerial mycelium (Fig. 117). Another observer reports short chains of conidia-like spores on the substrate hyphae on yeast-malt agar and salts-starch agar.

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, and salts-starch agar. Aerial mycelium may be poorly developed or absent on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (pale or grayish yellow to yellowish brown or olive brown) on yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. Yellow to yellow brown may or may not be modified with red (orange) on salts-starch agar. Reverse mycelium pigment on salts-starch agar is a pH indicator, changing from red or reddish brown to gray with the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Red to bluish gray pigment is found in the medium in salts-starch agar. This pigment may show the same change observed for reverse mycelium pigment with the addition of 0.05 N NaOH.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth. No growth or only a trace of growth with *i*-inositol, rhamnose, sucrose, or raffinose.

Streptomyces griseosporus Niida and Ogasawara. Description: Niida and Ogasawara (131); antibiotic production described by Kondo et al. (93). Type strain: Meiji Seika Kaisha B-793 (134). ISP 5562 from T. Niida, Meiji Seika Kaisha, as B-793 = MS-1104. ISP description by Group F-2.

Spore-chain morphology: Section *Retinaculiaperti*. Spore chains may be flexuous (Fig. 118a) or in imperfect spirals, hooks, and loops (Fig. 118b). Flexuous chains are common. Mature spore chains are moderately long with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 119).

Color of colony: Aerial mass color in the Gray color series (2fe or e, moderate gray; 3fe, light brownish gray; or 5fe, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (pale or grayish yellow or sometimes light yellowish brown on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are

FIG. 109. *S. graminofaciens*. Spiral spore chains and terminal loops. (a) Spirals on oatmeal agar, 14 days. $\times 192$. (b) Same culture, $\times 812$. (c) Terminal hooks or loops on yeast-malt agar, 14 days. $\times 812$.

FIG. 110. *S. graminofaciens*. Warty spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 111. *S. griseoaurantiacus*. Waksman's starch agar. $\times 380$. (a) Open spirals of 3 to 4 turns. (b) Hooks, loops, and primitive spirals.

FIG. 112. *S. griseoaurantiacus*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 113. *S. griseochromogenes*. Loops and spirals on oatmeal agar, 7 days. $\times 850$.

FIG. 114. *S. griseochromogenes*. Spiny spores; electron micrograph from 28-day-old culture on yeast-malt agar.

FIG. 115. *S. griseoluteus*. Short, crooked RF spore chains. $\times 380$. (a) Salts-starch agar, 17 days. (b) Waksman starch agar, 17 days.

FIG. 116. *S. griseoluteus*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 117. *S. griseoluteus*. Unusual aerial morphology; agar plug cover slip preparation. $\times 150$. (a, b) Salts-starch agar, 5 days. (c) Yeast-malt agar, 7 days.

FIG. 118. *S. griseosporus*. RA morphology on glycerol-asparagine agar, 14 days. $\times 800$. (a) Straight to flexuous chains. (b) Hooks, loops, and primitive spirals.

FIG. 119. *S. griseosporus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptovorticillum griseovorticillatum (Shinobu and Shimada) Locci, Baldacci, and Petrolini Baldan. Descriptions: *Streptomyces griseovorticillatus* Shinobu and Shimada 1962, 170–175 (170); *Streptovorticillum griseovorticillatum* (Shinobu and Shimada) Locci, Baldacci, and Petrolini Baldan 1969, 9–40 (116). Type strain: Shinobu and Shimada's strain 722 (170). ISP 5507 from Y. Shimada as strain 722. ISP description by Group E-1.

Spore-chain morphology: Section *Verticillati*, umbellate monovorticillate (bivorticillate) (Fig. 120). Mature spore chains are short with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 121).

Color of colony: Aerial mass color in the Red color series (usually 4ec, grayish yellowish pink; sometimes 4ge, light grayish reddish brown; 4ie, light brown; or 3ca, pale orange-yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Yellowish brown or orange yellow on yeast-malt agar; grayish yellowish pink to light olive brown on oatmeal agar; yellowish brown to strong brown on salts-starch agar; pale or grayish yellow on glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and *i*-inositol are utilized for growth. Utilization of D-fructose is doubtful. No growth or only a trace of growth with L-arabinose, D-xylose, raffinose, sucrose, rhamnose, or D-mannitol.

Streptomyces helveticus (sic) (Krasil'nikov, Korenyako, and Nikitina) Pridham. Descriptions: *Actinomyces helveticus* Krasil'nikov, Korenyako, and Nikitina (103; p. 224, 227–228); *Streptomyces helveticus* (Krasil'nikov, Korenyako, and Nikitina) Pridham 1970, 18 (147). Type strain: INMI 1013b (Krasil'nikov et al., op. cit.) = ATCC 19841 (Pridham op. cit.). ISP 5431 from N. A. Krasil'nikov as 1013b. ISP description by Group D-11.

Spore-chain morphology: Section *Retinaculiperti* to *Spirales* (Fig. 122a). Straight to flexuous spore chains may also be common, especially when short spore chains are produced (Fig. 122b). This morphology is seen on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Sporulating aerial mycelium may be poorly developed or absent on yeast-malt agar. Spore surface: Smooth (Fig. 123).

Color of colony: Aerial mass color probably in the Red color series (3ca, pale orange yellow, to 4ca, light yellowish pink) on oatmeal agar and salts-starch agar when optimum sporulation occurs. Aerial mass color may also appear to be white or yellow (2ba or 2db, pale yellow) on oatmeal agar and salts-starch agar. Aerial mycelium is poorly developed on yeast-malt agar and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigment (light yellow or pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, and *i*-inositol are utilized for growth. Utilization of D-fructose is doubtful. No growth or only a trace of growth with rhamnose, sucrose, raffinose, or D-mannitol.

Streptomyces horton (sic) (Erikson) Pridham, Hesselstine, and Benedict. Descriptions: *Actinomyces horton* (sic) Erikson 1935, 36 (46); *Streptomyces horton* (sic) (Erikson) Pridham, Hesselstine, and Benedict 1958, 60 (148). Type strain: Erikson 600 (op. cit.) = NCTC 600 (D. M. Webley, Macaulay Institute for Soil Research, personal communication, August 1964). ISP 5266 from NCTC as NCTC 600. ISP description by Group E-3.

Spore-chain morphology: Section not determined. This strain does not produce sporulating aerial mycelium on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar, or other media tested by ISP collaborators. Erikson's original paper (op. cit.) includes no description of aerial mycelium on any medium used in his study except the following comment: "Very sparse straight aerial mycelium produced only once on potato." Three ISP collaborators who studied this strain agree that it probably does not belong in the genus *Streptomyces*. Spore surface: Not determined.

Color of colony: Aerial mass color not determined. Aerial mycelium is not formed on

yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (colorless or pale grayish yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, and D-mannitol are utilized for growth. Reports vary on utilization of D-fructose, *i*-inositol, rhamnose, and sucrose; utilization of these carbon sources is doubtful. No growth or only a trace of growth with raffinose.

Streptomyces humifer Pridham. Description: Actinomycete ATCC 13748 Schmitz et al. (167); *Nocardia humifera* Schmitz, Hooper, Lein, and Heinemann (168); *Streptomyces humifer* Pridham 1970, 39-40 (147). Not *Actinomyces humiferus* Gledhill and Casida 1969, 114 (57). Type strain: ATCC 13748 (167, 147). ISP 5602 from ATCC as ATCC 13748. ISP description by Group F-6.

Spore-chain morphology: Section not determined. No sporulating aerial mycelium is seen on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. The original descriptions of Schmitz et al. (op. cit.) and Pridham (op. cit.) state that aerial mycelium is absent on all media used.

Special characteristics: ISP observers record fragmentation of substrate mycelium (Fig. 124) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Electron micrographs show symmetrical fragmentation bodies in the substrate mycelium (Fig. 125). Cell-wall analysis by one ISP collaborator (Prauser) reveals the presence of L-diaminopimelic acid and the absence of L-arabinose in the cell wall, placing this strain in cell-wall type I, characteristic of *Streptomyces* (15). Cell-wall analysis by Pridham and Lyons (148, p. 210) also shows the presence of L-diaminopimelic acid and the absence of L-arabinose.

Color of colony: Aerial mass color not determined because of lack of aerial mycelium on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (colorless or light grayish yellow or pale yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in

the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *i*-inositol, D-mannitol, and D-fructose are utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, rhamnose, sucrose, and raffinose.

Streptomyces hydrogenans Lindner, Junk, Nesemann, and Schmidt-Thomé. Description: Lindner et al. (114). Type strain: ATCC 19631 = FHP 678 (G. Nesemann cited in *ATCC Catalogue of Strains*, 9th ed., 1970). ISP 5586 from E. F. Lessel, ATCC, as ATCC 19631. ISP description by Group F-4.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 126). Mature spore chains are generally long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 127).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar; White or Yellow color series on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs in the Gray color series are d, light gray, and 5fe, light grayish reddish brown. Nearest matching tab in the Yellow color series is 2ba, pale yellow.

Reverse side of colony: No distinctive pigments (pale or grayish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, and rhamnose are utilized for growth. No growth or only a trace of growth with *i*-inositol, D-mannitol, D-fructose, sucrose, or raffinose.

Streptomyces hygroscopicus (Jensen) Waksman and Henrici. Description: *Actinomyces hygroscopicus* Jensen 1931, 357-358 (85); *Streptomyces hygroscopicus* (Jensen) Waksman and Henrici 1948, 953 (208). Type strain: Jensen's strain is not extant (personal communication from H. L. Jensen, March 1965; T. G. Pridham, NRRL, April 1965). The Eli Lilly Research Laboratories strain M5-13184 = NRRL 2387 is suggested for the neotype strain. ISP 5578 from J. M. McGuire, Eli Lilly Research Laboratories, as M5-13184 = NRRL 2387. ISP description by Group F-4.

Spore-chain morphology: Section *Spirales*;

FIG. 120. *Stv. griseoverticillatum*. Umbellate monoverticillate (BV) morphology. $\times 960$. (a) On yeast-malt agar, 7 days. (b) Carbon-utilization medium plus sucrose, 10 days.

FIG. 121. *Stv. griseoverticillatum*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 122. *S. helveticus*. (a) Open spirals on oatmeal agar, 17 days. $\times 380$. (b) Straight, flexuous, and spiral spore chains on Waksman starch agar, 17 days. $\times 380$.

FIG. 123. *S. helveticus*. Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 124. *S. humifer*. Fragmentation of mycelium on agar surface of yeast-malt agar, 14 days. Phase contrast, $\times 700$.

FIG. 125. *S. humifer*. Cylindrical fragmentation bodies from agar surface or substrate mycelium on glycerol-asparagine agar, 14 days.

tight spirals in dense clusters (Fig. 128). Spirals may coalesce as dark, moist masses of spores. Mature spore chains generally contain 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Warty; individual spores are poorly delineated. (Fig. 129).

Special morphological characteristics: Moist, black, liquefied (hygroscopic) areas are found in the aerial mycelium in 14 to 21 days. These are especially common on oatmeal agar and salts-starch agar.

Color of colony: Aerial mass color in the Gray color series (3fe, 3li or 5ih, brownish gray; or 5fe, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Dark or medium gray areas are also reported on oatmeal agar and salts-starch agar, and moist black (hygroscopic) areas may be seen on older cultures.

Reverse side of colony: No distinctive pigments (colorless to grayish yellow, pale yellow, or light olive-brown or gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, except that dark discoloration may be seen beneath hygroscopic areas.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Good growth is reported on the carbon-free control medium as well as on L-arabinose, D-xylose, and L-inositol, so that utilization of these carbon sources is doubtful. Sucrose and raffinose are probably not utilized.

Streptomyces iakyrus deQueiroz and Albert. Description: V. M. deQueiroz and C. A. Albert (153). Type strain: IAUR 3923 (153) = ATCC 15375 (E. F. Lessel 1970, 74). ISP 5482 from E. F. Lessel, ATCC, as ATCC 15375. ISP description by Group E-2.

Spore-chain morphology: Section *Spirales* (Fig. 130). Mature spore chains are generally long with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 131).

Color of colony: Aerial mass color in the Gray or Red color series on oatmeal agar and salts-starch agar; nearest matching color tab in the Gray color series is 5fe, light grayish reddish brown, and in the Red color series, 5dc, grayish yellowish pink. These colors as well as white

aerial mycelium are reported for yeast-malt agar and glycerol-asparagine agar (a variety of colors reported on yeast-malt agar also includes tabs from the Yellow color series and the Blue color series).

Reverse side of colony: Greenish yellow, olive gray, olive, or olive brown on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but only slightly or not at all in tyrosine agar. Yellow to yellow-green pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, L-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces indigocolor (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. Descriptions: *Actinomyces indigocolor* Krasil'nikov, Sorokina, Alferova, and Bezzubenkova (104, p. 87-88); *Streptomyces indigocolor* (Krasil'nikov et al.) Pridham 1970, 18 (147). Type strain: INMI 206 (Krasil'nikov et al., op. cit.) = ATCC 19842 (Pridham, op. cit.). ISP 5432 from N. A. Krasil'nikov as INMI 206. ISP description by Group D-1.

Spore-chain morphology: Section *Spirales*, often with tight terminal coils or spirals (Fig. 132). Mature spore chains are moderately short but usually contain more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 133).

Color of colony: Aerial mass color in the Blue color series on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; White or Gray color series on oatmeal agar (sometimes White or Gray on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar). Nearest matching color tab in the Blue color series is 19dc, pale blue. When gray aerial mycelium is found, the nearest color tabs are d, light gray, and g-e, medium gray.

Reverse side of colony: Distinctive blue to violet or red pigmentation depending upon medium and pH. (Very dark green blue or gray blue on yeast-malt agar; gray blue to grayish purple on oatmeal agar and salts-starch agar; grayish purple to reddish black on glycerol-asparagine agar.) Reverse mycelium pigment is a pH indicator changing from red or violet to blue with the addition of 0.05 N NaOH and from blue or violet to red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but are usually not found in tyrosine agar. Blue or violet pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes recorded for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, sucrose, raffinose, *i*-inositol, and D-mannitol are all utilized for growth.

Streptomyces kanamyceticus Okami and Umezawa in Umezawa, Ueda, Maeda, Yagishita, Kondo, Okami, Uehara, Osato, Nitta, and Takeuchi. Description: Okami and Umezawa (196). Type strain: NIHJ K2J (196) = ATCC 12853. ISP 5500 from E. F. Lessel, ATCC, as ATCC 12853. ISP description by Group E-3.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 134). Sporulating aerial mycelium is usually not abundant or may be absent on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, although one observer reports long spore chains with 50 or more spores per chain on all of these media. Spore surface: Smooth (Fig. 135).

Special morphological characteristics: Terminal droplets showing wide variation in size are often found on aerial hyphae (Fig. 134). These may contain coalesced masses of spores (Fig. 135), but they do not appear to be sporangia.

Color of colony: Aerial mass color in the Yellow or White color series when sporulating aerial mycelium is present on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs from the Yellow color series are 1½fb, light yellow; 2db, pale yellow; and 1db, pale yellow green.

Reverse side of colony: No distinctive pigments (colorless to pale yellow or grayish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, raffinose, and D-mannitol are utilized for growth. No growth or only a trace of growth with *i*-inositol, rhamnose, or sucrose.

Streptovercillium kashmirens (Gupta and Chopra) Locci, Baldacci, and Petrolini Baldan. Descriptions: *Streptomyces kashmirens* Gupta

and Chopra 1963, 110–112 (65); *Streptovercillium kashmirens* (Gupta and Chopra) Locci, Baldacci, and Petrolini Baldan 1969, 45 (116). Type strain: Regional Research Laboratory, Kashmir strain RRL 37 A/9 (K. C. Gupta, personal communication, January 1966). ISP 5336 from K. C. Gupta, Regional Research Laboratory, Kashmir, as RRL 37 A/9. ISP description by Group F-1.

Spore-chain morphology: Section *Verticillati*, umbellate monovercillate (bivercillate) (Fig. 136). Mature spore chains are generally short with 3 to 10 or more spores per chain. This morphology is usually seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, although sporulation is not always good on these media. Spore surface: Smooth (Fig. 137).

Color of colony: Aerial mass color in the Red color series (5cb or 5dc, grayish yellowish pink) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. When aerial mycelium is poorly developed, the surface color may appear to be in the Gray (d, light gray, or 2dc, yellowish gray) or White color series. The original description of Gupta and Chopra (65) reports blue aerial mycelium on Emerson's medium.

Reverse side of colony: Distinctive red pigments (grayish red or moderate reddish brown on yeast-malt agar and oatmeal agar; light brown to dark brown on salts-starch agar and glycerol-asparagine agar). The reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth in 4 days; reaction may be weak on tyrosine agar. Yellow to orange or reddish pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose and *i*-inositol are utilized for growth. Only a trace of growth is seen with L-arabinose, D-xylose, D-mannitol, D-fructose, rhamnose, sucrose, or raffinose.

Streptomyces katrae Gupta and Chopra. Description: Gupta and Chopra (64). Type strain: ISP 5550 received directly as specimen of type strain from K. C. Gupta, Department of Microbiology, Regional Research Laboratory, Jammu Tawi, India. ISP description by Group E-6.

Spore-chain morphology: Section *Retinaculiaperti*. Long spore chains with terminal primitive spirals, hooks, or loops of wide diameter (Fig. 138). Some well defined spirals are

FIG. 126. *S. hydrogenans*. RF spore chains on glycerol-asparagine agar, 7 days. $\times 500$.

FIG. 127. *S. hydrogenans*. Smooth spores; electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 128. *S. hygroscopicus*. Tight spirals on glycerol-asparagine agar, 21 days. Spirals coalesce becoming dark "hygroscopic" masses. $\times 500$.

FIG. 129. *S. hygroscopicus*. Warty spores. (a) Individual spores of intact chain are not clearly delineated. Electron micrograph from 21-day-old culture on salts-starch agar. (b) Individual spores shown by disruption of chain. Electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 130. *S. iakyrus*. Spiral spore chains on oatmeal agar, 21 days. $\times 300$.

FIG. 131. *S. iakyrus*. Spiny spores; electron micrograph from 7-day-old culture on salts-starch agar.

FIG. 132. *S. indigocolor*. Spiral spore chains on yeast-malt agar, 17 days. $\times 500$.

FIG. 133. *S. indigocolor*. Spiny spores; chromium-shadowed electron micrograph from 25-day-old culture on glycerol-asparagine agar.

also seen. Mature spore chains are long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 139).

Color of colony: Aerial mass color in the Red color series (5dc, 5cb or 4ca, grayish yellowish pink; 5ca, light yellowish pink; or 3ca, pale orange yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (yellowish brown to olive brown on yeast-malt agar; grayish yellow to yellowish brown on salts-starch agar, oatmeal agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not on tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, and sucrose are utilized for growth. No growth or only a trace of growth with *D*-inositol, D-mannitol, rhamnose, or raffinose.

Streptovercillium ladakanus Hanka, Evans, Mason, and Dietz. Description: Hanka et al. (67). Type strain: Upjohn Co. UC 2654 (67) = NRRL 3191 (A. Dietz, Upjohn Co., personal communication, March 1969). ISP 5587 from T. G. Pridham as NRRL 3191. ISP description by Group F-4.

Spore-chain morphology: Section *Verticillati*, umbellate monovercillate (bivercillate) (Fig. 140). Mature spore chains are generally short with 3 to 10 or more spores per chain. This morphology can be seen on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but sporulation may be poor on these media. Spore surface: Smooth (Fig. 141).

Color of colony: Aerial mass color in the White or Yellow color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Abundant aerial mycelium is usually in the White color series; shorter or poorly developed aerial mycelium may be 2ba or 2db, pale yellow.

Reverse side of colony: Moderate orange to strong brown on yeast-malt agar; light or pale yellow on oatmeal agar; yellowish pink to grayish reddish orange on salts-starch agar, and grayish yellow to reddish brown or strong brown on glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a

trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and D-fructose are utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, *D*-inositol, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces lavenduligriseus (J. B. Routien, in Rao, Marsh, and Brooks, U.S. Patent 3,155,583, November 3, 1964). Description: Rao et al. (155). Type strain: Pfizer BA-6903 = ATCC 13306 (155). ISP 5487 from J. B. Routien, Chas. Pfizer and Co., Inc., as BA-6903 = FD 22124 = ATCC 13306. ISP description by Group E-3.

Spore-chain morphology: Section *Rectiflexibiles* to *Retinaculiaperti* (one observer records monovercillate sporophores). Clusters of short, flexuous spore chains include hooks, loops, and primitive spirals (Fig. 142). Straight spore chains are also seen, and spore chains or clusters of sporophores sometimes seem to be opposite or in whorls. These do not appear to have the uniformity or even spacing characteristic of verticillate cultures. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar; sporulation is poor or absent on glycerol-asparagine agar. Spore surface: Smooth (Fig. 143).

Color of colony: Aerial mass color in the Gray color series (3fe, light brownish gray; 3ge, light grayish yellowish brown; 3ig, grayish yellowish brown; or 2fe, medium gray) on yeast-malt agar, oatmeal agar, and salts-starch agar. Aerial mycelium is poorly developed or absent on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (brown to grayish yellow on yeast-malt agar and oatmeal agar; grayish yellow or pale yellow on salts-starch agar; and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. One of three observers reports reddish to orange pigment in the medium in yeast-malt agar and oatmeal agar and yellow pigment in glycerol-asparagine agar. Two observers report no pigment in ISP media. When soluble pigment is produced, it is reported to be pH sensitive, changing from red, orange, or yellow to violet with the addition of 0.05 N NaOH.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, and D-mannitol are utilized for growth. Reports vary on utilization of *D*-inositol. Utilization of rhamnose or sucrose is doubtful. No growth or only a trace of growth with raffinose.

FIG. 134. *S. kanamyceticus*. RF spore chains on glycerol-asparagine agar, 14 days. $\times 590$. Terminal droplets of various sizes can be seen on several chains; droplets contain coalesced masses of spores (see Fig. 135).

FIG. 135. *S. kanamyceticus*. Long chains of smooth spores including a mass of spores believed to be related to terminal droplets shown in Fig. 134. Electron micrograph from 14-day-old culture on glycerol-asparagine agar.

FIG. 136. *Stv. kashmirensis*. Umbellate monoverticillate (BV) morphology on Czapek's sucrose agar, 14 days. $\times 500$.

FIG. 137. *Stv. kashmirensis*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 138. *S. katrae*. RA morphology on glycerol-asparagine agar, 14 days. $\times 450$.

FIG. 139. *S. katrae*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

Streptomyces lazureus (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. Descriptions: *Actinomyces lazureus* Krasil'nikov et al. (104, p. 88). *Streptomyces lazureus* (Krasil'nikov et al.) Pridham 1970, 21 (147). Type strain: INMI 383-K = ATCC 19843 (147, p. 21). ISP 5433 from N. A. Krasil'nikov as INMI 383-K. ISP description by Group D-1.

Spore-chain morphology: Section *Spirales* to *Rectiflexibiles*. Flexuous spore chains (Fig. 144a) are most common on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar. Spirals are best developed on oatmeal agar (Fig. 144b). Spore surface: Smooth (Fig. 145).

Color of colony: Aerial mass color in the Red or Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tab in the Red color series is usually 5dc, grayish yellowish pink; nearest matching tabs in the Gray color series are 2dc, yellowish gray; 3fe, light brownish gray; and 5fe, light grayish reddish brown.

Reverse side of colony: Distinctive grayish blue to grayish purple or reddish gray pigmentation (depending upon pH) on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; yellowish gray on oatmeal agar. Reverse mycelium pigment is a pH indicator, changing from reddish or violet to blue with the addition of 0.05 N NaOH and from blue to violet or red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Red, violet, or blue pigment is usually found in the medium in yeast-malt agar, salts-starch agar, and glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes recorded for reverse mycelium pigment with the addition of 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, *i*-inositol, and D-mannitol are utilized for growth. Utilization of raffinose is doubtful. No growth or only a trace of growth with sucrose.

Streptomyces libani Baldacci and Grein. Description: Baldacci and Grein (10). Type strain: 2343FI = IPV 1945 (E. Baldacci, personal communication, April 1968). ISP 5555 from E. Baldacci as 2343FI = IPV 1945. ISP description by Group F-1.

Spore-chain morphology: Section *Spirales* (Fig. 146). Tight terminal spirals are usually seen on moderately short chains of 10 or more spores. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 147).

Color of colony: Aerial mass color in the Gray

color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs reported for aerial mass color on yeast-malt agar, oatmeal agar, and glycerol-asparagine agar are d, light gray; e, medium gray; and 2dc and 2bc, yellowish gray. Nearest matching tabs reported for salts-starch agar are 3fe, light brownish gray; 4li, brownish gray; and 3ge, light yellowish brown.

Reverse side of colony: Gray or pale yellow to orange yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are utilized for growth. Utilization of L-arabinose is doubtful.

Streptomyces listeri (Erikson) Waksman and Henrici. Descriptions: *Actinomyces listeri* Erikson 1935, 35 (46); *Streptomyces listeri* (Erikson) Waksman and Henrici 1948, 961 (208). (Not a streptomycete, Pridham and Lyons [149] 183-221.) Type strain: NCTC 434 = Erikson 434 (208). ISP 5297 from S. T. Cowan, NCTC, as NCTC 434. ISP description by Group C-2.

Spore-chain morphology: Section not determined. Sporulating aerial mycelium is not found on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Sporulating aerial mycelium is also absent on Czapek's agar and Krainsky agar. Spore surface: Not determined.

Color of colony: Not determined. Note: Erikson's original description (op. cit.) indicates that scant white aerial mycelium was found on potato agar after 4 months and on potato plug and glycerine agar. Spores on the scant aerial mycelium are described as cylindrical. Pridham and Lyons (149) report that this strain does not contain L-diaminopimelic acid in whole-cell hydrolysates. It contains *meso* and/or D-diaminopimelic acid and ribose but no arabinose or galactose. They suggest that such strains are not properly included in the genus *Streptomyces* (15).

Reverse side of colony: No distinctive pigments (nearly colorless or light yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

FIG. 140. *Stv. ladakanus*. Umbellate monoverticillate (BV) morphology. $\times 500$. (a) Salts-starch agar, 7 days. (b) Oatmeal agar, 21 days.

FIG. 141. *Stv. ladakanus*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 142. *S. lavenduligriseus*. Imperfect spirals, hooks, and loops on salts-starch agar, 14 days. $\times 480$.

FIG. 143. *S. lavenduligriseus*. Smooth spores; electron micrograph from 14-day-culture on yeast-malt agar.

FIG. 144. *S. lazareus*. (a) Flexuous spore chains on yeast-malt agar, 14 days. (b) Spirals on oatmeal agar, 17 days.

FIG. 145. *S. lazareus*. Smooth spores; electron micrograph from 21-day-old culture on salts-starch agar.

FIG. 146. *S. libani*. Spirals on short spore chains; oatmeal agar, 14 days. $\times 600$.

FIG. 147. *S. libani*. Smooth spores. Scanning electron micrograph from 14-day-old culture on salts-starch agar.

Carbon utilization: Only a trace of growth or no growth is found on carbon-utilization medium plus glucose or other carbon sources included in the ISP studies. Absence of good vegetative growth on the carbon utilization medium plus glucose may suggest that growth is not supported by the basal medium.

Streptomyces lividans (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. Descriptions: *Actinomyces lividans* Krasil'nikov et al. (104; p. 109-110, 90-100); *Streptomyces lividans* (Krasil'nikov et al.) Pridham 1970, 21 (147). Type strain: INMI 32-13 (N. A. Krasil'nikov, personal communication, December 1966) = ATCC 19844 (Pridham op. cit.). ISP 5434 from N. A. Krasil'nikov as INMI 32-13. ISP description by Group D-1.

Spore-chain morphology: Section *Spirales* (Fig. 148). Mature spore chains are moderately long, with more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 149).

Color of colony: Aerial mass color in the Gray or Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Most representative color tabs from the Gray color series are g, medium gray; d, light gray; 5fe, light grayish reddish brown; 3ge, light grayish yellowish brown; and 2dc, yellowish gray. Color tabs from the Red color series are 5dc or 5cb, grayish yellowish pink, and 4ge, light grayish reddish brown.

Reverse side of colony: Distinctive pale to dark grayish purple or grayish reddish purple on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from reddish or violet to blue with the addition of 0.05 N NaOH and from violet or blue to red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Blue or violet pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is pH sensitive, showing the same color changes recorded for the reverse mycelium pigments.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth, but growth on sucrose or raffinose may be less than on the other carbon sources.

Streptomyces longispororuber (Krasil'nikov) Waksman. Descriptions: *Actinomyces longisporus ruber* Krasil'nikov 1941, 22 (100); *Streptomyces longispororuber* (Krasil'nikov) Waks-

man (209, p. 99). Type strain is not extant. Suggested neotype: INA 11668/54 (T. P. Preobrazhenskaya, April 1969; Hütter [80, p. 289]). ISP 5599 from T. P. Preobrazhenskaya as INA 11668/54. ISP description by Group F-5.

Spore-chain morphology: Section *Spirales* (Fig. 150). Spirals may be found on oatmeal agar or salts-starch agar but are rarely found on yeast-malt agar or glycerol-asparagine agar. Sporulation is generally poor on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. One observer reports only sterile aerial mycelium on these media. Spore surface: Not determined. Spores are poorly defined in electron micrographs submitted by ISP observers.

Color of colony: Aerial mass color in the Red color series (5ca or 7ca, light yellowish pink; 4ea, moderate yellowish pink; or 5cb or 6ec, grayish yellowish pink) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. One observer also reports 10ec, grayish purplish pink, in the Violet color series on salts-starch agar.

Reverse side of colony: Distinctive red pigments (strong or deep reddish orange or purplish pink). Substrate pigment is a pH indicator, changing from yellow orange or orange to pink with the addition of 0.05 N HCl and orange or pink to yellow orange or yellow with the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, *i*-inositol, D-mannitol, and D-fructose are utilized for growth. Reports vary on the utilization of D-xylose. No growth or only a trace of growth with sucrose, rhamnose, or raffinose.

Streptomyces lusitanus (Villax). The appropriate description or type strain for this organism is difficult to determine. The one published description (Villax 1963, 661-668) is based upon a selected mutant "industrial" strain, CBS 101-A = NCIB 9451. According to a personal communication from Villax (June 1968), CBS 101-A (= NCIB 9451) is not the original isolate but an industrial strain. According to the same communication, NCIB 9585 is the original isolate. This same information is found in Villax (202). The ISP study is based upon the strain designated by Villax (personal communication) as the original isolate named *Streptomyces lusitanus*. Type strain: NCIB 9585 (Villax op. cit.); this type strain differs from the industrial strain

(CBS 101-A = NCIB 9451) in several characteristics, including sporophore morphology and spore surface. ISP 5568 from NCIB at request of I. Villax as NCIB 9585. ISP description by Group F-3.

Spore-chain morphology: Section *Spirales* (Fig. 151). Spirals are best developed on salts-starch agar and glycerol-asparagine agar; flexuous chains as well as open spirals and imperfect spirals are common on yeast-malt agar and oatmeal agar. Mature spore chains generally are long, with 10 to 50 or more spores per chain. Spore surface: Spiny with short spines (Fig. 152a). Some spores may appear smooth (Fig. 152b).

Color of colony: Aerial mass color in the Gray or White color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs in the Gray color series are 3fe, light brownish gray, and 5fe, light grayish reddish brown.

Reverse side of colony: No distinctive pigments (pale or grayish yellow on oatmeal agar and glycerol-asparagine agar; olive brown or yellowish brown on yeast-malt agar and salts-starch agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment (or only a trace of yellow or pale olive) is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, and sucrose are utilized for growth. No growth or only a trace of growth with raffinose.

Streptomyces luteogriseus Schmitz, Deak, Crook, and Hooper. Description: Schmitz et al. (166). Type strain: ATCC 15072 (166). ISP 5483 from E. F. Lessel, ATCC, as ATCC 15072. ISP description by Group E-2.

Spore-chain morphology: Section *Spirales* (Fig. 153). Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 154).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs are 5fe, light grayish reddish brown, and 2dc, yellowish gray. One observer also reports aerial mycelium in the Red color series (5dc, grayish yellowish pink) on oatmeal agar and salts-starch agar.

Reverse side of colony: Strong yellowish brown to dark brown on yeast-malt agar; grayish

yellow to olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction may be weak in tyrosine agar. Yellow to brown pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces luteolutescens (Yen) Pridham. Description: *Actinomyces luteolutescens* Yen, H-c. 1956, 77 (219). *Streptomyces luteolutescens* (Yen) Pridham 1970, 41 (147). Type strain: INA 220 (G. F. Gauze, INA, personal communication, April 1969). ISP 5600 from G. F. Gauze as INA 220. ISP description by Group F-6.

Spore-chain morphology: Section *Rectiflexibiles*. Aerial mycelium is poorly developed on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; when present on these media or on Czapek's saccharose agar, straight to flexuous spore chains are formed (Fig. 155). Spore surface: Smooth (Fig. 156, 157).

Special characteristics: Cell-wall analysis by one collaborator (Prauser) shows the presence of L-diaminopimelic acid and the absence of L-arabinose, placing this strain in cell-wall type I, characteristic of organisms in the genus *Streptomyces* (15, 36).

Color of colony: Aerial mass color not determined because of poor development of sporulating aerial mycelium on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. One of three observers reports aerial mass color in the Yellow color series, 2ba, pale yellow, on salts-starch agar.

Reverse side of colony: No distinctive pigments (grayish yellow or pale yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of *i*-inositol is doubtful. No growth or only a trace of growth with sucrose or raffinose.

Streptomyces luteoreticuli Katoh and Arai.

FIG. 148. *S. lividans*. Spiral spore chains on salts-starch agar, 17 days. $\times 500$.

FIG. 149. *S. lividans*. Smooth spores; electron micrograph from 21-day-old culture on salts-starch agar.

FIG. 150. *S. longispororuber*. Spirals and aerial mycelium on oatmeal agar, 14 days. $\times 970$. Well defined spores were not reported by ISP observers.

FIG. 151. *S. lusitanus*. Spiral spore chains on yeast-malt agar, 14 days. $\times 800$.

FIG. 152. *S. lusitanus*. (a) Spiny spores with very short spines; electron micrograph from 14-day-old culture on yeast-malt agar. (b) Smooth and spiny spores; electron micrograph from 14-day-old culture on glycerol-asparagine agar.

FIG. 153. *S. luteogriseus*. Spiral spore chains on salts-starch agar, 14 days. $\times 500$.

FIG. 154. *S. luteogriseus*. Smooth spores; electron micrograph from 7-day-old culture on salts-starch agar.

Description: Katoh and Arai (90). (Additional citations, not seen: Arai and Katoh [3]; Arai and Katoh 1958, p. 267.) Type strain: The original description by Katoh and Arai (90) is based upon strain F-10. The ISP description is based upon strain IFM KS 2-74, sent to ISP by T. Arai as a suggested neotype strain. Note: The neotype strain IFM KS 2-74 = ISP 5509 differs in morphology from IPV 2000 = KCC-S 0173 = IFM 1027 studied by Locci et al. (116; p. 5, 48). ISP 5509 from T. Arai, IFM, as "neotype" IFM KS 2-74. ISP description by Group E-2.

Spore-chain morphology: Section *Umbellate Monoverticillate* (= *Streptomyces Verticillati*, biverticillate) (Fig. 158). Mature spore chains are generally short, with 3 to 10 or more spores per chain. This morphology is seen on oatmeal agar and sometimes on salts-starch agar. Sporulating aerial mycelium is usually thin or absent on yeast-malt agar or glycerol-asparagine agar. Spore surface: Smooth (Fig. 159).

Color of colony: Aerial mass color in the Yellow or Gray color series on oatmeal agar. Nearest matching color tabs in the Yellow color series are 1dc and 1½ec, pale yellow green, and 2db, pale yellow. Nearest matching tabs in the Gray color series are 2dc, yellowish gray, and 2ge, light olive brown.

Reverse side of colony: No distinctive pigments (olive brown to dark brown on yeast-malt agar, grayish yellow or yellowish brown to olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellowish to greenish yellow pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose and *i*-inositol are utilized for growth. Utilization of L-arabinose, D-xylose, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose is doubtful since only a small amount of growth is found on these carbon sources.

Streptomyces mediterranei Margalith and Beretta. Descriptions: Margalith and Beretta (120). (Name and antibiotic production, without description, in Sensi et al. [169].) Thiemann (181) places this strain in the genus *Nocardia*. Type strain: Lepetit S.p.A. ME/83 (Margalith et al., op. cit.); ATCC 13685 (Lepetit Laboratories). ISP 5501 from E. F. Lessel, ATCC, as ATCC 13685. ISP description by Group E-7.

Spore-chain morphology: Sporulating aerial mycelium is generally not produced on yeast-

malt agar or glycerol-asparagine agar and is also thin or absent on oatmeal agar and salts-starch agar. This is in agreement with the original description (op. cit.) which states "*S. mediterranei* produces very few spores when grown on the media used for classification purposes." Mature spore chains, when found, show some loops, hooks, and primitive spirals suggestive of section *Retinaculiaperti* (Fig. 160); other infrequent spore chains may be straight to flexuous (RF). Spore surface: Irregularly folded with some surface projections resembling spines (Fig. 161).

Special morphological characteristics: Two observers report production of oidia-like spores or fragments in the substrate mycelium.

Color of colony: Aerial mass color not determined; sporulation is inadequate for color determination on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Distinctive yellowish pink to orange or orange brown on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, and sucrose are utilized for growth. Utilization of raffinose is doubtful.

Chainia minutisclerotica Thirumalachar 1965. See *Streptomyces minutiscleroticus* (Thirumalachar) Pridham 1970.

Streptomyces minutiscleroticus (Thirumalachar) Pridham. Description and nomenclature: *Chainia minutisclerotica* Thirumalachar (184); *Streptomyces minutiscleroticus* (Thirumalachar) Pridham 1970, 41 (147). Type strain: HACC 147 = ATCC 17757 = ATCC 19346 = CBS 231.65 (147). ISP 5301 from M. J. Thirumalachar as HACC 147. ISP description by Group F-2.

Spore-chain morphology: Section *Spirales* (Fig. 162). Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 163).

Special morphological characteristics: Sclerotic granules are produced (Fig. 164-166). Minute sclerotic granules are produced on broad hyphae, often on the agar surface or vegetative substrate (Fig. 166). One observer compares these small sclerotia to actinosporangium-like formations, on

FIG. 155. *S. luteolutescens*. RF spore chains on oatmeal agar, 14 days. $\times 880$.

FIG. 156. *S. luteolutescens*. Smooth spores; electron micrograph from 28-day-old culture on salts-starch agar.

FIG. 157. *S. luteolutescens*. Unusual spores from salts-starch agar, 28 days. See Fig. 156.

FIG. 158. *S. luteoreticuli*. Umbellate monovercillate (BV) morphology on carbon-utilization medium plus inositol, 16 days. $\times 300$.

FIG. 159. *S. luteoreticuli*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 160. *S. mediterranei*. RA morphology on salts-starch agar, 7 days. (a) $\times 240$. (b) $\times 320$. RF morphology also may be seen, but sporulating aerial mycelium is usually thin or absent.

FIG. 161a, b. *S. mediterranei*. Folded spore surface with some irregularities resembling spines. Electron micrograph from 14-day-old culture on oatmeal agar.

oatmeal agar and salts-starch agar. Sclerotic granules are reported on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar in 7 to 21 days.

Color of colony: Aerial mass color in the Gray or Yellow color series (2dc, yellowish gray; 24½dc, pale yellow green; or 2ba, pale yellow) on yeast-malt agar and salts-starch agar; Yellow color series (2ba, pale yellow) on oatmeal agar and glycerol-asparagine agar.

Reverse side of colony: Strong brown on yeast-malt agar; grayish yellow to orange yellow or brown on oatmeal agar and salts-starch agar; yellowish brown, orange yellow or reddish brown on glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Some yellow pigment may or may not be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. When present, this pigment is not pH sensitive.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth with sucrose or raffinose.

Streptomyces mirabilis Ruschmann. Description: Ruschmann (163). Type strain: Ankermann strain (80) = Lederle Laboratories AC-680 (H. Tresner, personal communication, April 1968). ISP 5553 from H. Tresner, Lederle Laboratories, as AC-680. ISP description by Group E-7.

Spore-chain morphology: Section *Spirales* (Fig. 167). Sterile hyphae may be abundant; these are often flexuous or hooked. Mature spore chains are moderately long, with more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but sporulation may be poor, especially on yeast-malt agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 168).

Color of colony: Aerial mass color in the Gray color series (2fe, medium gray; 3fe, light brownish gray; also 3ig, 4ig, 3li, grayish brown and brownish gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Grayish yellow becoming moderate olive brown to dark olive or dark brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; grayish blue or grayish green and moderate yellowish brown on yeast-malt agar. Substrate pigment is not a pH indicator or is modified only slightly from olive brown to dark brown by 0.05 N NaOH on oatmeal agar and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and in trace

amounts in tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Reports vary on utilization of D-xylose. No growth or only a trace of growth with sucrose or raffinose.

Streptomyces moderatus (F. Reusser, U.S. Patent 3,317,400, May 2, 1967). Description: Reusser (160). Type strain: NRRL 3150 (160) = Upjohn Co. UC 2995 (Alma Dietz, Upjohn Co., personal communication, January 1968). ISP 5529 from T. G. Pridham, NRRL, as NRRL 3150. ISP description by Group E-5.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 169). Mature spore chains long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 170a, b, c).

Color of colony: Aerial mass color in the Red color series (5cb, grayish yellowish pink, or 3ec, grayish yellow, to 3ca, pale orange yellow) on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; White color series on oatmeal agar. (Aerial mycelium may be in the White color series on yeast-malt agar, salts-starch agar, or glycerol-asparagine agar if observations are made before 21 days.)

Reverse side of colony: Grayish yellow is usually modified to grayish yellowish pink, reddish brown, or strong brown in 14 to 21 days. Reverse mycelium pigment is not a pH indicator or is changed only slightly from light brown to light pinkish brown by the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Some red pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth, although growth on sucrose may be significantly less than on other carbon sources tested.

Streptomyces moro-okaensis Niida, Hama-moto, Tsuruoka, and Hara. Description: Niida et al. (130). Type strain: SF-337 (130) = ATCC 19166 (M. Oda, Meiji Seika Kaisha Ltd., personal communication, March 1967). ISP 5503 from E. F. Lessel, ATCC, as ATCC 19166. ISP description by Group E-5.

Spore-chain morphology: Section *Verticillati*;

FIG. 162. *S. minutiscleroticus*. (a) Spiral spore chains on salts-starch agar, 14 days. $\times 112$. (b) Yeast-malt agar, 14 days. $\times 812$.

FIG. 163. *S. minutiscleroticus*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 164. *S. minutiscleroticus*. Sclerotic granules at margin of submerged colony on salts-starch agar, 21 days. (a) $\times 192$, (b) $\times 812$.

FIG. 165. *S. minutiscleroticus*. Sclerotic granules 13 to 28 μm in diameter on yeast-malt agar, 7 days. $\times 1,900$.

FIG. 166. *S. minutiscleroticus*. Direct oil-immersion observation of minute sclerotia on broad hyphae on agar surface of salts-starch agar, 7 days. $\times 1,900$.

mature spore chains are predominantly umbellate monoverticillate (biverticillate) (Fig. 171). Mature spore chains are moderately long, often with more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 172).

Color of colony: Aerial mass color in the Yellow color series (1dc, 1cb, or 1¹/₂ ec, pale yellow green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (pale yellow to pale greenish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *i*-inositol, D-mannitol, D-fructose, and raffinose are utilized for growth. Utilization of rhamnose is doubtful. No growth or only a trace of growth with L-arabinose, sucrose, or D-xylose.

Streptomyces naraensis Okuda, Ashino, Egawa, and Suzuki. Descriptions: Okuda et al. (140, 141). Type strain: ATCC 13788 (U.S. Pat. 3,074,855). ISP 5508 from E. F. Lessel, ATCC, as ATCC 13788. ISP description by Group F-1.

Spore-chain morphology: Section *Spirales* (Fig. 173), but good spirals are rare, and flexuous spore chains or short chains with only hooks or incomplete spirals are common (Fig. 174). This morphology is seen on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; aerial mycelium may be poorly developed or absent on oatmeal agar. Spore surface: Smooth (Fig. 175).

Color of colony: Aerial mass color in the Gray color series (2fe or e, medium gray; 3fe, light brownish gray; or 5fe, light grayish reddish brown) on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; aerial mycelium is usually poorly developed or absent on oatmeal agar.

Reverse side of colony: No distinctive pigments (brown to olive brown on yeast-malt agar; grayish yellow, olive brown, or yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow, is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, D-fructose, rhamnose, sucrose, and raffinose are utilized for growth. Utilization of L-arabinose and

i-inositol is doubtful, and there is no growth or only a trace of growth with D-mannitol.

Streptomyces natalensis Struyk, Hoette, Drost, Waisvisz, Van Eek, and Hoogerheide. Descriptions: Struyk et al. (179); Netherlands Patent 87323, 1957; British Pat. Specif. 844,289, 1960. Type strain: Koninklijke Nederlandsche Gist-en Spiritusfabriek strain F = CBS 700.57 = NRRL 2651 (J. C. Hoogerheide, KNGS; G. A. deVries, CBS, personal communication, September 1966). ISP 5357 from G. A. deVries as CBS 700.57. ISP description by Group D-8.

Spore-chain morphology: Section *Spirales*; open spirals of five or more regular turns as well as partial spirals and strongly flexuous spore chains are seen on yeast-malt agar and oatmeal agar (Fig. 176). Sporulating aerial mycelium may be poorly developed or absent on salts-starch agar and glycerol-asparagine agar, and spirals are usually not observed on these media. Mature spore chains are moderately long, with more than 10 spores per chain. Spore surface: Spiny (Fig. 177).

Color of colony: Aerial mass color in the Gray to Red color series (2dc, yellowish gray, or 3fe, light brownish gray in the Gray color series; 4ge, light grayish reddish brown, in the Red color series). These colors are seen when good sporulating aerial mycelium is found on yeast-malt agar or oatmeal agar. White (nonsporulating) aerial mycelium may be found on salts-starch agar and glycerol-asparagine agar or may be absent on these media.

Reverse side of colony: No distinctive pigments (pale or grayish yellow or greenish yellow to light yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment (or only a faint trace of yellow) is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *i*-inositol, D-mannitol, and D-fructose are utilized for growth. Reports vary on the utilization of raffinose, sucrose, and D-xylose; utilization of these carbon sources is doubtful. No growth or only a trace of growth with L-arabinose or rhamnose.

Streptomyces neyagawaensis Yamamoto, Nakazawa, Horii, and Miyake. Description: Yamamoto et al. (218); see also Horii et al. (76). Type strain: IFO 3784 (Institute for Fermentation, Osaka, personal communication, March 1969). ISP 5588 from Institute for Fermentation as IFO 3784. ISP description by Group F-4.

Spore-chain morphology: Section *Spirales* (Fig. 178) on oatmeal agar and salts-starch agar. Short

FIG. 167. *S. mirabilis*. Spiral spore chains on yeast-malt agar, 7 days. $\times 448$.

FIG. 168. *S. mirabilis*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 169. *S. moderatus*. RF spore chains on yeast-malt agar, 21 days. $\times 600$.

FIG. 170. *S. moderatus*. Smooth spores. (a) Electron microscope silhouette from 10-day-old-culture on salts-starch agar. (b) Carbon repligraph from same preparation. (c) Scanning electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 171. *S. moro-okaensis*. Umbellate monoverticillate (BV) morphology. (a) Glycerol-asparagine agar, 14 days. $\times 250$. (b) Glycerol-asparagine agar, 21 days. $\times 600$.

FIG. 172. *S. moro-okaensis*. Smooth spores. (a) Electron micrograph from 14-day-old culture on oatmeal agar. (b) Scanning electron micrograph from 21-day-old culture on yeast-malt agar.

spore chains may form incomplete spirals (hooks) or flexuous to straight chains on yeast-malt agar and glycerol-asparagine agar. Spore chains are short on some media but long chains of 10 to 50 or more spores per chain may also be found. Spore-chain morphology is often difficult to observe when spore chains and aerial hyphae coalesce in black moist (hygroscopic) masses. Spore surface: Smooth (Fig. 179).

Special morphological characteristics: Surface of growth may become moist and black (hygroscopic) on older cultures.

Color of colony: Aerial mass color in the Gray color series (3fe, light brownish gray and 5fe, light grayish reddish brown on yeast-malt agar, oatmeal agar, and salts-starch agar; 2dc, yellowish gray or 5ih, brownish gray on glycerol-asparagine agar.

Reverse side of colony: Dark olive on yeast-malt agar; yellowish gray to light olive gray or brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment, or a trace of gray or olive brown pigment, is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces nigellus (Prokop. U.S. Pat. 3,094,461, June 18, 1963). Description: Prokop (151). Type strain: Abbott M-259 = NRRL 2920 (151). ISP 5490 from T. J. Oliver, Abbott Laboratories, as Abbott M-259 = NRRL 2920. ISP description by Group E-4.

Spore-chain morphology: Section *Spirales* (Fig. 180). Spirals are often open. Short spore chains often form loops, hooks, and imperfect spirals of smaller diameter than those normally identified as RA. Mature spore chains have 3 to 10 or often more than 10 spores per chain, but long chains are not found. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar, and carbon-utilization media. Spirals are best developed on salts-starch agar and on carbon-utilization media with a suitable carbon source. Spore surface: Smooth (Fig. 181).

Color of colony: Aerial mass color in the Gray color series (e, d, or 2fe, medium gray, or 3fe, light brownish gray, to 4li, brownish gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (colorless to pale or grayish yellow on oatmeal

agar, salts-starch agar, and glycerol-asparagine agar; light yellow to orange yellow on yeast-malt agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Chainia nigra [Thirumalachar]. Description: Specimen received from M. J. Thirumalachar; no record of publication found. Type strain: HACC 146 (Thirumalachar, personal communication, April 1965) = ATCC 17756 (Lessel and Hatt [113]). ISP 5302 from M. J. Thirumalachar as HACC 146. ISP description by group F-3.

Spore-chain morphology: Section *Spirales* (Fig. 182). Spiral spore chains often appear to coalesce in moist globules (Fig. 183) or to show autolysis. Mature spore chains may have more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 184).

Special morphological characteristics: Sclerotia-like structures are formed in 7 to 14 days on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color of colony: Aerial mass color in the White or Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tab in the Gray color series is 2dc, yellowish gray.

Reverse side of colony: Dark brown on yeast-malt agar and sometimes on glycerol-asparagine agar; usually grayish yellow to yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar and tyrosine agar. A weak brown discoloration may or may not appear in tryptone-yeast broth after 4 days. Two observers report that no pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar; one observer reports dark yellowish brown in yeast-malt agar, oatmeal agar, and glycerol-asparagine agar in 14 to 21 days. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces nobilis Baldacci, Locci, and

FIG. 173. *S. naraensis*. Rare spiral spore chains from 14-day-old growth on oatmeal agar. $\times 600$.

FIG. 174. *S. naraensis*. Short spore chains with hooks, loops, and partial spirals on salts-starch agar, 14 days. $\times 300$.

FIG. 175. *S. naraensis*. Smooth spores. (a) Electron micrograph from 21-day-old culture on yeast-malt agar. (b) Scanning electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 176. *S. natalensis*. Open spirals on yeast-malt agar, 7 days. $\times 500$.

FIG. 177. *S. natalensis*. Spiny spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 178. *S. neyagawaensis*. Spiral spore chains from 7-day-old culture on salts-starch agar. $\times 500$.

FIG. 179. *S. neyagawaensis*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

Farina. Description: Baldacci, Locci, and Farina (12). Type strain: IPV-631. ISP 5441 from E. Baldacci as IPV-631. ISP description by Group D-2.

Spore-chain morphology: Pseudo-verticillate branching resembling *Streptovorticillum* is common (Fig. 185). Baldacci et al. discussed this characteristic in the original description for the species (12). Flexuous spore chains and hooked or looped chains arising singly or alternately along axial hyphae also reported by ISP observers. The wavy spore chains and terminal hooks and loops suggest RA morphology; spore chains are moderately short with 6 to 30 spores per chain. (Because of the confusing resemblance between the morphology shown in Fig. 185 and true verticillate morphology of the genus *Streptovorticillum*, ISP 5441 was resubmitted to E. Baldacci for further study. In a personal communication, October 1969, he reports: "We have examined the strain used in the cooperative study, the strain you recently sent us, the original culture, the strain deposited in ATCC and the results are as follows. All strains comply with the original description of *S. nobilis* and none shows verticillate structures. Pseudo-verticillate branching is present as already described.") This morphology is seen on yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 186).

Color of colony: Aerial mass color in the Red or White color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. One observer reports a red "secondary mycelium" with traces of white "tertiary mycelium" on yeast-malt agar. Both red and white aerial mycelium were reported on salts-starch agar and glycerol-asparagine agar. Sporulating aerial mycelium is often thin and may be absent on oatmeal agar. (Colors reported for mature aerial mycelium include 5ge, light reddish brown; 7ca, light yellowish pink; and 6ec and 5dc, grayish yellowish pink).

Reverse side of colony: Distinctive reddish orange on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; reddish orange to strong reddish brown on yeast-malt agar. On oatmeal agar, salts-starch agar, and glycerol-asparagine agar, the reverse mycelium pigment may be changed slightly from red to orange by 0.05 N NaOH or from red to violet with the addition of 0.05 N HCl. (Two of three observers report no change.)

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-mannitol, and raffinose are utilized for growth. Reports vary on the utilization of all other carbohydrates tested, including L-arabinose, D-xylose, *i*-inositol, D-fructose, rhamnose, and sucrose. Two observers report utilization of all of these carbon sources except rhamnose.

Streptomyces nogalater Bhuyan and Dietz. Description: Bhuyan and Dietz (24). Type strain: NRRL 3035 (A. Dietz, Upjohn Co., personal communication, March 1968). ISP 5546 from T. G. Pridham, NRRL, as NRRL 3035. ISP description by Group E-6.

Spore-chain morphology: Section *Rectiflexibiles* to *Retinaculiaperti* or possibly *Spirales*. Spore chains may be straight, strongly flexuous (Fig. 187), or in irregular spirals. Straight to flexuous chains are usually seen on yeast-malt agar and glycerol-asparagine agar; strongly flexuous, RA or S spore chains may be found on oatmeal agar and salts-starch agar. Spore surface: Smooth (Fig. 188).

Color of colony: Aerial mass color in the Gray color series (3fe or 4ig, light brownish gray; 4li, brownish gray; 3ig, grayish yellowish brown; or 2ih, light olive gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Orange yellow to light yellowish pink on yeast-malt agar; light yellow to orange yellow on oatmeal agar; pale or grayish yellow on salts-starch agar and glycerol-asparagine agar. One observer reports that the reverse mycelium pigment is a pH indicator changing from orange to dark red or dark violet with the addition of 0.05 N NaOH and from orange to yellow orange with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Red or yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. One observer reports that this pigment is pH sensitive, showing the same changes observed with the reverse mycelium pigments when 0.05 N NaOH or HCl is added.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, rhamnose, and raffinose are probably utilized for growth, but reports vary for L-arabinose, D-fructose, and rhamnose. No growth or only a trace of growth is seen with sucrose or *i*-inositol.

Streptomyces novaecaesareae Waksman and Henrici. Descriptions: Waksman and Henrici (208, p. 951). *Actinomyces violaceus-caeseri* (sic) Waksman and Curtis 1916, 111-112 and 127 (207); Waksman 1919, 158-160 (203). See also Pridham et al. (150, p. 209). Type strain: CBS

FIG. 180. *S. nigellus*. Spirals and terminal hooks or coils on salts-starch agar, 7 days. $\times 280$.

FIG. 181. *S. nigellus*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 182. *Chainia nigra*. Spiral spore chains on yeast-malt agar, 7 days.

FIG. 183a, b. *Chainia nigra*. Coalesced spirals on oatmeal agar, 14 days. $\times 800$.

FIG. 184. *Chainia nigra*. Smooth spores; electron micrograph from 14-day-old culture on half-strength Emerson's potato dextrose agar.

FIG. 185. *S. nobilis*. Verticillate or pseudo-verticillate morphology on yeast-malt agar, 21 days. $\times 900$.

FIG. 186. *S. nobilis*. Smooth spores; electron micrograph from 7-day-old culture on salts-starch agar.

(Waksman and Curtis) = CBS 134.20 = NRRL B-1267 = IMRU 3831 (G. A. deVries, Ruth Gordon, T. G. Pridham, personal communications, September 1966, December 1969). ISP 5358 from G. A. deVries, CBS, as CBS 134.20. ISP description by Group E-1.

Spore-chain morphology: Section undetermined. Aerial mycelium is not found on any of the ISP media. The original description for *Actinomyces violaceus-caeseri* Waksman and Curtis (207) states that on Czapek agar: "Aerial mycelium produced very late; . . . Conidia could not be demonstrated," and little or no aerial mycelium was reported for other media included in the original description. Spore surface: Undetermined.

Color of colony: Could not be determined.

Reverse side of colony: Distinctive grayish blue or blue green to grayish violet or red violet pigment is produced on oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but the pigment is not always present on these media. Reverse mycelium is usually grayish yellow to grayish olive on yeast-malt agar. Reverse mycelium pigment is a pH indicator, changing from pale violet to pale grayish blue with the addition of 0.05 N NaOH and from pale violet to reddish violet or pale grayish red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Blue or violet pigment is sometimes found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; it is most consistently present in oatmeal agar. This pigment is pH sensitive, showing the same changes reported for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Chainia ochracea Kuznetsov 1962. See *Streptomyces ochraceiscleroticus* (Kuznetsov) Pridham 1970.

Streptomyces ochraceiscleroticus (Kuznetsov) Pridham. Description and nomenclature: *Chainia ochracea* Kuznetsov 1962, 534-539 (110); *Streptomyces ochraceiscleroticus* (Kuznetsov) Pridham 1970, 22 (147). Type strain: 10A-30 (Kuznetsov, op. cit.) = RIA 710 = ATCC 15814 (Pridham, op. cit.). ISP 5594 from E. F. Lessel, ATCC, as ATCC 15814. ISP description by Group F-5.

Spore-chain morphology: Section *Spirales* (Fig. 189). Mature spore chains are moderately long with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 190).

Special morphological characteristics: Sclero-

tia-like granules are formed on glycerol-asparagine agar (Fig. 191) and other media.

Color of colony: Aerial mass color in the Yellow or Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. White or gray aerial mycelium may also be seen on these media. Nearest matching color tab recorded for the Yellow color series is 2ba, pale yellow; nearest tabs in the Red color series are 4ie, light brown, and 3ea, light orange-yellow.

Reverse side of colony: Strong brown, moderate orange, or orange yellow on yeast-malt agar and glycerol-asparagine agar; light yellow, yellow or light yellowish brown on oatmeal agar and salts-starch agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Actinomyces ochroleucus Neukirch. Description: Neukirch 1902, 4-13. *Actinomyces albus* subsp. *ochroleucus* (Neukirch) Wollenweber 1920, 13 (214). Type strain (suggested neotype): ATCC 3006 = CBS 138.21 strain Wollenweber ([214, p. 14]; G. A. deVries, CBS, personal communication, March 1969). ISP 5591 from E. F. Lessel, ATCC, as ATCC 3006. ISP description by Group F-5.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 192). Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but sporulating aerial mycelium may be poorly developed on oatmeal agar and salts-starch agar. Spore surface: Smooth (Fig. 193).

Color of colony: Aerial mass color in the Yellow color series (1½db, pale greenish yellow; 1½ec, pale yellowish green; or 1ba, 2ba, or 2db, pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (yellowish brown to olive brown on yeast-malt agar; pale light yellow to greenish yellow or light olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment, or only a trace of greenish yellow, is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

FIG. 187. *S. nogalater*. Strongly flexuous spore chains on oatmeal agar, 8 days. $\times 920$. (RA to spiral chains are also reported).

FIG. 188. *S. nogalater*. Smooth spores; electron micrograph from 7-day-old culture on oatmeal agar.

FIG. 189. *S. ochraceiscleroticus* (*Chainia ochracea*). Scanning electron micrograph showing spiral spore chains. $\times 2,400$.

FIG. 190. *S. ochraceiscleroticus*. Smooth spores. (a) Electron micrograph silhouette. (b) Scanning electron micrograph from 21-day-old culture on salts-starch agar. Spiral shown is same as in lower right corner of Fig. 189.

FIG. 191. *S. ochraceiscleroticus*. Sclerotium from 21-day-old culture on salts-starch agar. $\times 1,200$. Note spirals on surface of sclerotial body.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth. No growth or only a trace of growth with *i*-inositol, rhamnose, sucrose, or raffinose.

Streptomyces odorifer (Rullmann) Waksman. Descriptions: *Cladothrix odorifera* Rullmann 1895, 44 (162); *Streptomyces odorifer* (Rullmann) Waksman (209, p. 79–80). Type strain (neotype): IMRU 3334 (206, p. 251). ISP 5347 from S. A. Waksman as IMRU 3334. ISP description by Group F-1. (Note: Group D-1 studied CBS strain *Actinomyces odorifer* [Rullmann] Lieske = *S. albus* strain *odorifer* which CBS received from Institut Pasteur, Paris, in March 1914 [ISP 5370]. The CBS strain differs from the IMRU strain in melanin production and in carbon utilization. Two of three observers report darkening of peptone-yeast-iron agar and tryptone-yeast broth, but not tyrosine agar, by the CBS strain in 2 or 4 days; the IMRU strain is melanin negative. The CBS strain utilizes rhamnose but does not utilize sucrose, whereas the IMRU strain uses sucrose and not rhamnose. The two strains were alike in utilization of other carbon sources and in all other ISP characteristics.)

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 194). Flexuous chains are common. Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but aerial mycelium may be poorly developed on salts-starch agar. Spore surface: Smooth (Fig. 195).

Color of colony: Aerial mass color in the Yellow color series (1ba, 2ba or 2db, pale yellow, or 1dc, pale yellow green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (strong brown to olive brown on yeast-malt agar; light yellow to greenish yellow, grayish yellow, or light brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment is found in the medium in yeast-malt agar and salts-starch agar. (One observer also reports yellow pigment in oatmeal agar and glycerol-asparagine agar.) This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and sucrose are utilized for growth. No growth or only a trace of growth with *i*-inositol, rhamnose, or raffinose.

Actinomyces oligocarboxophilus (Beijerinck and van Delden) Lantusch. Descriptions: It is not clear from the original description of *Bacillus oligocarboxophilus* Beijerinck and van Delden 1903 (19) that this isolate was an actinomycete; but see also

Beijerinck (17, 18). The description of *Actinomyces oligocarboxophilus* (Beijerinck and van Delden) Lantusch 1922, 309–319 (111) is apparently based upon a new isolate by Lantusch and not on Beijerinck and van Delden's type strain. Foster (50) made incidental reference to *Streptomyces oligocarboxophila* (sic) = *Carboxydomonas oligocarboxophilus* but did not identify or describe the strain or authors. Type strain: Undetermined. CBS 101.18, strain Beijerinck, was received by CBS directly from Beijerinck's laboratory in March 1918 and is presumed to be the type strain (G. A. deVries, CBS, personal communication, May 1968; Hütter [80, p. 233]), although it differs from the original description in some characteristics (74, 75, 80). ISP 5589 from G. A. deVries as CBS 101.18 strain Beijerinck. ISP description by Group F-5.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 196 and 197). Mature spore chains are long with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 198).

Color of colony: Aerial mass color in the Yellow color series (1ba, 2ba, 2db, pale yellow; 1cb, pale yellow green; or 1½db, pale greenish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (pale or grayish yellow to light olive brown) on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of sucrose and raffinose is doubtful. No growth or only a trace of growth with *i*-inositol.

Chainia olivacea Thirumalachar 1960. See *Streptomyces olivaceiscleroticus* Pridham 1970.

Streptomyces olivaceiscleroticus Pridham (*Chainia olivacea* Thirumalachar). Descriptions: *Chainia olivacea* Thirumalachar in Kalakutskii and Krasil'nikov 1960, 45 (89); Thirumalachar and Sukapure (185); *Streptomyces olivaceiscleroticus* Pridham 1970, 41 (147) (= *Chainia olivacea* Thirumalachar). Type strain: IMRU 3751 = ATCC 15722 = CBS 296.66 (Pridham op. cit.). ISP 5595 from E. F. Lessel, ATCC, as ATCC 15722. ISP description by Group F-5.

Spore-chain morphology: Section *Spirales* (Fig. 199). Mature spore chains generally contain 10 to 50 spores per chain. This morphology may be seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, or

FIG. 192. *A. ochroleucus*. (a) RF spore chains on oatmeal agar, 14 days. $\times 474$. (b) Scanning electron micrograph from 21-day-old culture on yeast-malt agar. $\times 2,400$.

FIG. 193. *A. ochroleucus*. Smooth spores. (a) Electron micrograph silhouette. (b) Scanning electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 194. *S. odorifer*. RF spore chains on glycerol-asparagine agar, 14 days. $\times 960$.

FIG. 195. *S. odorifer*. Smooth spores; electron micrograph from 21-day-old culture on glycerol-asparagine agar.

FIG. 196. *A. oligocarophilus*. RF spore chains on yeast-malt agar, 8 days.

FIG. 197. *A. oligocarophilus*. Scanning electron micrograph showing RF chains of collapsed spores. $\times 2,400$.

FIG. 198. *A. oligocarophilus*. Smooth spores. (a) Electron micrograph from 21-day-old culture on salts-starch agar. (b) Scanning electron micrograph from 21-day-old culture on yeast-malt agar.

sporulating aerial mycelium may be poorly developed on various media. Spore surface: Smooth (Fig. 200).

Special morphological characteristics: Tight spirals may coalesce (simple sclerotia?) (Fig. 201). One of three observers reports sclerotia formation (Fig. 202).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray; 3ge, light grayish yellowish brown; 3-4li, brownish gray; or 2ge, light olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. White or yellow (2ba, pale yellow) aerial mycelium is also reported.

Reverse side of colony: No distinctive pigments (grayish yellow to olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Reddish pigment is sometimes found in the medium in yeast-malt agar, oatmeal agar, and salts-starch agar. Yellowish green pigment may be present in yeast-malt agar and glycerol-asparagine agar, or pigment may be absent in these media; pigments are not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces omiyaensis Umezawa and Okami. Description: Umezawa and Okami (195). Type strain: NIHJ 102 (195) = NRRL B-1587 (T. G. Pridham, NRRL, personal communication, April 1968). ISP 5552 from T. G. Pridham as NRRL B-1587. ISP description by Group E-6.

Spore chain morphology: Section *Rectiflexibiles* (Fig. 203). Mature spore chains are generally long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 204).

Color of colony: Aerial mass color in the Gray color series (d, light gray, or 2dc, yellowish gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (light yellow, pale yellow or grayish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, and rhamnose are utilized for growth. Only a trace of growth is seen on L-arabinose or D-fructose, and

i-inositol, D-mannitol, raffinose, and sucrose are not utilized.

Streptovorticillium orinoci Cassinelli, Grein, Orezzi, Pennella, and Sanfilippo. Description: Cassinelli et al. (30). Type strain: Farmitalia 1882 FI (30) = ATCC 23202 (B. Camerino, personal communication, July 1968). ISP 5571 from B. Camerino, Farmitalia Istituto Ricerche de Base as 1882 FI. ISP description by Group F-3.

Spore-chain morphology: Section *Umbellate Monoverticillate* (= *Streptomyces* Section *Verticillati*, biverticillate) (Fig. 205). Mature spore chains generally contain more than 10 spores per chain. This morphology is usually not seen on ISP yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but sporulating aerial mycelium may be observed in the scant growth on carbon-utilization medium enriched with raffinose, D-fructose, rhamnose, or *i*-inositol or on half-strength Emerson potato-dextrose agar. Spore surface: Smooth (Fig. 206).

Color of colony: Sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Aerial mass color on carbon-utilization medium plus fructose is in the Gray color series.

Reverse side of colony: Strong yellow or deep yellow on yeast-malt agar, glycerol-asparagine agar, and on half-strength Emerson potato-dextrose agar. Colorless to pale or grayish yellow on salts-starch agar and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose is utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, or raffinose.

Streptomyces ostreogriseus (Whitfield et al., Glaxo Labs. Ltd., British Pat. Specif. 793,797, April 23, 1958). Description: Whitfield et al. (213); see also Ball et al. (13, p. 1-24) and Bessel et al. (23). Type strain: Glaxo Laboratories Ltd. E. 129 = NRRL 2558 = NCIB 8792 (213). ISP 5511 from T. G. Pridham, NRRL, as NRRL 2558. ISP description by Group E-5.

Spore-chain morphology: Section *Rectiflexibiles*. Mature spore chains are long, often with more than 50 spores per chain (Fig. 207). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 208).

Color of colony: Aerial mass color in the Gray color series (d, light gray, or 3fe, light brownish gray) on yeast-malt agar, oatmeal agar, and salts-starch agar; Gray or White color series on glycerol-asparagine agar.

FIG. 199. *S. olivaceiscleroticus* (*Chainia olivacea*). Spiral spore chains. (a) $\times 970$ on salts-starch agar, 14 days. (b) Scanning electron micrograph on salts-starch agar, 21 days. $\times 2,400$.

FIG. 200. *S. olivaceiscleroticus* (*Chainia olivacea*). Smooth spores; scanning electron micrograph from 21-day-old culture on salts-starch agar.

FIG. 201. *S. olivaceiscleroticus* (*Chainia olivacea*). Tight spirals adhere to one another and appear to coalesce into moist masses or globules. From 22-day-old culture on yeast-malt agar. See also Fig. 199b.

FIG. 202. *S. olivaceiscleroticus* (*Chainia olivacea*). Sclerotia; scanning electron micrograph from 21-day-old culture on salts-starch agar. $\times 600$.

FIG. 203. *S. omiyaensis*. RF spore chains on oatmeal agar, 8 days. $\times 430$.

FIG. 204. *S. omiyaensis*. Smooth spores; electron micrograph from 28-day-old culture on oatmeal agar.

FIG. 205. *Stv. orinoci*. Umbellate monoverticillate (BV) morphology on salts-starch agar, 14 days. $\times 850$.

FIG. 206. *Stv. orinoci*. Smooth spores; electron micrograph from 14-day-old culture on half-strength Emerson potato-dextrose agar.

Reverse side of colony: No distinctive pigments (grayish yellow on oatmeal agar and glycerol-asparagine agar, light yellowish brown to brown on yeast-malt agar, and salts-starch agar).

Color in medium: Melanoid pigments are formed weakly or not at all in peptone-yeast-iron agar. Melanoid pigments are not formed in tyrosine agar. No pigment is found in the medium in yeast-malt agar and salts-starch agar. A faint greenish or yellowish pigment may sometimes be found in oatmeal agar and glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, sucrose, and raffinose are utilized for growth. Utilization of *i*-inositol is doubtful. No growth or only a trace of growth with D-mannitol.

Streptomyces pactum Bhuyan, Dietz, and Smith. Description: Bhuyan, Dietz, and Smith (25). Type strain: UC 2432 = NRRL 2939 (A. Dietz, Upjohn Co., personal communication, January 1968). ISP 5530 from T. G. Pridham, NRRL, as NRRL 2939. ISP description by Group E-6.

Spore-chain morphology: Section *Spirales* (Fig. 209). Mature spore chains contain 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but sporulation is usually poor on glycerol-asparagine agar. Spore surface: Hairy (Fig. 210).

Color of colony: Aerial mass color in the Gray color series (d, light gray, or e, medium gray) on oatmeal agar and salts-starch agar; Gray or Blue color series on oatmeal agar. Nearest matching color tab in the Blue color series is 19fe, pale blue. On glycerol-asparagine agar, aerial mycelium is in the White color series.

Reverse side of colony: No distinctive pigments (light yellowish brown, grayish yellow, or grayish greenish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, or glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose is utilized for growth, and only a trace of growth is reported with D-fructose. No growth with L-arabinose, D-xylose, *i*-inositol, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces pallidus (Reusser. U.S. Pat. 3,317,400, May 2, 1967). Description: Reusser (160). Type strain: NRRL 3149 (160). ISP 5531 from T. G. Pridham, NRRL, as NRRL 3149. ISP description by Group E-4.

Spore-chain morphology: Section *Spirales* or *Verticillati*, monoverticillate-spira (Fig. 211). Three observers placed this strain in section *Verticillati* as a monoverticillate form with imperfect spirals or hooks and loops of small diameter at the ends of short, unbranched spore chains. Hooks, loops, and primitive spirals of large diameter, as found in true RA cultures, are not reported. Spore surface: Smooth (Fig. 212).

Color of colony: Aerial mass color in the Red color series (5ca, light yellowish pink, or 5cb, grayish yellowish pink) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; white aerial mycelium may also be seen, especially on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (light or pale yellow to light olive-brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; orange yellow or light brown on yeast-malt agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces paraguayensis (de Almeida) Waksman. Description: *Actinomyces paraguayensis* de Almeida 1940, 201-203 (37). *Streptomyces paraguayensis* (de Almeida) Waksman 1961, 255 (206). Type strain: CBS strain Gammel = CBS 104.48 received by CBS from J. A. Gammel, Western Reserve Univ., Cleveland, Ohio, USA 1948 = strain 285 from Laboratorio de Microbiologia, São Paulo, Brazil. ISP 5567 from G. A. deVries, CBS, as CBS 104.48 (strain Gammel). ISP description by Group F-3.

Spore-chain morphology: Section *Spirales* (Fig. 213). Spirals are reported on yeast-malt agar, oatmeal agar, and salts-starch agar, but sporulating aerial mycelium is generally thin or absent on ISP media. No aerial mycelium is reported on glycerol-asparagine agar, and collaborators were unable to get good aerial mycelial growth on such special media as Gauze Medium No. 1 or half-strength Emerson potato-dextrose agar. Spore surface: Smooth (Fig. 214).

Special characteristics: This organism was originally isolated from cutaneous lesions of a human mycetoma of the thorax (37).

Color of colony: The thin aerial mycelium sometimes found on yeast-malt agar, oatmeal

FIG. 207. *S. osteogriseus*. Flexuous (RF) spore chains on yeast-malt agar, 21 days. $\times 600$.

FIG. 208. *S. osteogriseus*. Smooth spores; scanning electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 209. *S. pactum*. Spirals on oatmeal agar, 7 days. $\times 920$.

FIG. 210. *S. pactum*. Hairy spores; electron micrograph from 8-week-old culture on salts-starch agar.

FIG. 211. *S. pallidus*. (a) Imperfect or irregular spirals on glycerol-asparagine agar, 20 days. $\times 200$. (b) Hooks and loops of small diameter distributed in a manner suggesting monoverticillate morphology; yeast-malt agar, 8 days. $\times 280$.

FIG. 212. *S. pallidus*. Smooth spores; electron micrograph from 7-day-old culture on oatmeal agar.

agar, or salts-starch agar is in the White color series.

Reverse side of colony: Olive brown to strong brown on yeast-malt agar; grayish yellow, orange yellow, strong yellow or brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not found in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. A blue, pH-sensitive pigment is reported by one observer in half-strength Emerson potato-dextrose agar. Blue-gray needle-like crystals are found on the surface of this special medium.

Carbon utilization: D-Glucose, L-arabinose, and D-fructose are utilized for growth. Reports vary on the utilization of sucrose, *i*-inositol, D-mannitol, and raffinose, but utilization of these carbon sources is doubtful, and there is no growth with rhamnose or D-xylose.

Streptovercillium parvisporogenes Locci, Baldacci, and Petrolini Baldan (Routien, in Chas. Pfizer and Co., Inc., British Pat. Specif. 832,391, April 6, 1960). Descriptions: Routien, in Chas. Pfizer and Co. (32); see also Canadian Pat. 619,094, April 25, 1961; Locci, Baldacci, and Petrolini Baldan (116, p. 37). Type strain: ATCC 12568 (116). ISP 5473 from J. Routien, Chas. Pfizer and Co., as ATCC 12568. ISP description by Group E-1.

Spore-chain morphology: Section *Verticillati*, umbellate monovercillate (biverticillate) (Fig. 215). This morphology is seen on yeast-malt agar and oatmeal agar; a sporulating aerial mycelium is usually not produced on salts-starch agar and may also be absent on glycerol-asparagine agar. Spore surface: Smooth or with some surface irregularities (Fig. 216).

Color of colony: Aerial mass color in the Red, White, or Yellow color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. The yellow color (1ba, 2ba, or 2db, pale yellow) is representative of aerial color in the absence of sporulation. Aerial mass color should be determined on a sporulating surface. Mature (21 day) sporulating aerial mycelium on oatmeal agar and on carbon-utilization medium plus fructose is in the Red color series (3ca, pale orange yellow).

Reverse side of colony: No distinctive pigments (pale or grayish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; yellowish brown or olive brown on yeast-malt agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth; weakly or not at all in tyrosine agar. No pigment, or only a trace of yellow, is found

in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose and *i*-inositol are utilized for growth. Reports vary on utilization of D-mannitol, and utilization of D-fructose is doubtful. Only a trace of growth is seen on L-arabinose, D-xylose, rhamnose, sucrose, and raffinose.

Streptomyces parvus (Krainsky) Waksman and Henrici. Description: *Actinomyces parvus* Krainsky 1914, 662 (99); *Sterptomyces parvus* (Krainsky) Waksman and Henrici 1948, 939 (208). Type strain: Suggested neotype is IMRU 3686 according to Waksman (206). IMRU 3686 = NRRL B-1455 (Ruth Gordon for S. A. Waksman, personal communication, June 1966). ISP 5348 from S. A. Waksman as IMRU 3686. ISP description by Group D-1.

Spore-chain morphology: Section *Rectiflexibiles*. Mature spore chains generally contain 10 to 50 or sometimes more than 50 spores per chain (Fig. 217). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 218).

Color of colony: Aerial mass color in the Yellow color series (1ba, 2ba, pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (light yellow to light greenish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth on sucrose, *i*-inositol, and raffinose.

Streptomyces peruviansis (anonymous, Societe des Usines Chimiques Rhone-Poulenc, British Pat. Specif. 846801, August 31, 1960). Description: Societe des Usines Chimiques Rhone-Poulenc (177). Type strain: Rhone-Poulenc 6227 = NRRL 2757 (177). ISP 5592 from C. W. Hesseltine, NRRL, as NRRL 2757. ISP description by Group F-5.

Spore-chain morphology: Section *Spirales* (Fig. 219). Regular spirals of 2 to 10 turns are common. Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal

agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 220) or sometimes smooth (Fig. 221).

Color of colony: Aerial mass color in the Blue or White color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Blue aerial mycelium is most consistently produced on salts-starch agar. Nearest matching color tab in the Blue color series is 19dc, pale blue.

Reverse side of colony: No distinctive pigments (colorless to light or grayish yellow on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction may be weak or delayed in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces phaeofaciens Maeda, Okami, Taya, and Umezawa. Description: Maeda et al. (119). Type strain: NIHJ T-23 (119) = CBS 426.64 = ATCC 15034 = NRRL B-1516 (G. A. deVries, personal communication, September 1966). ISP 5367 from G. A. deVries, CBS, as CBS 426.64. ISP description by Group D-1.

Spore-chain morphology: Section *Spirales*. Mature spore chains are long, with 10 to 50 or more spores per chain (Fig. 222). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 223).

Color of colony: Aerial mass color usually in the Gray color series (3ih, dark gray; 3ig, grayish yellowish brown; 3ge, light grayish yellowish brown; or 5fe, light grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; the yellow to reddish brown aerial mycelium may also fall in the Red color series as represented by color tab 4ge, light grayish reddish brown.

Reverse side of colony: No distinctive pigments (greenish yellow to light olive brown on yeast-malt agar; pale yellow to light olive gray on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but are formed only weakly or as trace amounts in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth with sucrose or raffinose.

Chainia poonensis Thirumalachar 1960. See *Streptomyces poonensis* (Thirumalachar) Pridham 1970.

Streptomyces poonensis (Thirumalachar) Pridham. Descriptions: *Chainia poonensis* Thirumalachar (89); *Streptomyces poonensis* (Thirumalachar) Pridham 1970, 42 (147). Type strain: IMRU 3752 = ATCC 15723 = CBS 295.66 (Pridham, op. cit.). ISP 5596 from E. F. Lessel, ATCC, as ATCC 15723. ISP description by Group F-6.

Spore-chain morphology: Section *Spirales* (Fig. 224). Mature spore chains generally contain 3 to 10 or more spores per chain. Aerial mycelium may be absent or spiral spore chains may be seen on yeast-malt agar and salts-starch agar. Straight spore chains are reported on oatmeal agar. Spore surface: Smooth (Fig. 225).

Special morphological characteristics: Sclerotia are abundant on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar in 14 days (Fig. 226). One observer (Prausser) reports L-diaminopimelic acid and no arabinose in the cell wall, placing this strain in cell-wall type I (15).

Color of colony: Aerial mass color in the White color series on yeast-malt agar, oatmeal agar, or salts-starch agar when aerial mycelium is produced. Aerial mycelium is usually not seen on

FIG. 213. *S. paraguayensis*. Spiral spore chains. (a) Open spirals on glycerol-asparagine agar, 8 days. $\times 800$. (b) Tight spirals on salts-starch agar, 14 days. $\times 850$.

FIG. 214. *S. paraguayensis*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 215. *Stv. parvisporogenes*. Umbellate monoverticillate (BV) morphology on carbon-utilization medium plus mannose, 10 days. $\times 600$.

FIG. 216. *Stv. parvisporogenes*. Smooth to warty spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 217. *S. parvus*. RF spore chains on oatmeal agar, 14 days. $\times 812$.

FIG. 218. *S. parvus*. Smooth spores; chromium-shadowed electron micrograph from 26-day-old culture on oatmeal agar.

FIG. 219. *S. peruvienensis*. Spiral spore chains. (a) Oatmeal agar, 14 days. $\times 970$. (b) Scanning electron micrograph, salts-starch agar, 21 days. $\times 1,200$.

FIG. 220. *S. peruvienensis*. Spiny spores; scanning electron micrograph from 21-day-old culture on salts-starch agar (cf. Fig. 221).

FIG. 221. *S. peruvienensis*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

glycerol-asparagine agar and may be absent on oatmeal agar or other ISP media.

Reverse side of colony: Colorless on glycerol-asparagine agar; yellow to yellow brown is modified by red becoming reddish brown, brownish pink, or purplish pink on yeast-malt agar, oatmeal agar, and salts-starch agar within 21 days. Only one of three observers reports reverse mycelium pigment is pH sensitive, changing from pink to violet with the addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Two observers report no pigment in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; one observer reports pinkish pigment in yeast-malt agar, oatmeal agar and salts-starch agar. He reports that this pigment is pH sensitive, changing from pink to violet with the addition of 0.05 N NaOH.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, and D-fructose are utilized for growth. Reports vary on utilization of rhamnose; no growth or only a trace of growth with sucrose or raffinose.

Streptomyces prasinusporus Tresner, Hayes, and Backus. Description: Tresner, Hayes, and Backus (188). Type strain: Lederle BD-278 = ATCC 17918 (188). ISP 5506 from H. T. Tresner as Lederle BD-278 = ATCC 17918. ISP description by Group E-3.

Spore-chain morphology: Section *Spirales* with irregular spirals of a few turns and loops and hooks of small diameter (Fig. 227). Spirals are often clumped or tangled. Mature spore chains are generally short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Hairy, with short hairs (Fig. 228).

Color of colony: Aerial mass color usually in the Green color series when good sporulation occurs on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar (11i, olive gray; 11g, light grayish olive, or 24½ih, dark greenish gray). Aerial mass color may also be in the Gray color series (2ih, light olive gray or, if sporulating aerial mycelium is less well developed, g, medium gray, or 2dc, yellowish gray).

Reverse side of colony: No distinctive pigments (pale yellow to light olive gray on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; grayish greenish yellow on yeast-malt agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. No pigment

is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of sucrose and raffinose is doubtful.

Streptomyces pulcher (J. B. Routien, in Rao, Renn, and Marsh. U.S. Pat. 3,311,357, March 28, 1967). Description: Rao, Renn and Marsh (158). Type strain: Chas. Pfizer and Co. BA-15934 = ATCC 13849 (158). ISP 5566 from J. B. Routien, Chas. Pfizer and Co., as BA-15934 = FD 18464 = ATCC 13849. ISP description by Group F-3.

Spore-chain morphology: Section *Spirales* to *Retinaculiaperti*. Short spore chains often form incomplete or imperfect spirals or hooks and loops (Fig. 229). The short chains (generally with more than 10 spores per chain) are not typical of the hooks, loops, and open spirals on long chains of true RA cultures. This morphology is sometimes seen on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but ISP observers do not agree on the medium showing best aerial mycelium and spore-chain morphology. Spore surface: Smooth (Fig. 230a) to warty (Fig. 230b).

Color of colony: Aerial mass color in the Gray color series when adequate sporulating aerial mycelium is formed on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar; aerial mycelium may be white or absent on some media. Nearest matching color tabs in the Gray color series range from b and 2fe, medium gray, to 2ih, light olive gray, and 3ih, dark gray.

Reverse side of colony: Olive brown to orange brown on yeast-malt agar; colorless, pale or grayish yellow or light yellowish brown on oatmeal agar and salts-starch agar; colorless to reddish orange on glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth with sucrose or raffinose.

Chainia purpurogena Thirumalachar 1964. See *Streptomyces purpurogeniscleroticus* (Thirumalachar) Pridham 1970.

Streptomyces purpurogeniscleroticus Pridham (*Chainia purpurogena* Thirumalachar). De-

FIG. 222. *S. phaeofaciens*. Spiral spore chains on salts-starch agar, 18 days. $\times 500$.

FIG. 223. *S. phaeofaciens*. Smooth spores; chromium-shadowed electron micrograph from 26-day-old culture on oatmeal agar.

FIG. 224a,b. *S. poonensis* (*Chainia poonensis*). Spiral spore chains on yeast-malt agar, 21 days. Spores in tight spirals appear to coalesce into droplets. $\times 1,760$.

FIG. 225. *S. poonensis* (*Chainia poonensis*). Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 226. *S. poonensis* (*Chainia poonensis*). Small sclerotia on salts-starch agar, 15 days. $\times 445$.

scriptions: *Chainia purpurogena* Thirumalachar (185); *Streptomyces purpurogeniscleroticus* Pridham 1970, 43 (*Chainia purpurogena* Thirumalachar). Type strain: ISP 5271 from Thirumalachar, personal communication, M. J. Thirumalachar, October 1964 (presumably same as NRRL B-2952 = CBS 409.66). ISP 5271 directly from M. J. Thirumalachar as specimen of type strain. ISP description by Group F-2.

Spore-chain morphology: Section *Spirales* (Fig. 231) on yeast-malt agar and salts-starch agar. Sporulation may be thin on these media and is generally absent on oatmeal agar and glycerol-asparagine agar. Mature spore chains generally contain 10 or more spores per chain. Spore surface: Smooth (Fig. 232).

Special morphological characteristics: Sclerotia are produced on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar in 14 days (Fig. 233).

Color of colony: Aerial mass color in the White color series on yeast-malt agar and salts-starch agar; aerial mycelium is not produced on oatmeal agar or glycerol-asparagine agar.

Reverse side of colony: Grayish yellow on salts-starch agar; brown or reddish brown on yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. One of three observers reports the reddish brown reverse mycelium pigment is changed from dark brown to light brown with the addition of 0.05 N HCl. The other observers report no change.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Reddish or yellowish pigment is sometimes found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. This pigment is pH sensitive, changing from brown to reddish brown or red with the addition of 0.05 N NaOH and from brown to yellowish brown or yellow with the addition of 0.05 N HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces rectus Henssen 1957. See *Streptomyces thermophilus* (Gilbert) Waksman and Henrici 1948 (208). Not *Actinomyces rectus* Krasil'nikov 1949 (101). Not *Actinomyces thermophilus* (sic) Berestnev 1897, 181 (20). Strain A₁₁ is proposed by Henssen as the neo-type for *Streptomyces rectus* = *Actinomyces thermophilus* (Gilbert) Waksman and Henrici (see Henssen, 70, p. 214 and 216). This strain has been studied by ISP collaborators as ISP 5365 and is described under the name *Streptomyces thermophilus*.

Streptomyces regalis (Reusser. U.S. Pat. 3,317,400, May 2, 1967). Description: Reusser (160). Type strain: NRRL 3151 (160). ISP 5532 from T. G. Pridham, NRRL, as NRRL 3151. ISP description by Group E-7.

Spore-chain morphology: Section *Spirales*. Spirals may be open (Fig. 234a) or compact (Fig. 234b). Spiral spore chains sometimes (but not always) occur in whorls resembling a verticillate-spira morphology (Fig. 234c). Mature spore chains are long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 235). Some spores have peculiar blunt appendages, longer than those usually found in warty spores.

Color of colony: Aerial mass color in the Blue color series (19dc or 19fe, pale blue) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but aerial mycelium may be thin and white or absent on glycerol-asparagine agar. Aerial mycelium is sometimes in the Gray color series (d) on oatmeal agar.

Reverse side of colony: Distinctive grayish blue to dark blue or dark grayish purple pigment on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; dark olive green to reddish black or purplish black on yeast-malt agar. Reverse mycelium pigment is a pH indicator, changing from violet to blue with the addition of 0.05 N NaOH and from violet to reddish violet or pink with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth; melanin production is weak or absent on tyrosine agar. Blue or violet pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes recorded for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces regensis Gupta, Sobti, and Chopra. Description: Gupta, Sobti, and Chopra 1963, 12-16 (66). Type strain: Regional Research Laboratory, Tawai, Kashmir, strain *Streptomyces* X-5263 (66). ISP 5551 from K. C. Gupta as type strain (K. C. Gupta, personal communication, March 1968). ISP description by Group E-7.

Spore-chain morphology: Section *Spirales* or *Rectiflexibiles*. Spirals are poorly developed, usually with only one or two turns or with hooks

FIG. 227. *S. prasinosporus*. Irregular spirals on yeast-malt agar, 14 days. $\times 590$.

FIG. 228. *S. prasinosporus*. Hairy spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 229. *S. pulcher*. (a) Spirals and incomplete spirals on colloidal chitin agar, 7 days. $\times 800$. (b) Spirals on glycerol-asparagine agar, 14 days. $\times 850$.

FIG. 230. *S. pulcher*. (a) Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar. (b) Warty spores, electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 231. *S. purpurogeniscleroticus* (*Chainia purpurogena*). Spiral spore chains on salts-starch agar, 14 days. $\times 600$.

FIG. 232. *S. purpurogeniscleroticus* (*Chainia purpurogena*). Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 233. *S. purpurogeniscleroticus* (*Chainia purpurogena*). Sclerotia on yeast-malt agar, 14 days. $\times 100$.

and loops of small diameter on short lateral spore chains (Fig. 236a). Flexuous or straight chains are also common (Fig. 236b). Aerial hyphae may be long, but spore chains are often moderately short, with 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth or irregularly folded (Fig. 237a, b).

Color of colony: Aerial mass color in the Gray or Yellow color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Representative color tabs from the Gray color series are 2dc, yellowish green; 2ge, light olive brown; and 3fe, light brownish gray. Representative color chips from the Yellow color series are 1 $\frac{1}{2}$ ec - 1cb, pale yellow green, and 1ba - 2ba, pale yellow.

Reverse side of colony: Moderate to strong or dark yellow, greenish yellow, or olive on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Strong yellow or strong brown on yeast-malt agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. Yellow pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces rishiriensis Kawaguchi, Tsukura, Okanishi, Miyaki, Ohmori, Fujisawa, and Koshiyama. Description: Kawaguchi et al. (91). Type strain: Bristol-Banyu Research Institute strain 404Y3 (91) = ATCC 14812 (Kawaguchi, personal communication, October 1967). ISP 5489 from E. F. Lessel, ATCC, as ATCC 14812. ISP description by Group E-3.

Spore-chain morphology: Section *Spirales* to *Retinaculiaperti*. Spirals are usually open; flexuous spore chains and chains with terminal hooks or loops are also common (Fig. 238). Mature spore chains are long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar, but sporulating aerial mycelium is usually not formed on glycerol-asparagine agar. Spore surface: Smooth (Fig. 239).

Color of colony: Aerial mass color in the Gray color series (5fe, light grayish reddish brown; 3fe, light brownish gray; 5ih, brownish gray; or 3ih, dark gray) on yeast-malt agar, oatmeal agar, and salts-starch agar. Sporulation is usually

inadequate for color determination on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (colorless to pale yellow or grayish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; light olive brown on yeast-malt agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-fructose, rhamnose, sucrose, and raffinose are utilized for growth. No growth or only a trace of growth with D-mannitol.

Streptomyces rosa (Reusser [Upjohn Co.]. U.S. Pat. 3,317,400, May 2, 1967). Description: Reusser (160). Type strain: NRRL 3152 (160). ISP 5533 from T. G. Pridham, NRRL, as NRRL 3152. ISP description by Group E-6.

Spore-chain morphology: Section *Spirales* (Fig. 240). Some spirals are open and irregular suggesting RA morphology. Mature spore chains are moderately long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 241).

Color of colony: Aerial mass color in the Red color series (4ec, grayish yellowish pink; 4ge, light grayish reddish brown; or 3ca, pale orange yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Strong brown, dark brown or reddish brown on yeast-malt agar and oatmeal agar; dark grayish brown on salts-starch agar; grayish yellow to yellowish brown on glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator or is changed only slightly with the addition of 0.05 N NaOH or HCl.

Color in medium: Melanoid pigments are not formed in peptone yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow brown or greenish pigment is found in the medium in yeast-malt agar, oatmeal agar, and salts-starch agar. This pigment is only slightly pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only a trace of growth with *i*-inositol, sucrose, or raffinose.

FIG. 234. *S. regalis*. (a) Open spirals on yeast-malt agar, 14 days. (b) Compact spirals on oatmeal agar, 14 days. (c) Pseudoverticillate arrangement of spiral spore chains on yeast-malt agar, 14 days. All $\times 600$.

FIG. 235. *S. regalis*. Spiny spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 236. *S. regensis*. (a) Spirals of one or two turns on salts-starch agar, 21 days. (b) Straight to flexuous chains on oatmeal agar, 21 days. $\times 594$.

FIG. 237. *S. regensis*. (a) Smooth spore surface from 14-day-old culture on oatmeal agar. (b) Irregular folded spore surface from 14-day-old culture on glycerol-asparagine agar.

FIG. 238. *S. rishiriensis*. Open spirals, loops, and hooks. (a) On yeast-malt agar, 14 days. (b) On salts-starch agar, 14 days. $\times 600$.

FIG. 239. *S. rishiriensis*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

Chainia rosea Thirumalachar 1966. See *Streptomyces roseiscleroticus* Pridham 1970.

Streptomyces roseiscleroticus Pridham (*Chainia rosea* Thirumalachar). Descriptions: *Chainia rosea* Thirumalachar (186); *Streptomyces roseiscleroticus* Pridham 1970, 43 (147) (*Chainia rosea* Thirumalachar). Type strain: HACC-144 (Thirumalachar, personal communication, April 1965) = ATCC 17755 = CBS 226.65 (Pridham 1970, op. cit.). ISP 5303 from M. J. Thirumalachar as HACC 144. ISP description by Group F-3.

Spore-chain morphology: Section *Spirales* (Fig. 242). Mature spore chains are short to long, sometimes with more than 50 spores per chain. This morphology is sometimes seen on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar or Gauze Medium No. 1. Sporulating aerial mycelium is often absent on various media. Spore surface: Smooth (Fig. 243).

Special morphological characteristics: Sclerotia are produced on yeast-malt agar (Fig. 244), oatmeal agar, salts-starch agar, glycerol-asparagine agar, and Gauze Medium No. 1 in 7 to 14 days.

Color of colony: Aerial mass color in the White color series when adequate aerial mycelium is produced on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar, or Gauze Medium No. 1. Reports vary on the media supporting good growth of aerial mycelium.

Reverse side of colony: Yellow to yellow brown is modified by red to strong (reddish) brown on yeast-malt agar and to reddish orange or deep orange on oatmeal agar. Reverse mycelium on salts-starch agar and glycerol-asparagine agar may be colorless, light yellow, orange, or strong brown. No change is reported in reverse mycelium color after the addition of 0.05 N NaOH or HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of brown is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of sucrose, *i*-inositol, and raffinose is doubtful.

Streptomyces roseoflavus Arai. Description: Arai (2). Type strain: Chiba strain 320 (2) = IMRU 3672 (Ruth Gordon, IMRU, personal communication, January 1968). ISP 5536 from S. A. Waksman, IMRU, as IMRU 3672. ISP description by Group E-5.

Spore-chain morphology: Section *Retinaculiperti* or *Spirales*. Flexuous spore chains are common; RA and S spore chains may not be seen on some media. Mature spore chains of more than 50 spores per chain may be seen if good sporulation occurs, but sporulation is often poor on yeast-malt agar, oatmeal agar, salts-starch agar, and especially on glycerol-asparagine agar. Spore surface: Smooth (Fig. 245).

Color of colony: Aerial mass color in the Red or Yellow color series on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; Yellow color series on oatmeal agar. Representative color tabs from the Red color series are 3ca, pale orange yellow; 4ec, grayish yellowish pink; and 5ca, light yellowish pink. Representative chips from the Yellow color series are 1 or 2ba, pale yellow; and 1½ec, pale yellowish green. (Yellow colors may represent poor sporulation.)

Reverse side of colony: Moderate to deep orange on yeast-malt agar; grayish yellow to orange yellow or yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, or glycerol-asparagine agar; a trace of yellow to orange pigment may or may not be present in salts-starch agar.

Carbon utilization: D-Glucose, L-arabinose, and D-xylose are utilized for growth. Utilization of fructose is doubtful. No growth or only a trace of growth with *i*-inositol, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces roseogriseus (Routien in Sobin, Celmer, and Koe, U.S. Pat. 3,113,074, December 3, 1963). Description: Sobin et al. (176). Not *Actinomyces roseogriseus* Yen and Chou 1964, 428-438 (220); not *Streptomyces roseogriseus* (Yen and Chou) Pridham 1970, 43 (147). Type strain: Chas. Pfizer and Co. strain 18330-4 = ATCC 12414 (176). ISP 5488 from J. B. Routien, Chas. Pfizer and Co. as strain 18330-4 = FD 11373 = ATCC 12414. ISP description by Group E-3.

Spore-chain morphology: Section *Rectiflexibiles*. Mature spore chains are generally long, with more than 50 spores per chain (Fig. 246). This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar; sporulating aerial mycelium may be poorly developed on glycerol-asparagine agar. Spore surface: Smooth (Fig. 247).

Color of colony: Aerial mass color in the Gray or Red color series on yeast-malt agar, oat-

meal agar, and salts-starch agar. Sporulating aerial mycelium may be poorly developed on glycerol-asparagine agar. Representative color tabs from the Gray color series are 5fe, light grayish reddish brown, and 2fe, medium gray. Representative color tabs from the Red color series are 5cb and 5dc, grayish yellowish pink.

Reverse side of colony: No distinctive pigments (pale or grayish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; moderate brown on yeast-malt agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Chainia rubra (Thirumalachar, unpublished). Description: Not seen. Type strain: Strain HAAC-143 was submitted to the ISP as the type strain for *Chainia rubra* by M. J. Thirumalachar and has also been deposited in the American Type Culture Collection as ATCC 17754. ISP 5304 from M. J. Thirumalachar as HAAC-143. ISP description by Group F-4.

Spore-chain morphology: Section *Spirales* (Fig. 248). Mature spore chains generally contain more than 10 and sometimes more than 50 spores per chain. Production of aerial mycelium with spiral morphology is variable on various media but is sometimes seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (?) or spiny (?) with very short spines (Fig. 249).

Special morphological characteristics: Sclerotia are produced on oatmeal agar, salts-starch agar, and glycerol-asparagine agar in 14 to 21 days (Fig. 250).

Color of colony: Aerial mass color in the Red or White color series on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; Red or Yellow color series on yeast-malt agar. Nearest matching color tabs in the Red color series are 4ec, 5ec, 5cb, 5dc, and 6ec, all grayish yellowish pink. Nearest matching tabs in the Yellow color series on yeast-malt agar are 2ca and 2db, pale yellow.

Reverse side of colony: Distinctive red pigments: Reddish brown to strong (reddish) brown on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; yellowish pink to deep orange or strong brown on oatmeal agar. Reverse mycelium pigment is not a pH indicator or is changed only slightly with the addition of

0.05 N NaOH or HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth, but a faint reddish brown or yellow pigment may be produced in these media and in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive or is changed only slightly when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Reports vary on utilization of sucrose, and the utilization of *i*-inositol is doubtful. No growth or only a trace of growth with raffinose.

Streptomyces salmonicida Rucker. Descriptions: *Streptomyces salmonicida* Rucker 1949, 659-664 (161); *Nocardia salmonicida* (Rucker) Pridham 1970, 44 (147); see also Pridham and Lyons (149, p. 204). Type strain: Rucker strain = Lederle A-7604 = NRRL B-2778. Notes: Strain A-7604 and strain IPV 925 and strain NRRL B-1472 were submitted to the original author, R. Rucker, in 1967 for pathogenicity tests. Strain A-7604 produced typical pathogenic lesions in visceral organs of 4-inch sockeye salmon 4 weeks after intraperitoneal inoculation. Strains NRRL B-1472 and IPV 925 did not produce pathogenic lesions (R. R. Rucker, Fish and Wildlife Service, U.S.D.A., personal communication, December 1967). Strains NRRL B-1472 and IPV 925 are verticillate cultures which differ from the original description (161) and from the ISP description of the type strain A-7604. ISP 5472 from H. Tresner, Lederle Laboratory as Lederle A-7604. ISP description by Group E-1.

Spore-chain morphology: Section *Rectiflexibiles*. Only one of three observers found sporulating aerial mycelium on yeast-malt agar, oatmeal agar, or salts-starch agar. Spores are not found on glycerol-asparagine agar. Flexuous spore chains of moderate length may be seen on Pridham and Gottlieb's carbon-utilization medium enriched with xylose (Fig. 251). Spore surface: Smooth (Fig. 252).

Color of colony: Aerial mass color in the Red color series (3ca, pale orange yellow, to 5ca, light yellowish pink, on yeast-malt agar and Pridham and Gottlieb's carbon-utilization medium plus xylose). Aerial mycelium is not found on glycerol-asparagine agar and is also absent or white on oatmeal agar and salts-starch agar.

Reverse side of colony: Moderate orange or orange yellow to strong brown on yeast-malt agar; no distinctive pigments (pale yellow or grayish yellow to nearly colorless) on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

FIG. 240. *S. rosa*. Spiral spore chains on oatmeal agar, 7 days. $\times 1,100$.

FIG. 241. *S. rosa*. Smooth spores; electron micrograph from 28-day-old culture on oatmeal agar.

FIG. 242. *S. roseiscleroticus* (*Chainia rosea*). Spiral spore chains on carbon-utilization medium plus xylose, 12 days. $\times 800$.

FIG. 243. *S. roseiscleroticus* (*Chainia rosea*). Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 244. *S. roseiscleroticus* (*Chainia rosea*). Sclerotium from 14-day-old culture on yeast-malt agar. $\times 850$.

FIG. 245. *S. roseoflavus*. Smooth spores; electron micrograph from 10-day-old culture on salts-starch agar. (a) Electron microscope silhouette. (b) Carbon repligraph.

FIG. 246. *S. roseogriseus*. RF morphology. (a) On salts-starch agar, 21 days. $\times 600$. (b) On yeast-malt agar, 14 days. $\times 230$.

FIG. 247. *S. roseogriseus*. Smooth spores; electron micrograph from 21-day-old culture on yeast-malt agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and D-fructose are utilized for growth. Utilization of D-xylose is doubtful. No growth or only a trace of growth with L-arabinose, *i*-inositol, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces saprophyticus nom. dub. Comments: Gasperini (53, p. 226) makes incidental mention of *actinomyces saprophyticus* (sic) as the species also described as *Foersteri* (sic), a variety of *actinomyces cromogenus* (sic). Hütter (78, p. 370; 80, p. 234) and Waksman (206, p. 322) consider that *A. saprophyticus* Gasperini should be placed with the nomina dubia. Hütter (80, p. 215 and 225) uses the name *Streptomyces saprophyticus* in reference to strain ATCC 3351, which he considers to be a strain of *S. griseus* Waksman and Henrici. Strain ATCC 3351 was deposited by Waksman in 1947 under the name *Streptomyces albus* (Rossi-Doria emend. Krainsky) Waksman and Henrici = *Actinomyces saprophyticus* Loeffler (E. F. Lessel, ATCC, personal communication, February 1968). ISP 5537 received by ISP from E. F. Lessel as strain ATCC 3351 has been studied by Group E-7.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 253). Mature spore chains generally short, with 3 to 10 spores per chain, but long spore chains of more than 50 spores are reported by one observer. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but sporulation may be poor on these media. Spore surface: Smooth (Fig. 254).

Color of colony: Aerial mass color in the Yellow color series (1 ½db, pale greenish yellow, or 1db, 2db, 1ba, pale yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Immature or poorly developed aerial mycelium is white.

Reverse side of colony: No distinctive pigments (colorless, pale grayish yellow, light olive brown, or grayish greenish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth. Utilization of rhamnose is doubtful,

and there is no growth or only a trace of growth with *i*-inositol, sucrose, or raffinose.

Streptomyces sclerotialis Pridham (*Chainia antibiotica* Thirumalachar). Descriptions: *Chainia antibiotica* Thirumalachar 1955, 935 (183); also Thirumalachar and Sukapure 1964, 157-166 (185); *Streptomyces sclerotialis* Pridham 1970, 44 (147) (= *Chainia antibiotica* Thirumalachar). Type strain: *Chainia antibiotica*, ATCC 15721 (Pridham, op. cit.). ISP 5269 from M. J. Thirumalachar, Hindustan Antibiotics, Ltd., as specimen of type strain. ISP description by Group F-1.

Spore-chain morphology: Section *Spirales* (Fig. 255). Spirals are best developed on salts-starch agar. Aerial mycelium may be poorly developed on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but some spirals or chains can usually be found on these media. Spore surface: Smooth (Fig. 256 and 257).

Special morphological characteristics: One of three observers reports sclerotia and fragmentation of substrate mycelium on glycerol-asparagine agar in 21 days. A second observer reports "globular sporangia" on yeast-malt agar, oatmeal agar, and salts-starch agar and "coremia" on yeast-malt agar in 7 to 14 days. The scanning electron microscope shows coalesced masses of spores (Fig. 257).

Color of colony: Aerial mycelium is generally poorly developed on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Sporulating aerial mycelium adequate for color determination may be formed on salts-starch agar; it is in the White color series. One observer reports aerial mycelium in the Yellow color series (2fb, light yellowish red; 1db, pale yellow green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; this may be the color of the vegetative (substrate mycelium) growth.

Reverse side of colony: No distinctive pigments (orange yellow or yellowish brown on yeast-malt agar, light grayish yellow or light yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

FIG. 248. *Chainia rubra*. Spiral spore chains on salts-starch agar, 14 days. $\times 500$.

FIG. 249. *Chainia rubra*. (a) Smooth spores. (b) Spores with minute warts or spines. Electron micrographs from 21-day-old cultures on yeast-malt agar.

FIG. 250. *Chainia rubra*. Small sclerotia-like granules on oatmeal agar, 21 days. $\times 500$.

FIG. 251. *S. salmonicida*. Flexuous spore chains on carbon-utilization medium plus xylose, 27 days. $\times 900$.

FIG. 252. *S. salmonicida*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 253. *S. saprophyticus*. RF spore chains on yeast-malt agar, 7 days. $\times 200$.

FIG. 254. *S. saprophyticus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 255. *S. sclerotialis* (*Chainia antibiotica*). Spiral spore chains on salts-starch agar, 14 days. $\times 600$. (See also Fig. 257.)

FIG. 256. *S. sclerotialis* (*Chainia antibiotica*). Smooth spores. (a) Electron micrograph from 21-day-old culture on salts-starch agar. (b) Carbon repligraph from 10-day-old culture on salts-starch agar. (See also Fig. 257.)

FIG. 257. *S. sclerotialis* (*Chainia antibiotica*). Scanning electron micrograph seems to show spores adhering to one another, both in the spore coils (lower left, center, and upper left) and in straight chains of spores. A tendency for the tight spore coils of sclerotia-forming streptomycetes and "hygroscopic" species to adhere and "coalesce" in masses of varying complexity from single coils to large granular masses and globular bodies is also evident with the lower magnifications of optical microscopes.

Streptovorticillium septatum Locci, Baldacci, and Petrolini Baldan. (Prokop. U.S. Pat. 3,117,916, January 14, 1964). Descriptions: *Streptovorticillium septatum* Prokop 1964 (152); Locci, Baldacci, and Petrolini Baldan 1969, 42 (116). Type strain Abbott M-741 = NRRL 2974 (Prokop, 1964, op. cit.) = IPV 2047 (Locci et al., 1969, op. cit.). ISP 5577 from D. R. L. Girolami, Abbott Laboratories, as M-741. ISP description by Group F-4.

Spore-chain morphology: Section *Umbellate Monoverticillate* (= *Streptomyces Verticillati*, biverticillate) (Fig. 258). Mature spore chains are generally short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 259).

Color of colony: Aerial mass color in the Yellow or Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar (white is also present). Nearest matching color tabs in the Yellow color series are 2db and 2ba, pale yellow, and 1cb, pale yellow green. Nearest matching tabs in the Red color series are 4ec and 5cb, grayish yellowish pink, and 3ca, pale orange yellow. Red aerial mycelium may sometimes occur as scattered tufts of longer aerial hyphae in a yellow or white background.

Reverse side of colony: No distinctive pigments (olive brown to strong brown on yeast-malt agar; pale grayish yellow on oatmeal agar and salts-starch agar; grayish yellow to pale yellowish green on glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar in 14 days, or a trace of yellow may sometimes be seen in yeast-malt agar, oatmeal agar, and salts-starch agar in 21 days.

Carbon utilization: D-Glucose and *D*-inositol are utilized for growth. Reports vary on growth on D-fructose, but utilization of this sugar is doubtful. No growth or only a trace of growth with L-arabinose, D-xylose, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces showdoensis Nishimura, Matsumura, Komatsu, Katō, Shimaoka, and Tanaka. Descriptions: Nishimura et al. (134); also Nishimura (133). Type strain: Shionogi and Co. Z-452 = ATCC 15105 (133, 134). ISP 5504 from E. F. Lessel, ATCC, as ATCC 15105. ISP description by Group E-7.

Spore-chain morphology: Section *Rectiflexibiles*. Mature spore chains are generally long, with

10 to 50 or more spores per chain (Fig. 260). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 261).

Color of colony: Aerial mass color in the Gray or Yellow color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. White aerial mycelium may also be seen on these media. Most representative color tabs from the Gray color series are 2dc, yellowish gray, and 3ge, light grayish yellowish brown, and from the Yellow color series, 2db and 2ba, pale yellow.

Reverse side of colony: No distinctive pigments (orange yellow or yellowish brown on yeast-malt agar; pale or grayish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth and weakly in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, and D-fructose are utilized for growth. Utilization of L-arabinose and sucrose is doubtful. No growth or only a trace of growth with *D*-inositol, D-mannitol, rhamnose, or raffinose.

Streptomyces spadiceus (Bromer, Hoehn, and McGuire for Eli Lilly & Co., U.S. Pat. 3,467,751, September 16, 1969). Description: Bromer et al., (26). Type strain: Eli Lilly M5-21009 = ATCC 19017 (26). ISP 5476 from D. H. Lively, Eli Lilly & Co., as ATCC 19017. ISP description by Group E-1.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 262). Mature spore chains are moderately long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar. Sporulating aerial mycelium may or may not be found on glycerol-asparagine agar. Spore surface: Smooth (sometimes wrinkled, but without true spines or warts) (Fig. 263a, b).

Color of colony: Aerial mass color in the Gray color series (3ig, grayish yellowish brown; 3fe, light brownish gray; or 5fe, light grayish reddish brown on yeast-malt agar and oatmeal agar; g or e, medium gray, on salts-starch agar). Sporulating aerial mycelium may be poorly developed on glycerol-asparagine agar.

Reverse side of colony: Moderate to strong orange on yeast-malt agar; pale or grayish yellow to light yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. One of three observers reports that the reverse mycelium pigment in yeast-malt agar is a pH indicator,

changing from yellow or orange to reddish orange with the addition of 0.05 N NaOH and from orange to yellow orange with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. Orange pigment is found in the medium in yeast-malt agar, and yellow or orange pigment is found in oatmeal agar and salts-starch agar. No pigment is found in glycerol-asparagine agar. One of three observers reports the pigment in yeast-malt agar is pH sensitive, showing the same color changes recorded for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, and D-fructose are utilized for growth. Reports vary on utilization of *i*-inositol, rhamnose, and raffinose. No growth or only a trace of growth with sucrose.

Streptomyces spectabilis Dietz, in Waksman 1961. Descriptions: Waksman (206, p. 276); British Pat. 811,757, Apr. 8, 1959; Mason, Dietz, and Smith (123). Name and antibiotic production only, without description, in Siminoff et al. (175). Type strain: NRRL 2494 (Mason, Dietz, and Smith, op. cit.). ISP 5512 from T. G. Pridham, NRRL, as NRRL 2494. ISP description by Group E-7.

Spore-chain morphology: Section *Rectiflexibiles* with straight to flexuous spore chains (Fig. 264a). Distribution of sporophores sometimes suggests verticillate morphology (Fig. 264b), but true whorls or verticils are not produced. Mature spore chains are long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 265).

Color of colony: Aerial mass color in the Red color series (7ca or 5ca, light yellowish pink; 5gc, light reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. White aerial mycelium is sometimes produced.

Reverse side of colony: Distinctive reddish orange pigment on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is changed only slightly by the addition of 0.05 N NaOH or HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and sometimes in tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and

raffinose are utilized for growth. Utilization of rhamnose is doubtful. No growth or only a trace of growth with sucrose.

Streptomyces steffisburgensis subsp. *steffisburgensis* Dietz. Description: Dietz (41). Type strain: U.C. 5044 = NRRL 3193 (41). ISP 5547 from T. G. Pridham, NRRL, as NRRL 3193. ISP description by Group E-7.

Spore-chain morphology: Section *Spirales*, but short spore chains often produce spirals of only one turn, incomplete spirals, and hooks or even short, straight spore chains (Fig. 266). Mature spore chains are generally short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, and salts-starch agar, but aerial mycelium is poorly developed on glycerol-asparagine agar. Spore surface: Warty or spiny with blunt spines (Fig. 267). Only one of the three ISP observers assigned to this strain had access to an electron microscope. He interprets spores shown by transmission electron microscope silhouette in Fig. 267 as spiny. In the original description (41), the strain is characterized as having spiny spores. In a more recent report (42), this strain is selected as the representative for warty spores. The 1971 report (42) includes use of the scanning electron microscope and carbon replica methods for spore surface determination.

Color of colony: All three ISP observers place the aerial mass color in the Blue color series (19dc or 22fe, pale blue) on yeast-malt agar, oatmeal agar, and salts-starch agar and on glycerol-asparagine agar when adequate aerial mycelium is developed. Aerial mycelium is generally thin on ISP media. Dietz (41), using different media, places this strain in the Gray color series.

Reverse side of colony: Reports vary from grayish yellow or dark orange yellow and grayish red to dark bluish green on yeast-malt agar; grayish yellow or pale yellow on oatmeal agar; light brown or pale yellowish pink and strong yellowish brown on salts-starch agar; light yellowish brown, grayish red, or moderate reddish brown to grayish blue on salts-starch agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but only weakly on tyrosine agar. Pink to pale blue or violet pigment is found in small amounts in the medium in salts-starch agar and glycerol-asparagine agar and sometimes in yeast-malt agar or oatmeal agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rham-

FIG. 258. *Streptovorticillum septatum*. Umbellate monovorticillate (BV) morphology on oatmeal agar, 21 days. $\times 500$.

FIG. 259. *Streptovorticillum septatum*. Smooth spores; electron micrograph from 21-day-old culture on oatmeal agar.

FIG. 260. *S. showdoensis*. RF spore chains on yeast-malt agar, 7 days. $\times 130$.

FIG. 261. *S. showdoensis*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 262. *S. spadicus*. RF spore chains from 7-day-old culture on yeast-malt agar. $\times 800$.

FIG. 263. *S. spadicus*. (a) Rough silhouette probably resulting from wrinkles and folds seen more clearly in Fig. 263b. (b) "Smooth" spore surface with wrinkles and folds in spores, especially in lower part of chain; salt-starch agar, 14 days.

nose, sucrose, and raffinose are all utilized for growth.

Streptomyces subutilus Arai and Kuroda. Description: Arai and Kuroda (4). Type strain: IFM 713 (4). ISP 5445 from T. Arai, Institute of Food Microbiology, Chiba Univ., as IFM 713. ISP description by Group D-8.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 268). Long, straight, or slightly flexuous spore chains often contain more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 269).

Color of colony: Aerial mass color in the Red color series (4ec, 5ec, 6ec, 5cb, grayish yellowish pink) on yeast-malt agar, oatmeal agar, and salts-starch agar; Red or White color series on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (moderate orange yellow or moderate orange brown on yeast-malt agar, pale yellow or grayish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but are formed only weakly or not at all in tyrosine agar. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and D-fructose are utilized for growth. Reports vary on utilization of sucrose and D-mannitol, but growth is not abundant on these media. No growth or only a trace of growth with L-arabinose, D-xylose, *i*-inositol, rhamnose, or raffinose.

Streptomyces sulphureus (Gasparini) Waksman. Descriptions: For taxonomy and nomenclature of this strain, see Waksman (206, p. 278) and Baldacci (7). *Actinomyces bovis sulphureus* Gasparini 1894, 86 (54); *Actinomyces bovis* (Harz) Waksman 1919, 102-104 (203); *Streptomyces sulphureus* (Gasparini) Waksman 1961, 278 (206). Not *A. sulphureus* Berestnev 1897, according to Waksman (206). Type strain: *S. sulphureus* strain Gasparini = IPV 510 (suggested neotype; probably the strain studied by Gasparini according to E. Baldacci, personal communication, November 1963). ISP 5104 from E. Baldacci, IPV, as IPV 510. ISP description by Group E-1.

Spore-chain morphology: Section *Spirales* or *Retinaculiaperti*. Short, crooked chains form irregular and imperfect spirals, hooks, or loops (Fig. 270). These are not representative of the large hooks, loops, and primitive spirals seen in

typical RA cultures. This morphology is seen on yeast-malt agar and oatmeal agar and sometimes on glycerol-asparagine agar. Morphology may also be observed on carbon-utilization medium enriched with D-glucose. Spore surface: Smooth (Fig. 271).

Color of colony: Aerial mass color in the Yellow color series (1¹/₂fb, light yellow, or 1¹/₂db, pale greenish yellow) on yeast-malt agar and oatmeal agar and sometimes on salts-starch agar or glycerol-asparagine agar if adequate aerial mycelium is developed.

Reverse side of colony: No distinctive pigments (yellowish brown to olive brown on yeast-malt agar; grayish yellow, grayish greenish yellow, or olive on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth or are formed very weakly in peptone-yeast-iron agar and tryptone-yeast broth. No pigment is usually found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but one of three observers reports a pale violet pigment in oatmeal agar in 14 days. This pigment becomes pale yellowish brown with the addition of 0.05 N HCl.

Carbon utilization: Growth is poor on carbon-utilization medium enriched with D-glucose. Comparison with growth on D-glucose suggests equal or better utilization of L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose, but utilization of all carbon sources should be verified on a basal medium supporting better growth. Sucrose apparently is not utilized, and reports vary on the utilization of raffinose and *i*-inositol.

Streptomyces takataensis (Anonymous). Name and antibiotic but no description appears in abstract by Iwashita, Ueda, and Fujimoto (83). Description appears in patents issued to Chugai Seiyaku Kabushiki Kaisha (33, 34). Type strain: C-11 according to patents (op. cit.). ISP 5576 from Y. Okami as specimen of type strain. ISP description by Group F-3.

Spore-chain morphology: Section *Umbellate Monoverticillate* (= *Streptomyces* section *Verticillati*, biverticillate) (Fig. 272). Verticils are rare, and it is difficult to determine whether or not they are evenly spaced and representative of *Streptoverticillium* morphology. Mature sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but morphological observations can be made on Pridham and Gottlieb carbon-utilization medium enriched with D-fructose. In some instances, a secondary whorl of

FIG. 264. *S. spectabilis*. RF spore chains. (a) On salts-starch agar, 14 days. (b) On yeast-malt agar, 14 days. $\times 594$.

FIG. 265. *S. spectabilis*. Smooth spores. (a) Electron micrograph from 14-day-old culture on salts-starch agar. (b) Scanning electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 266. *S. steffisburgensis*. Short spirals on oatmeal agar, 7 days. $\times 512$.

FIG. 267. *S. steffisburgensis*. Spores spiny with short, blunt spines. Blunt spines may also suggest warty spore surface.

FIG. 268. *S. subutilus*. RF spore chains. (a) On yeast-malt agar, 21 days. (b) On oatmeal agar, 7 days. $\times 800$.

FIG. 269. *S. subutilus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

spores appears to give rise to a tertiary umble from its center (Fig. 273). Spore surface: Smooth (Fig. 274).

Color of colony: Aerial mass color in the Red color series on carbon-utilization medium plus D-fructose or on Gauze Medium No. 1. Nearest matching color tab from the Red color series on these media is 3ca, pale orange yellow. Color of sporulating aerial mycelium cannot be determined on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: Yellowish brown to strong brown on yeast-malt agar and Gauze Medium No. 1; yellowish to yellowish brown or olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; grayish yellow on carbon-utilization medium.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but only weakly or not at all in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar, but a dark brown soluble pigment is reported for carbon-utilization medium enriched with D-glucose or D-mannitol.

Carbon utilization: D-Glucose, *i*-inositol, D-mannitol, and D-fructose are utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, rhamnose, sucrose, or raffinose.

Streptomyces tauricus (Ivanitskaya, Upiter, Sveshnikova, and Gauze) Pridham. Descriptions: *Actinomyces tauricus* Ivanitskaya, Upiter, Sveshnikova, and Gauze 1966, 973-976 (82); *Streptomyces tauricus* (Ivanitskaya et al.) Pridham 1970, 27 (147). Type strain: INA 8173 (G. F. Gauze, personal communication, May 1968). ISP 5560 from G. F. Gauze as INA 8173. ISP description by Group F-2.

Spore-chain morphology: Section *Spirales* (Fig. 275) or *Retinaculiaperti*. Terminal spirals of several turns and some hooks or loops are found on long spore chains of 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 276).

Color of colony: Aerial mass color in the Red color series (5cb or 6ec, grayish yellowish pink; 5ca, light yellowish pink; 3ca, pale orange yellow; or 7ca, light yellowish pink) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Distinctive red pigments. Grayish red, reddish brown, or yellowish pink on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, chang-

ing from orange or red to blue or violet with the addition of 0.05 N NaOH and from brownish red to yellowish red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but weakly or not at all in tyrosine agar. Red (pink) pigment is sometimes found in the medium in yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. When pigment is present in the medium it is pH sensitive, showing the same changes observed with the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces tenebrarius Higgins and Kastner. Description: Higgins and Kastner (72). Type strain: ATCC 17920 (72). ISP 5477 from C. E. Higgins, Eli Lilly & Co., as ATCC 17920. ISP description by Group E-1.

Spore-chain morphology: Section *Spirales* (Fig. 277). Short chains of 10 or more spores may be straight, curved into hooks, or formed into crooked and irregular spirals of only a few turns. Open spirals and strongly flexuous chains may be found when longer spore chains are formed. This morphology is seen on oatmeal agar, salts-starch agar, and glycerol-asparagine agar, but sporulation is poor on yeast-malt agar. Spore surface: Smooth (Fig. 278).

Special morphological characteristics: Sclerotia-like knots and anastomoses in aerial hyphae are common (Fig. 279).

Color of colony: Aerial mass color in the Red color series (3ca, pale yellow orange) on oatmeal agar and salts-starch agar; Red or White color series on glycerol-asparagine agar. Aerial mycelium is usually not produced on yeast-malt agar.

Reverse side of colony: No distinctive pigments (light yellow, pale yellow, or grayish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in Difco-ISP yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar, but one observer records a red, soluble pigment on an inorganic salts-starch agar prepared from reagents in his laboratory. The original description (72) records a pH-sensitive, red, soluble pigment in certain media not included in the ISP studies.

Carbon utilization: D-Glucose, *i*-inositol, and D-fructose are utilized for growth. Utilization of sucrose is doubtful. No growth or only a trace of

growth with L-arabinose, D-xylose, D-mannitol, rhamnose, or raffinose.

Streptomyces tetanusemus nom. nud. (?) *Actinomyces tetanusemus* is listed without description in a table of antibiotic-producing actinomycetes (212, p. 227). *S. tetanusemus* IMRU 3367 is mentioned without description by Kützner (109, p. 180), and the strain has been maintained under this name at the Institute of Microbiology, Rutgers University Collection, as IMRU 3367 (R. Gordon for S. A. Waksman, personal communication, February 1969). ISP 5585 from S. A. Waksman as IMRU 3367. ISP description by Group F-4.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 280). Mature spore chains are usually short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 281).

Color of colony: Aerial mass color in the Yellow color series on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; Yellow or Gray color series on yeast-malt agar or Gauze Medium No. 1. Nearest matching color tabs in the Yellow color series are 1cb and 1½ec, pale yellow green, and 1ba and 2ba, pale yellow. Nearest matching color tabs in the Gray color series are 2dc, yellowish gray, and 3ge, light grayish yellowish brown.

Reverse side of colony: No distinctive pigments (yellowish brown or orange yellow on yeast-malt agar; grayish or greenish yellow to light olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellowish to yellowish green pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, and D-mannitol are utilized for growth. No growth or only a trace of growth with *i*-inositol, rhamnose, sucrose, or raffinose.

Streptomyces thermodiastaticus (Bergey et al.) Waksman. Descriptions: Thermophilic Type 8, Var. a, Bergey 1919, 304 (21); *Actinomyces thermodiastaticus* Bergey, Harrison, Breed, Hammer, and Huntoon 1923, 370 (22); *Streptomyces thermodiastaticus* (Bergey et al.) Waksman 1953, 102 (204). Type strain: No longer extant; suggested neotype, CUB 387 (T. Cross, Univ. Bradford, personal communication, May 1968). ISP 5573 from T. Cross as CUB 387. ISP description by Group F-4.

Spore-chain morphology: Section *Spirales* (Fig.

282). Spirals are often irregular or imperfect; hooks or incomplete spirals and crooked spore chains are common. Mature spore chains are moderately short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Special incubation temperature: Incubation temperatures used by ISP collaborators included 37, 45, 48, and 51 °C; typical morphology, color reactions, and physiology are seen within this range. Spore surface: Warty or spiny (very small "warts" or very blunt spines, Fig. 283).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs in the Gray color series include 3fe, light brownish gray; 3ig, grayish yellowish brown; 3ge, light grayish yellowish brown; and 2ge, light olive brown. Colors are essentially the same at incubation temperatures from 37 to 51 °C.

Reverse side of colony: Dark brown on yeast-malt agar; grayish yellow, yellowish brown, or olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. When reddish (brown) pigment is present in the substrate mycelium, it is somewhat pH sensitive, changing from reddish brown to olive brown or olive with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth except that a grayish yellow or olive yellow pigment is found in tyrosine agar in 2 to 4 days. Faint reddish (brown) or yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. When present, this pigment is pH sensitive, changing from brownish to red with the addition of 0.05 N NaOH and from brownish to olive green with the addition of 0.05 N HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, and raffinose are utilized for growth. No growth or only a trace of growth with sucrose. No difference in carbon utilization is seen in cultures incubated at 37 and 51 °C.

Streptomyces thermoflavus (Kudrina and Maksimova) Pridham. Descriptions: *Actinomyces thermoflavus* Kudrina and Maksimova 1963, 626 (108); *Streptomyces thermoflavus* (Kudrina and Maksimova) Pridham 1970, 27 (147). Type strain: Not available (T. P. Preobrazhenskaya, personal communication, July 1968). Suggested neotype: Strain of Okafor (135) = CUB 75 (suggested by T. Cross, Univ. Bradford, July 1968).

FIG. 270. *S. sulphureus*. Short spirals and incomplete spirals and hooks on carbon-utilization medium plus glucose, 21 days. $\times 900$.

FIG. 271. *S. sulphureus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 272. *S. takataensis*. Possible umbellate monoverticillate (BV) morphology on carbon-utilization medium plus fructose, 9 days. $\times 315$.

FIG. 273. *S. takataensis*. Secondary whorls, capped with tertiary umbels; carbon-utilization medium plus fructose, 14 days. $\times 850$.

FIG. 274. *S. takataensis*. Smooth spores; electron micrograph from 14-day-old culture on carbon-utilization medium plus fructose.

FIG. 275. *S. tauricus*. Terminal spirals on oatmeal agar, 14 days. $\times 300$.

FIG. 276. *S. tauricus*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 277. *S. tenebrarius*. (a) Tight spirals and short chains with incomplete spirals on oatmeal agar, 14 days. $\times 900$. (b) Open spirals or flexuous chains on salts-starch agar, 14 days. $\times 800$.

FIG. 278. *S. tenebrarius*. Smooth spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 279. *S. tenebrarius*. (a) Tangled aerial mycelium with sclerotia-like masses, salts-starch agar, 14 days. $\times 900$. (b) Anastomosis of aerial hyphae on oatmeal agar, 14 days. $\times 900$.

ISP 5574 from T. Cross as CUB 75. ISP description by Group F-5.

Special incubation temperature: ISP collaborators studied this strain at incubation temperatures of 37, 43, and 45 C. One collaborator reports sporulation did not occur at 48 C on salts-starch agar or glycerol-asparagine agar.

Spore-chain morphology: Section *Spirales* (Fig. 284). Irregular and incomplete spirals, hooks, and crooked spore chains are common, but loose to tight spirals of several turns are also found. Mature spore chains generally contain more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 285a) or warty with very small projections (scanning electron microscope, Fig. 285b).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tabs are 2fe and e, medium gray; d, light gray; 3fe, light brownish gray; and 2dc, yellowish gray.

Reverse side of colony: Deep yellow to strong brown on yeast-malt agar; yellow to orange yellow or orange on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth, except for a slight discoloration which may or may not appear in tyrosine agar after 4 days. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: Reports on carbon utilization are extremely variable for this organism. One or more of the three observers found utilization for each of the carbon sources tested including D-glucose, L-arabinose, D-xylose, *D*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose.

Streptomyces thermonitrificans Desai and Dhala. Description: Desai and Dhala (40). Type strain: NCIM 2007 (40) = ATCC 23385 (deposited in ATCC by authors). ISP 5579 from ATCC as ATCC 23385. ISP description by Group F-6.

Spore-chain morphology: Section *Rectiflexibiles* or *Spirales*. Short spore chains often have only 3 to 10 spores per chain. On yeast-malt agar, salts-starch agar, and glycerol-asparagine agar, the chains are usually crooked or twisted (Fig. 286a). Longer chains may form irregular and imperfect spirals, especially on oatmeal agar and occasionally on salts-starch agar (Fig. 286b). Spore surface: Smooth (Fig. 287).

Color of colony: Aerial mass color in the Gray color series when adequate sporulation occurs on

yeast-malt agar, oatmeal agar, and salts-starch agar. Immature aerial mycelium is white; sporulating aerial mycelium is not found on glycerol-asparagine agar. Nearest matching color tabs are 3li and 4li, brownish gray; 3ge, light grayish yellowish brown; and 2ge, light olive brown.

Reverse side of colony: No distinctive pigments (grayish olive to dark grayish brown on yeast-malt agar; grayish yellow to grayish yellowish green or grayish olive on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth according to ISP observers. (The original description by Desai and Dhala [op. cit.] states that this strain is H₂S and melanin positive.) No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, *D*-inositol, D-mannitol, D-fructose, and sucrose are utilized for growth. No growth or only a trace of growth with L-arabinose, rhamnose, and raffinose.

Streptomyces thermophilus (Gilbert) Waksman and Henrici (= *Streptomyces rectus* Henssen). Descriptions: *Actinomyces thermophilus* Gilbert 1904, 383 (56); *Streptomyces thermophilus* (Gilbert) Waksman and Henrici 1948, 956 (208); *Streptomyces rectus* (= *Streptomyces thermophilus*) Henssen 1957 (69, p. 386) and 1967 (70, p. 216). Not *Actinomyces rectus* Krasil'nikov, 1949 (101). Not *Actinomyces thermophilus* (sic) Berestnev 1897, 181 (20). Type strain of Gilbert not extant. Proposed neotype: Henssen strain A₁₁ = ATCC 19282 = CBS 275.66 (Henssen [70, p. 216]). ISP 5365 from G. A. deVries, CBS, as Henssen strain A₁₁. ISP description by Group D-11.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 288). Some hooks or loops may be seen on yeast-malt agar or oatmeal agar, but spirals are not reported. RF morphology with spore chains with generally 10 to 50 spores per chain may be seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar cultures incubated at 27 to 28 C for 14 days. Spore surface: Spiny (Fig. 289).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray; 3fe, light brownish gray; or 2ge, light olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (colorless to pale or grayish yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are

FIG. 280. *S. tetanusemus*. RF spore chains on yeast-malt agar, 14 days. $\times 500$.

FIG. 281. *S. tetanusemus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 282. *S. thermodiastaticus*. Irregular spirals on glycerol-asparagine agar, 14 days, at 37 C. $\times 500$.

FIG. 283. *S. thermodiastaticus*. Very small warts. Electron micrographs from 14- to 19-day-old cultures at 45 to 48 C on oatmeal agar. (a) Surface structures are visible on ghost outer membrane of spore chain. (b) "Warts" are dislodged from the spore surface in preparation of the electron microscope grid.

FIG. 284. *S. thermoflavus*. Spiral spore chains. (a) Regular spirals on salts-starch agar, 14 days, at 37 C. (b) Irregular spirals, scanning electron micrograph. $\times 2400$.

FIG. 285. *S. thermoflavus*. (a) Spores smooth or with inconspicuous warts. (b) Warty spores seen with scanning electron microscope. Compare with *S. thermodiastaticus*, Fig. 283.

FIG. 286. *S. thermonitrificans*. (a) Short crooked or twisted spore chains on salts-starch agar, 8 days at 50 C. $\times 880$. (b) Irregular spirals on salts-starch agar, 7 days at 55 C.

FIG. 287. *S. thermonitrificans*. Smooth spores; electron micrograph from 14-day-old culture at 55 C on salts-starch agar.

formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but reaction may be weak or delayed in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and sucrose are utilized for growth. No growth or only a trace of growth with rhamnose or raffinose.

Streptomyces thermoviolaceus subsp. *thermoviolaceus* (Henssen) Henssen and Schnepf. Descriptions: *Streptomyces thermoviolaceus* Henssen 1957, 388 (69); *Streptomyces thermoviolaceus* subsp. *pingens* Henssen 1957, 389 (69). Corrected to conform to rule 7 (International Code of Nomenclature of Bacteria 1966, 465); *Streptomyces thermoviolaceus* subsp. *thermoviolaceus* (Henssen) Henssen and Schnepf 1967, 217 (70). Type strain: Henssen strain R-77 (Aino Henssen, personal communication, December 1966). ISP 5443 from A. Henssen as R-77. ISP description by Group E-6.

Spore-chain morphology: Section *Spirales* (Fig. 290). Spirals are best developed on carbon-utilization medium plus raffinose. Imperfect spirals or loops may be common on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 291).

Color of colony: Aerial mass color in the Red color series (5dc, grayish yellowish pink) when adequate sporulating aerial mycelium is present, but sporulation is generally poor on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar at 28 °C. ISP observers did not incubate at the higher temperatures (40 to 50 °C) recommended by Henssen (69, p. 389).

Reverse side of colony: No distinctive pigments (olive brown on yeast-malt agar and oatmeal agar; grayish yellow to pale greenish yellow on salts-starch agar and glycerol-asparagine agar). The reverse mycelium pigment is pH sensitive, changing from yellow or brown to gray or bluish gray with addition of 0.05 N NaOH and becomes red-dish with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Red or violet pigment is found in the medium in yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. This pigment is pH sensitive, changing from violet to blue with the addition of 0.05 N NaOH and from violet to red with the addition of 0.05 N HCl.

Carbon utilization: D-Glucose, D-xylose, D-mannitol, and D-fructose are utilized for growth. Utilization of L-arabinose is doubtful. No growth or only a trace of growth with *i*-inositol, rhamnose, sucrose, or raffinose.

Streptomyces thioluteus Okami. Descriptions: Okami 1952, 30–32 (136); Umezawa, Maeda, and Kosaka 1948, 512–517 (194); Waksman (206, p. 279–280). Type strain: NIHJ A-26 (Okami op. cit.) = ATCC 12310 = IFO 3364 (Okami, personal communication, August 1963). ISP 5027 from Y. Okami as NIHJ 26A. ISP description by Group C-1.

Spore-chain morphology: Section not determined. Aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Spore surface: Not determined.

Color of colony: Aerial mass color not determined; sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar or on Gauze Medium No. 1.

Reverse side of colony: No distinctive pigments (light to moderate olive on yeast-malt agar; pale or grayish yellow to light olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose and *i*-inositol are utilized for growth. No growth or only a trace of growth with L-arabinose, D-xylose, D-mannitol, D-fructose, rhamnose, sucrose, or raffinose.

Streptomyces tropicalensis Gupta. Description: Gupta (63a). Type strain: RRL 61B/6 = ATCC 17963 (deposited by Gupta in ATCC in response to request for type strain, E. F. Lessel, personal communication, November 1967). ISP 5520 from E. F. Lessel, ATCC, as ATCC 17963 = RRL 61B/6. ISP description by Group E-4.

Spore-chain morphology: Section *Verticillati*. Mature sporophores are predominantly umbellate monoverticillate (biverticillate) (Fig. 292). Mature spore chains are generally short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 293).

Color of colony: Aerial mass color in the Red color series (4ec, 5ec, 5cb, 6ec, grayish yellowish pink, or sometimes 3ca, pale orange yellow) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Strong brown or dark brown on yeast-malt agar; yellowish brown to olive brown on oatmeal agar; grayish yellow to brown on salts-starch agar; grayish yellow, light

yellow, or orange yellow on glycerol-asparagine agar. Substrate pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose and *L*-inositol are utilized for growth. Reports vary on utilization of D-fructose; no growth or only a trace of growth with *L*-arabinose, D-xylose, D-mannitol, rhamnose, sucrose, or raffinose.

Streptomyces tuius Albert and de Queiroz. Descriptions: Albert and de Queiroz (1); Netherlands Pat. Appl. 6,404,698, April, 1964. Type strain: Isolation number is given as IAU 4564 (Albert and de Queiroz, op. cit.); IAU culture collection number 3121 (Vilneyde de Lima, personal communication, May 1969; Netherlands Pat. Appl. op. cit.) = ATCC 19007 (de Lima, personal communication; Lessel, 1970, 76). ISP 5505 from E. F. Lessel, ATCC, as ATCC 19007 = IAU 3121. ISP description by Group E-2.

Spore-chain morphology: Section *Spirales* (*Verticillati*?) (Fig. 294a). Spiral spore chains often arise in verticils from long axial hyphae, suggesting monoverticillate morphology (Fig. 294b,c). Spirals are usually open and wavy; hooked spore chains are also present. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 295).

Color of colony: Aerial mass color in the Gray color series (5fe, light grayish reddish brown; 2dc, yellowish gray; d—e, light to medium gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Distinctive red pigments on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar. Reverse color is reddish black on yeast-malt agar and grayish reddish brown, dark pale red, or dark grayish pink on salts-starch agar and glycerol-asparagine agar; grayish brown on oatmeal agar. One of three observers reports that the reverse mycelium pigment is a pH indicator, changing from red to violet with the addition of 0.05 N NaOH and to a more intensive red with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth. Melanin reaction may be weak or absent in tyrosine agar. Red, reddish brown, or violet pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. According to one observer only, this pigment is pH sensitive, showing the

same changes observed in the reverse mycelium pigment.

Carbon utilization: D-Glucose, *L*-arabinose, D-xylose, *L*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces tumuli (Millard and Beeley) Waksman. Descriptions: *Actinomyces tumuli* Millard and Beeley 1927, 296–311 (125); *Streptomyces tumuli* (Millard and Beeley) Waksman 1953, 117 (204). Type strain: CBS strain Millard and Beeley = NRRL B-1580. ISP 5605 from T. G. Pridham, NRRL, as NRRL B-1580. ISP description by Group F-6.

Spore-chain morphology: Section not determined. Sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. This strain does produce *L*-diaminopimelic acid but no *L*-arabinose (149, p. 200). Spore surface: Not determined.

Color of colony: Aerial mass color not determined; sporulating aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (grayish yellow to orange yellow on yeast-malt agar; light grayish yellow or light yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, *L*-arabinose, D-xylose, *L*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of sucrose and raffinose is doubtful.

Streptomyces versipellis (Oliver, Prokop, Sinclair, Warren, and Winfield, Abbott Laboratories, U.S. Pat. 2,972,569, Feb. 21, 1961). Description: Oliver et al. (142). (Name and antibiotic without further description in Umezawa [191, p. 822].) Type strain: NRRL 2528 (U.S. Pat., 2,972,569 op. cit.) = Abbott M 352 (T. J. Oliver, personal communication, October 1967). Note: This strain has also been named *S. mutabilis* in the patent literature, e.g., Canadian Pat. 584,283, Sept. 29, 1959; U.S. Pat. 3,169,902, Feb. 16, 1965. The name *S. mutabilis* was changed by Oliver et al., op. cit., because of prior use of the specific epithet *mutabilis* by Preobrazhenskaya and Ryabova (146) in reference to a different strain: ISP 5491 from T. J. Oliver as Abbott M 352 = NRRL 2528. ISP description by Group E-7.

Spore-chain morphology: Section *Spirales* (Fig. 296), but aerial mycelium is poorly devel-

oped on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. When spores and spiral chains are present, they often coalesce in moist droplets (hygroscopic masses, Fig. 297a,b). This morphology may be seen on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar, or sporulating aerial mycelium may be absent on these media; aerial mycelium is usually not formed on oatmeal agar. Spore surface: Smooth.

Special morphological characteristics: All three observers report conidia-like spores or hyphae on the agar surface as well as the hygroscopic masses of spores noted above.

Color of colony: Aerial mass color in the Gray or White color series when sporulating aerial mycelium is produced in sufficient quantity for color determination on yeast-malt agar, salts-starch agar, or glycerol-asparagine agar; aerial mycelium is often absent or difficult to observe because of moist exudate on these media.

Reverse side of colony: No distinctive pigments (pale yellow to light yellowish brown or olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction may be weak or delayed (4 days) on tyrosine agar. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces vinaceus Jones. Description: Jones (88). Not *S. vinaceus* (Mayer et al.) Waksman and Henrici 1953, 42 (208). Type strain: NRRL 2382 (T. G. Pridham, NRRL, personal communication, November 1967). ISP 5515 from T. G. Pridham, NRRL, as NRRL 2382. ISP description by Group E-5.

Spore-chain morphology: Section *Retinaculia-perti* or *Spirales* (Fig. 298). Primitive spirals or open imperfect spirals as well as hooks and loops of wide diameter are common. Mature spore chains are generally long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 299).

Color of colony: Aerial mass color in the Red color series (4gc or 4ec, grayish yellowish pink; 5gc, light reddish brown; 5dc, grayish yellowish pink; 5ca, light yellowish pink) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; white aerial mycelium may also be present on glycerol-asparagine agar.

Reverse side of colony: Strong brown or orange brown on yeast-malt agar; orange yellow, yellowish brown, or grayish yellowish pink on oatmeal agar and salts-starch agar; grayish yellow to moderate yellowish pink on glycerol-asparagine agar. Reverse mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tryptone-yeast broth, and Gauze Medium No. 2, but not in tyrosine agar. No pigment (or only a trace of yellow or pink) is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-mannitol, and D-fructose are utilized for growth. Utilization of L-arabinose is doubtful or weak. No growth or only a trace of growth with D-xylose, *i*-inositol, rhamnose, sucrose, or raffinose.

Streptomyces violaceoniger (Waksman and Curtis) Waksman and Henrici. Descriptions: *Actinomyces violaceus-niger* Waksman and Curtis 1916, 111 (207); *Streptomyces violaceoniger* (Waksman and Curtis) Waksman and Henrici 1948, 947 (208). See also: Hütter (80, p. 307). Type strain: Not extant; Suggested neotype, NRRL B-1476 (80, p. 307). ISP 5563 from T. G. Pridham, NRRL, as NRRL B-1476. ISP description by Group F-2.

Spore-chain morphology: Section *Spirales* with tight or compact spirals (Fig. 300). Spirals often entangled in masses which become moist and black. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 301).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar; young aerial mycelium may be white, and in 14 to 21 days part of the colony becomes black and moist (autolysis?). Collaborators selected a wide variety of color tabs in the Gray color series as nearest matching colors. These included 2dc, yellowish gray; 3ig, grayish yellowish brown; 4ig, light grayish brown; 3li and 5ih, brownish gray; 5fe, light grayish reddish brown; and 3ih, dark gray.

Reverse side of colony: Variable from nearly colorless, grayish yellow or light olive green to dark olive or dark grayish green. Reverse mycelium pigment is not pH sensitive.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose,

FIG. 288. *S. thermophilus*. RF spore chains on oatmeal agar, 14 days at 27 C.

FIG. 289. *S. thermophilus*. Spiny spores; electron micrograph from 14-day-old culture on oatmeal agar at 27 C.

FIG. 290. *S. thermoviolaceus*. Spiral spore chains on carbon-utilization medium plus raffinose, 28 C. $\times 950$.

FIG. 291. *S. thermoviolaceus*. Smooth spores; electron micrograph from 11-day-old culture on carbon-utilization medium plus mannitol.

FIG. 292. *S. tropicalensis*. Umbellate monoverticillate (BV) spore chains on salts-starch agar, 20 days. $\times 600$.

FIG. 293. *S. tropicalensis*. Smooth spores; electron micrograph from 10-day-old culture on salts-starch agar.

FIG. 294. *S. tuius*. (a) Spiral spore chains on salts-starch agar, 14 days. $\times 300$. (b, c) Monoverticillate arrangement of spirals on glycerol-asparagine agar. $\times 300$.

FIG. 295. *S. tuius*. Smooth spores; electron micrograph from 7-day-old culture on oatmeal agar.

FIG. 296. *S. versipellis*. Spiral spore chains on oatmeal agar, 7 days.

FIG. 297. *S. versipellis*. Globular or "hygroscopic" masses of spores. (a) On salts-starch agar, 28 days. $\times 300$. (b) Cohesion of spores in development of hygroscopic masses, yeast-malt agar, 7 days. $\times 550$.

rhamnose, sucrose, and raffinose are all utilized for growth.

Streptomyces violatus (Artamonova and Krasil'nikov) Pridham. Descriptions: *Actinomyces violatus* Artamonova and Krasil'nikov (159, p. 322-330; 334; English translation, 1966, p. 317/324; 328). *Streptomyces violatus* (Artamonova and Krasil'nikov) Pridham 1970, 30 (147). Type strain: INMI 1205 (Artamonova and Krasil'nikov 1960, 328 op. cit.) = RIA 708 (Krasil'nikov, personal communication, April 1964) = ATCC 15892 (Pridham 1970, 30 op. cit.). ISP 5209 from N. A. Krasil'nikov as RIA 708 = INMI 1205. ISP description by Group B-11.

Spore-chain morphology: Section *Spirales* (Fig. 302). Mature spore chains are moderately long, with 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 303).

Color of colony: Aerial mass color in the White or Red color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Nearest matching color tab in the Red color series is 5cb, grayish yellowish pink.

Reverse side of colony: Distinctive reddish to violet pigments: light grayish reddish brown on yeast-malt agar; light reddish purple to dark purplish pink or yellowish pink on oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from red or pink to violet or blue with the addition of 0.05 N NaOH and from violet to yellowish pink or orange with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but appear slowly or not at all in tyrosine agar. Red to violet pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is pH sensitive, showing the same changes recorded for the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, sucrose, raffinose, *i*-inositol, and D-mannitol are all utilized for growth.

Chainia violens Kalakutskii and Krasil'nikov in Rautenshtein 1960. See *Streptomyces violens* Pridham 1970.

Streptomyces violens (Kalakutskii and Krasil'nikov) Pridham. Descriptions: *Chainia* sp. 1212 = *Chainia violens* Kalakutskii and Krasil'nikov (159, p. 455; English translation, 1966, p. 41-51); *Streptomyces violens* (Kalakutskii and Krasil'nikov) Pridham 1970, 30 (147). Not *Strep-*

tomyces (*Actinomyces*) *violans* (sic) (Artamonova and Krasil'nikov) Pridham 1970, 29 (147). Type strain: INMI 1212 (Kalakutskii and Krasil'nikov [159]) = RIA 565 = ATCC 15898 = CBS 451.65 (L. V. Kalakutskii, personal communication, May 1969). Note: INMI 1212 is also designated as type strain for *Actinomyces violarius* Artamonova and Krasil'nikov (N. A. Krasil'nikov, personal communication, April 1964). See Shirling and Gottlieb (174, p. 499). Although the INMI strain number is the same for *A. violarius* and *C. violens*, the strain number in the RIA collection is not the same. Further, the descriptions submitted by ISP collaborators are not the same for *A. violarius* INMI 1212 = RIA 157 cf. *C. violens* INMI 1212 = RIA 565. Neither of these specific epithets is to be confused with that in the name *A. violans* (sic) Artamonova and Krasil'nikov or that in *S. violans* (Artamonova and Krasil'nikov) Pridham, which is based upon the type strain INMI 167. ISP 5597 from V. D. Kuznetsov as RIA 565. ISP description by Group F-6.

Spore-chain morphology: Section not determined. Aerial mycelium is not produced on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar. Spore surface: Not determined.

Special morphological characteristics: Sclerotia (Fig. 304) are produced on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, and the substrate (vegetative) mycelium fragments into rod-shaped or coccoid elements on these media (Fig. 305). One observer (Prauser) reports L-diaminopimelic acid and the absence of arabinose in the cell wall (cell-wall type I; see reference 15).

Color of colony: Aerial mass color not determined; aerial mycelium absent on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (colorless on glycerol-asparagine agar; pale or grayish yellow to light olive on yeast-malt agar, oatmeal agar, and salts-starch agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. (One observer reports melanin is produced on a peptone-yeast-iron agar of different composition. A pale yellow pigment in oatmeal agar is reported by one observer, and another reports orange or pinkish pigment in glycerol-asparagine agar. The latter is pH sensitive, changing from orange or rose to violet or light purple with the addition of 0.05 N NaOH.)

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth.

FIG. 298. *S. vinaceus*. RA morphology on salts-starch agar, 21 days. $\times 600$.

FIG. 299. *S. vinaceus*. Smooth spores; scanning electron micrograph from 21-day-old culture on yeast-malt agar.

FIG. 300. *S. violaceoniger*. Compact spirals in masses of spirals on glycerol-asparagine agar, 14 days. $\times 812$.

FIG. 301. *S. violaceoniger*. Smooth spores; electron micrograph from 16-day-old culture on yeast-malt agar.

FIG. 302. *S. violatus*. Spiral spore chains on yeast-malt agar, 14 days. $\times 200$.

FIG. 303. *S. violatus*. Spiny spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 304. *S. violens* (*Chainia violens*). Sclerotia on yeast-malt agar, 14 days.

FIG. 305. *S. violens* (*Chainia violens*). Fragmentation of vegetative or surface mycelium on glycerol-asparagine agar, 21 days. $\times 700$.

Streptomyces viridifaciens Gourevitch and Lein. U.S. Pat. 2,712,517. July 5, 1955. Description: Gourevitch and Lein (63). Not *S. viridofaciens* (sic) Kawato and Shinobu 1959 (92). Kawato and Shinobu strain 608 was renamed *S. herbaricolor* Kawato and Shinobu 1959 q.v. (R. Shinobu, personal communication, May 1968). Type strain: BL-567201 = ATCC 11989 (63). ISP 5239 from K. Crook, Jr., Bristol Laboratories, as BL-567201 = ATCC 11989. ISP description by Group B-5.

Spore-chain morphology: Section *Retinaculipertii*. Open loops and primitive open spirals are common (Fig. 306a). Straight to flexuous chains may also be seen (Fig. 306b). Mature spore chains have 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 307).

Color of colony: Aerial mass color in the Gray color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar (3ih, dark gray, to 3li, brownish gray, in 14- to 21-day-old cultures; younger cultures, 2ih, light olive-gray).

Reverse side of colony: No distinctive pigments (olive brown to dark brown on yeast-malt agar; grayish greenish yellow, light grayish olive to light olive brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Only a trace amount of yellowish green pigment is found in the medium in yeast-malt agar, oatmeal agar, or glycerol-asparagine agar. (Diffusible pigment may be absent on these media.)

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, and sucrose are utilized for growth. Only a trace of growth is found with *i*-inositol, D-mannitol, rhamnose, or raffinose.

Actinomyces viridis Millard and Burr 1926, 616. Not *Actinomyces viridis* (Lombardo-Pellegrino) Baldacci; not *Streptomyces viridis* (Lombardo-Pellegrino) Waksman 1953; not *Actinomyces viridis* Duché. See: *Streptomyces viridogenes* (Millard and Burr) Waksman 1953.

Streptomyces viridis (Lombardo-Pellegrino) Waksman. Descriptions: *Streptothrix viridis* Lombardo-Pellegrino 1903, 1065-1068 (118); *Actinomyces viridis* (Lombardo-Pellegrino) Baldacci 1940, 159 (8); *Streptomyces viridis* (Lombardo-Pellegrino) Waksman 1953, 101 (204). Not *A. viridis* Millard and Burr or *S. viridogenes* (Millard and Burr) Waksman 1953 (204). Type strain: Suggested neotype is strain Baldacci 398 = IPV 398 (Hütter [79, p. 79]). ISP 5381 from E. Bal-

dacci, IPV, as IPV 398 = strain Baldacci 398. ISP description by Group E-3.

Spore-chain morphology: Section *Spirales* (Fig. 308). Mature spore chains are frequently short, with 3 to 10 or more spores per chain so that spirals of only one or two turns or incomplete spirals and hooks are common. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 309).

Color of colony: Aerial mass in the Blue color series (19fe or 19dc, pale blue, or 22fe, pale green) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Olive brown on yeast-malt agar; grayish olive, pale green, or pale blue on oatmeal agar and salts-starch agar; pale yellow on glycerol-asparagine agar. Reverse mycelium pigment is pH sensitive, changing from bluish or greenish to red or pink with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. Blue pigment may be found in the medium in oatmeal agar. When present, this pigment is pH sensitive, changing from bluish to pink with the addition of 0.05 N HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-fructose, and rhamnose are utilized for growth. Reports vary on utilization of D-mannitol; utilization of sucrose or raffinose is doubtful.

Actinomyces viridiviolaceus Ryabova and Preobrazhenskaya. Descriptions: *Actinomyces viridiviolaceus* Ryabova and Preobrazhenskaya (55, p. 188; English translation, p. 143); *Streptomyces viridiviolaceus* (Ryabova and Preobrazhenskaya) Pridham, Hesseltine, and Benedict 1958, 70 (148). Type strain: INA 5276/56 (G. F. Gauze, personal communication, September 1964; see also Gauze [61, p. 20]). ISP 5280 from G. F. Gauze as INA 5276/56. ISP description by Group B-10.

Spore-chain morphology: Section *Spirales* (Fig. 310). Mature spore chains are moderately long, with 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny to hairy (Fig. 311).

Color of colony: Aerial mass color in the Gray color series (3fe, light brownish gray; 5fe or 5ge, light grayish reddish brown; 3ig, grayish yellowish brown) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Strong brown or reddish brown on yeast-malt agar and glycerol-asparagine

agar; yellowish brown or olive brown on oatmeal agar and salts-starch agar. Reverse mycelium pigment is a pH indicator, changing from yellow or orange to violet with the addition of 0.05 N NaOH and from violet or red to orange with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Orange or red pigment is found in the medium in yeast-malt agar, salts-starch agar, and glycerol-asparagine agar but not in oatmeal agar. This pigment is pH sensitive, showing the same changes observed with the reverse mycelium pigment.

Carbon utilization: D-Glucose, L-arabinose, D-mannitol, and D-fructose are utilized for growth. Utilization of D-xylose, *i*-inositol, or sucrose is doubtful. No growth or only a trace of growth with rhamnose or raffinose.

Streptomyces viridochromogenes (Krainsky) Waksman and Henrici. Descriptions: *Actinomyces viridochromogenes* Krainsky 1914, 680 and 684 (99); Waksman and Curtis 1916, 127 (207); Waksman 1919, 163–165 (203); *Streptomyces viridochromogenes* (Krainsky) Waksman and Henrici 1948 (208). Type strain: NRRL B-1511 = SC 3324 (proposed neotype, W. Trejo, Squibb Inst., personal communication, November 1963). ISP 5110 from W. H. Trejo as SC 3324 = NRRL B-1511. ISP description by Group E-1.

Spore-chain morphology: Section *Spirales* (Fig. 312). Mature spore chains are generally long, often with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 313).

Color of colony: Aerial mass color in the Green color series (24ih, grayish green; 24½ih, dark grayish green), Yellow color series (24½dc, pale yellow green) or Gray color series (2dc, yellowish gray) on yeast-malt agar. It is in the Yellow (1dc, pale yellow green), Green (24½li, dark greenish gray), or Blue (22fe, pale green) color series on oatmeal agar. It is in the Blue (19dc, pale blue; 22fe, pale green) color series on salts-starch agar. It is in the Blue (19dc, pale blue; 22fe, pale green) or Yellow (1dc, pale yellow green) color series on glycerol-asparagine agar.

Reverse side of colony: Olive brown to dark olive on yeast-malt agar; grayish green to grayish olive on oatmeal agar; grayish yellow, olive brown or greenish yellow on salts-starch agar and glycerol-asparagine agar. Reverse mycelium pigment is a pH indicator, changing from bluish or greenish brown to reddish or purplish brown with the addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar and tryptone-

yeast broth; tyrosine agar may or may not be darkened in 2 to 4 days. Greenish pigment is found in the medium in oatmeal agar. This pigment is pH sensitive, changing from blue green or greenish to pink with the addition of 0.05 N HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, and raffinose are utilized for growth. Utilization of sucrose is doubtful.

Streptomyces viridoflavus Waksman and Taber. Descriptions: Waksman and Taber 1953 (209, p. 66–68); Waksman (206, p. 288–290). Not *Actinomyces viridiflavus* (sic) Duché. Type strain: IMRU 3685 (206, p. 290). ISP 5237 from S. A. Waksman as IMRU 3685. ISP description by Group B-10.

Spore-chain morphology: Section *Verticillati* (?). The spore-chain morphology and spore-surface ornamentation could not be determined by the three ISP collaborators who studied this strain. They did not find sporulating aerial mycelium on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar, or other media. The original description by Waksman and Taber (209, p. 66–68) states: "Tendency to lose property of producing aerial mycelium." However, another collaborator, T. G. Pridham, reports occasional production of true whorls regularly distributed on axial hyphae and characteristic of verticillate morphology (media not specified). This observation, together with the negative carbon-utilization pattern, suggests that this strain may belong in the genus *Streptoverticillium* Baldacci (T. G. Pridham, personal communication, May 1971).

Color of colony: Aerial mass color could not be determined on yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: Dark greenish yellow or light olive brown or grayish yellow on yeast-malt agar, salts-starch agar, and glycerol-asparagine agar; light grayish yellow on oatmeal agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar, or soluble pigment may be absent.

Carbon utilization: Little or no growth occurs on Pridham and Gottlieb carbon-utilization medium enriched with glucose, suggesting inability to grow on this mineral salts basal medium. There is no growth with D-glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, or raffinose.

Streptomyces viridogenes Waksman 1953 = *Actinomyces viridis* Millard and Burr 1926. De-

FIG. 306. *S. viridifaciens*. RA morphology. (a) Primitive spirals, hooks, and loops on salts-starch agar, 14 days. $\times 400$. (b) Flexuous chains on glycerol-asparagine agar, 14 days. $\times 200$.

FIG. 307. *S. viridifaciens*. Smooth spores; electron micrograph from 10-day-old culture on oatmeal agar.

FIG. 308. *S. viridis* (Lombardo-Pellegrino) Waksman. Spiral spore chains on yeast-malt agar, 14 days. $\times 480$.

FIG. 309. *S. viridis*. Spiny spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 310. *S. viridiviolaceus*. Spiral spore chains on glycerol-asparagine agar, 14 days. $\times 580$.

FIG. 311. *S. viridiviolaceus*. Spiny to hairy spores; electron micrograph from 14-day-old culture on glycerol-asparagine agar.

FIG. 312. *S. viridochromogenes*. Spiral chains on oatmeal agar, 7 days. $\times 500$.

FIG. 313. *S. viridochromogenes*. Spiny spores; electron micrograph from 21-day-old culture on yeast-malt agar.

scriptions: *Actinomyces viridis* Millard and Burr 1926, 616–618 (126); *Streptomyces viridogenes* (Millard and Burr) Waksman = *S. viridis* (sic) of Millard and Burr, Waksman 1953, 109 (204). Not *Streptothrix viridis* Lombardo-Pellegrino 1903, 1066 (118); not *Streptomyces viridis* (Lombardo-Pellegrino) Waksman 1953, 101–102 (204); not *Actinomyces viridis* (Lombardo-Pellegrino) Baldacci 1940, 159 (8); not *Actinomyces viridis* Duché 1934, 311–317 (43). Type strain: IMRU 3372 (S. A. Waksman, personal communication, September 1966) = CBS 369.66 (G. A. deVries, CBS, personal communication, September 1966) = ATCC 3372 (E. F. Lessel, ATCC, personal communication, February 1967). ISP 5454 from E. F. Lessel, ATCC, as ATCC 3372; ISP 5396 from S. A. Waksman as IMRU 3372. ISP 5454 was studied by Group D-6; ISP 5396 by Group D-4. Results of the two studies are identical and are combined here as a single description.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 314). Spore chains are flexuous or crooked and are generally short, with 3 to 10 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 315).

Color of colony: Aerial mass color in the Gray color series (2fe, medium gray; 2dc, yellowish gray; 3fe, light brownish gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Reverse side of colony: Olive brown, grayish brown, or reddish brown on yeast-malt agar; olive, olive brown, or yellowish brown on oatmeal agar, salts-starch agar, and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Grayish green pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. This pigment is somewhat pH sensitive, changing from grayish olive to pink or grayish brown with the addition of 0.05 N HCl.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of *i*-inositol, raffinose, or sucrose is doubtful.

Streptomyces viridosporus (Parke, Davis and Co., Brit. Pat. Specif. 712,547, July 28, 1954). Description: Parke, Davis and Co. (143). Type strain: Parke Davis 04889 = NRRL 2414 (143). ISP 5243 from C. W. Hesseltine, NRRL, as NRRL 2414. ISP description by Group B-12.

Spore-chain morphology: Section *Spirales* (Fig. 316). Spirals are sometimes irregular or imperfect when spore chains are short. Mature spore chains are generally short but contain more than 10

spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny to hairy (Fig. 317).

Color of colony: Aerial mass color in the Green color series on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Three observers selected a variety of color tabs as the nearest matching color including: 2ih, light olive; 1¹/₂li, olive gray; 1¹/₂ge, 1¹/₂ig, lig, light grayish olive; and 24¹/₂ih, dark greenish gray.

Reverse side of colony: No distinctive pigments (yellowish brown to olive brown on yeast-malt agar; pale grayish yellow to light yellowish brown or grayish olive on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth in 2 to 4 days. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. No growth or only trace of growth with sucrose or raffinose.

Streptomyces werraensis (Wallhäuser and Huber. German Pat. Application [DAS] 1,142,989). Description: Wallhäuser and Huber (111). Type strain: ATCC 14424 (111). ISP 5486 from E. Lessel, ATCC, as ATCC 14424. ISP description by Group E-3.

Spore-chain morphology: Section *Spirales* or RA. Imperfect spirals, flexuous chains, hooks, and loops are common (Fig. 318); well-developed spirals are rare. Mature spore chains generally contain 10 to 50 or more spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Spiny (Fig. 319).

Color of colony: Aerial mass color in the Gray color series (2dc, yellowish gray; 3fe, light brownish gray; g or e, medium gray) on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Aerial mycelium is sometimes absent or poorly developed on oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (nearly colorless or pale yellowish gray on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, *i*-inositol, D-mannitol, D-fructose, and rhamnose are utilized for growth. Reports vary

on amount of growth on sucrose, but utilization is doubtful. No growth or only a trace of growth with raffinose.

Streptomyces willmorei (Erikson) Waksman and Henrici. Descriptions: *Actinomyces willmorei* Erikson 1935, 36 (46); *Streptomyces willmorei* (Erikson) Waksman and Henrici 1948, 966-967 (208). Type strain: ATCC 6867 = NCTC 1856 = ETH 16706 (E. Lessel, ATCC, personal communication, April 1967). ISP 5459 from E. Lessel, ATCC, as ATCC 6867. ISP description by Group D-7.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 320). Mature spore chains are short to moderately long, usually with more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 321).

Color of colony: Aerial mass color in the Gray, Yellow, or White color series on yeast-malt agar, oatmeal agar, and salts-starch agar; White or Yellow color series on glycerol-asparagine agar. Nearest matching color tabs in the Gray color series are d, medium gray, and 2dc, yellowish gray. Nearest matching color tabs in the Yellow color series are 2ba and 2db, pale yellow.

Reverse side of colony: No distinctive pigments (light olive brown or yellowish brown on yeast-malt agar; colorless to pale grayish yellow or light grayish olive on oatmeal agar, salts-starch agar, and glycerol-asparagine agar).

Color in medium: Melanoid pigments are not formed (or only a very weak discoloration occurs) in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. No pigment or only a trace of yellow is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, D-xylose, D-mannitol, D-fructose, and rhamnose are utilized for growth. Utilization of L-arabinose is doubtful. No growth or only a trace of growth with *i*-inositol, sucrose, or raffinose.

Streptomyces xanthocidicus Asahi, Nagatsu, and Suzuki. Description: Asahi et al. (6). Type strain: IPCR (Tokyo) 51-4 (6). ISP 5575 from Y. Okami as IPCR 51-4. ISP description by Group F-3.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 322). Mature spore chains generally are long and straight, with more than 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Spore surface: Smooth (Fig. 323).

Color of colony: Aerial mass color in the Gray

color series (5fe, light grayish reddish brown; 3fe, light brownish gray; d-2fe, light to moderate gray) on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar, and Gauze Medium No. 1.

Reverse side of colony: No distinctive pigments (colorless to pale grayish yellow on glycerol-asparagine agar; grayish yellow on oatmeal agar and salts-starch agar; light yellowish brown to brown on yeast-malt agar and on Gauze Medium No. 1).

Color in medium: Melanin reaction variable in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth; both weakly positive and negative reactions are recorded by different observers in 2 to 4 days. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, D-fructose, sucrose, and raffinose are utilized for growth. No growth or only a trace of growth with *i*-inositol, D-mannitol, or rhamnose.

Streptomyces xantholiticus (Konev and Tsyganov) Pridham. Description: *Actinomyces xantholiticus* Konev and Tsyganov 1962, 1023-1026 (94). *Streptomyces xantholiticus* (Konev and Tsyganov) Pridham 1970, 31 (147). Type strain: LIA 1130/12 (Konev and Tsyganov op. cit.). ISP 5244 from Y. E. Konev as LIA 1130/12. ISP description by Group B-6.

Spore-chain morphology: Section *Spirales* (Fig. 324). Sporulating aerial mycelium is poorly developed on yeast-malt agar, oatmeal agar, salts-starch agar, and glycerol-asparagine agar. Two observers report compact spirals on salts-starch agar; one observer reports spirals on yeast-malt agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 325).

Color of colony: Aerial mass color in the Gray color series when adequate sporulating aerial mycelium is formed on salts-starch agar or glycerol-asparagine agar. Color of aerial mycelium cannot be determined on yeast-malt agar or oatmeal agar.

Reverse side of colony: Pale yellow green to greenish yellow on oatmeal agar, salts-starch agar, and glycerol-asparagine agar; moderate yellow to light olive brown on yeast-malt agar.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Yellow pigment is found in the medium in glycerol-asparagine agar and sometimes in oatmeal agar or salts-starch agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

Carbon utilization: D-Glucose, D-xylose, and D-fructose are utilized for growth. Utilization of *i*-inositol is doubtful; no growth or only a trace of growth with L-arabinose, D-mannitol, rhamnose, sucrose, or raffinose.

FIG. 314. *S. viridogenes* (*A. viridis* Millard and Burr). Crooked and flexuous spore chains on glycerol-asparagine agar, 21 days. $\times 800$.

FIG. 315. *S. viridogenes* (*A. viridis* Millard and Burr). Smooth spores; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 316. *S. viridosporus*. Spiral spore chains from 14-day-old culture on salts-starch agar. $\times 625$.

FIG. 317. *S. viridosporus*. Spiny to hairy spores; electron micrograph from 14-day-old culture on salts-starch agar.

FIG. 318. *S. werraensis*. Flexuous chains, hooks, and some imperfect spirals on oatmeal agar, 14 days. $\times 480$.

FIG. 319. *S. werraensis*. Spores with thin and inconspicuous spines; electron micrograph from 14-day-old culture on oatmeal agar.

FIG. 320. *S. willmorei*. RF morphology on glycerol-asparagine agar, 14 days. $\times 150$.

FIG. 321. *S. willmorei*. Smooth spores. (a) Electron micrograph from 14-day-old culture on glycerol-asparagine agar. (b) Carbon repligaph from 14-day-old culture on yeast-malt agar.

Streptomyces zaomyceticus Hinuma. Description: Hinuma (73). Type strain: Tohoku Univ. N-187 (73). ISP 5196 from N. Ishida, Tohoku Univ., as N-187. ISP description by Group B-6.

Spore-chain morphology: Section *Rectiflexibiles* (Fig. 326). Mature spore chains generally are long, often with more than 50 spores per chain. Long chains are flexuous, but true spirals are not formed. This morphology is seen on yeast-malt agar, oatmeal agar, and glycerol-asparagine agar but not on salts-starch agar. Spore surface: Smooth (Fig. 327).

Color of colony: Aerial mass color in the Gray or White color series on yeast-malt agar, oatmeal agar, and glycerol-asparagine agar. A good aerial mycelium is not produced on salts-starch agar. Nearest matching color tabs in the Gray color

series are 2dc, yellowish gray, and d, light gray.

Reverse side of colony: No distinctive pigments (olive brown to yellowish brown on yeast-malt agar; light grayish yellow to olive brown on oatmeal agar and salts-starch agar; grayish yellow on glycerol-asparagine agar).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar, and tryptone-yeast broth, but the reaction is weak in tyrosine agar. No pigment other than a melanoid pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar, or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, and D-xylose are utilized for growth. No growth or only a trace of growth with *D*-inositol, D-mannitol, D-fructose, rhamnose, sucrose, or raffinose.

FIG. 322. *S. xanthocidicus*. Very long, straight (RF) spore chains on glycerol-asparagine agar, 14 days. $\times 850$.

FIG. 323. *S. xanthocidicus*. Smooth spores; electron micrograph from 14-day-old culture on yeast-malt agar.

FIG. 324. *S. xantholiticus*. Spirals on oatmeal agar, 20 days. $\times 350$.

FIG. 325. *S. xantholiticus*. Smooth spores. Au/Pd-shadowed electron micrograph from 21-day-old culture on glycerol-asparagine agar.

FIG. 326. *S. zaomyceticus*. RF morphology on yeast-malt agar, 23 days. $\times 500$.

FIG. 327. *S. zaomyceticus*. Smooth spores. Au/Pd-shadowed electron micrograph from glycerol-asparagine agar, 21 days.

TABLE 1. *ISP strains with corresponding culture collection numbers*^a

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5001	<i>S. canescens</i>	II	19736	474.68	12751	1016
5002	<i>S. chattanoogensis</i>	II	13358 (19739) ^b	477.68	12754	1019
5003	<i>S. albogriseolus</i>	III	23875	614.68	12834	1101
5004	<i>Stv. griseocarneum</i>	II	12628 (19763)	501.68	3387; 12776	1043
5005	<i>Stv. cinnamoneum</i>	III	11874 (23897)	683.68	12852	1102
5009	<i>S. griseoplanus</i>	II	19766	504.68	12779	1046
5010	<i>S. calvus</i>	III	13382 (23890)	676.68	13200	1103
5011	<i>S. autotrophicus</i>	II	19727	466.68	12743	1008
5012	<i>S. cinereoruber</i>	II	19740	479.68	12756	1021
5013	<i>S. echinatus</i>	II	19748	487.68	12763	1029
5014	<i>S. eurythermus</i>	II	14975 (19749)	488.68	12764	1030
5015	<i>S. michiganensis</i>	II	14970 (19786)	538.68	12797	1065
5016	<i>S. narbonensis</i>	II	19790	542.68	12801	1069
5017	<i>S. canus</i>	II	12237 (19737)	475.68	12752	1017
5019	<i>S. pluricologrescens</i>	II	19798	550.68	12808	1077
5020	<i>S. fungicidicus</i>	V	27432	641.72	13340	1301
5021	<i>S. mediocidicus</i>	III	23936	920.68	13202	1104
5022	<i>S. filamentosus</i>	II	19753	492.68	12767	1034
5023	<i>S. nitrosporeus</i>	II	12769 (19792)	544.68	12803	1071
5024	<i>S. pyridomyceticus</i>	III	23953	936.68	13203	1105
5026	<i>S. pseudogriseolus</i>	III	12770 ^c (23949)	933.68	12902	1106
5027	<i>S. thioluteus</i>	V	12310	642.72	3364; 13341	1302
5028	<i>S. achromogenes</i>	II	12767 ^c (19719)	458.68	12735	1000
5029	<i>S. blastomyceticus</i>	II	19731	470.68	12747	1012
5030	<i>S. toyocaensis</i>	II	19814	567.68	12824	1094
5031	<i>S. minoensis</i>	II	19787	539.68	12798	1066
5032	<i>S. siyoensis</i>	II	13989 (19810)	563.68	12820	1090
5033	<i>S. aburaviensis</i>	III	23869	608.68	12830	1107
5034	<i>S. aerocolonigenes</i>	III	23870	609.68	13195	1108
5035	<i>S. massaporeus</i>	II	19785	537.68	12796	1064
5036	<i>S. spiroverticillatus</i>	II	19811	564.68	12821	1091
5037	<i>Stv. hiroshimense</i>	II	19772	510.68	12785	1052
5038	<i>S. luteoverticillatus</i>	III	23933	917.68	12887	1109
5039	<i>Stv. roseoverticillatum</i>	II	19807	560.68	12817	1087
5040	<i>S. orientalis</i>	II	19795	547.68	12806	1074
5041	<i>S. platensis</i>	III	23948	932.68	12901	1110
5042	<i>S. hawaiiensis</i>	II	12236 (19771)	509.68	12784	1051
5043	<i>S. alboniger</i>	II	12461 (19722)	461.68	12738	1003
5044	<i>S. fragilis</i>	III	23908	804.68	12862	1111
5045	<i>S. alboflavus</i>	III	12626 (23874)	613.68	13196	1112
5047	<i>S. griseinus</i>	III	23915	836.68	12869	1113

^a Abbreviations: ISP, International Streptomyces Project; ATCC, American Type Culture Collection, Rockville, Md., USA; CBS, Centraalbureau voor Schimmelcultures, Baarn, Netherlands; IFO, Institute for Fermentation, Osaka, Japan; RIA, Research Institute for Antibiotics, Moscow, USSR. *A.*, *Actinomyces*; *C.*, *Chainia*; *S.*, *Streptomyces*; *Stv.*, *Streptoverticillium*. II, Int. J. Syst. Bacteriol. **18**:69–189 (1968); III, Int. J. Syst. Bacteriol. **18**:279–392 (1968); IV, Int. J. Syst. Bacteriol. **19**:391–512 (1969); V, Int. J. Syst. Bacteriol. **22**:265–394 (1972).

^b Parentheses contain additional culture collection numbers for the same ISP strain.

^c Culture on deposit with the ATCC differed in some characters when compared with the ISP culture of the same strain.

TABLE 1. *Continued*

ISP	Name	ISP publication	ATCC	CBS	IFO	RIA
5048	<i>S. parvulus</i>	II	12434 (19796)	548.68	13193	1075
5049	<i>S. violaceoruber</i>	II	14980 (19816)	569.68	12826	1096
5051	<i>S. albireticuli</i>	II	19721	460.68	12737	1002
5052	<i>Stv. kentuchense</i>	III	12691 (23926)	910.68	12880	1114
5053	<i>S. ambofaciens</i>	III	23877	616.68	12836	1115
5054	<i>S. fasciculatus</i>	II	19751	490.68	12765	1032
5056	<i>S. bobili</i>	III	3310 (23889)	675.68	13199	1116
5057	<i>S. cacaoi</i>	II	3082 (19732)	471.68	12748	1013
5058	<i>S. californicus</i>	II	3312 (19734)	473.68	12750	1015
5060	<i>S. exfoliatus</i>	II	12627 (19750)	489.68	13191	1031
5061	<i>S. flaveolus</i>	II	3319 (19754)	493.68	12768	1035
5062	<i>S. flavovirens</i>	II	3320 (19758)	129.20 (496.68)	12771	1038
5063	<i>S. fradiae</i>	II	10745 ^c (19760)	498.68	12773	1040
5064	<i>S. gardneri</i>	III	23911	832.68	12865	1117
5065	<i>S. gelaticus</i>	III	3323 (23912)	833.68	12866	1118
5066	<i>S. griseobrunneus</i>	II	19762	500.68	12775	1042
5067	<i>S. griseolus</i>	II	3325 (19764)	502.68	12777	1044
5068	<i>S. halstedii</i>	II	10897 (19770)	508.68	12783	1050
5069	<i>S. lavendulae</i>	II	8664 (19777)	515.68	3177;	1057
					12789	
5070	<i>S. lipmanii</i>	II	3331 (19779)	532.68	12791	1059
5071	<i>S. nigrifaciens</i>	II	19791	543.68	12802	1070
5072	<i>S. olivaceus</i>	II	3335 (19794)	546.68	12805	1073
5073	<i>S. phaeochromogenes</i>	III	3338 ^c (23945)	929.68	12898	1119
5076	<i>S. roseus</i>	II	19808	561.68	12818	1088
5077	<i>S. rutgersensis</i>	II	3350 (19809)	562.68	12819	1089
5078	<i>S. scabies</i>	III	23962	945.68	12914	1120
5079	<i>S. verne</i>	IV	3353 (25509)	651.69	3112;	1289
					13097	
5080	<i>A. aureoverticillatus</i>	II	15854 (19726)	465.68	12742	679; 1007
5081	<i>A. luridus</i>	II	19782	534.68	12793	1061
5082	<i>S. violaceus</i>	IV	15888 (25515)	657.69	13103	1295
5083	<i>S. puniceus</i>	II	19801	553.68	12811	1080
5084	<i>S. caelestis</i>	II	15084 (14924; 19733)	472.68	12749	1014
5085	<i>S. chartreusis</i>	II	14922 (19738)	476.68	12753	1018
5086	<i>Stv. fervens</i>	V	27429	644.72	13343	1304
5088	<i>S. niveus</i>	II	19793	545.68	12804	1072
5089	<i>S. galbus</i>	III	23910	831.68	12864	1121
5090	<i>S. lanatus</i>	II	19775	513.68	12787	1055
5091	<i>S. murinus</i>	II	19788	540.68	12799	1067
5092	<i>S. althioticus</i>	II	19724	463.68	12740	1005
5093	<i>S. flavopersicus</i>	II	19756	494.68	12769	1036
5094	<i>S. virginiae</i>	II	19817	291.60 (570.68)	3729;	1097
					12827	
5095	<i>S. hirsutus</i>	II	19773	511.68	12786	1053
5096	<i>S. macrosporeus</i>	II	19783	535.68	12794	1062
5097	<i>S. pilosus</i>	II	19797	549.68	12807	1076
5098	<i>S. prasinopilosus</i>	II	19799	551.68	12809	1078
5099	<i>S. prasinus</i>	II	19800	552.68	12810	1079
5100	<i>S. ramulosus</i>	II	19802	554.68	12812	1081
5101	<i>S. tendae</i>	II	19812	565.68	12822	1092

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5103	<i>S. caeruleus</i>	V	27421	645.72	13344	1305
5104	<i>S. sulphureus</i>	V	27468	646.72	13345	1306
5105	<i>Stv. olivoreticuli</i>	III	23943	927.68	12896	1122
5106	<i>S. azureus</i>	II	14921 (19728)	467.68	12744	1009
5107	<i>S. curacoi</i>	II	13385 (19745)	484.68	12761	1026
5108	<i>S. cyaneus</i>	V	14923	647.72	13346	1307
5109	<i>S. nodosus</i>	III	14899 (23942)	926.68	12895	1123
5110	<i>S. viridochromogenes</i>	V	14920	648.72	13347	1308
5111	<i>S. xanthochromogenus</i>	II	19818	571.68	12828	1098
5112	<i>S. filipinensis</i>	III	23905	309.56 (801.68)	12860	1124
5113						
5114	<i>S. hachijoensis</i>	II	19769	507.68	12782	1049
5115	<i>S. recifensis</i>	II	19803	555.68	12813	1082
5116	<i>S. erythrogriseus</i>	V	27427			
5122	<i>S. roseosporus</i>	III	23958	941.68	12910	1125
5123	<i>S. herbaricolor</i>	III	23922	906.68	12876	1126
5124	<i>S. indigoferus</i>	III	23924	908.68	12878	1127
5125	<i>S. phaeopurpureus</i>	III	23946	930.68	12899	1128
5127	<i>S. aureofaciens</i>	III	10762 (23884)	664.68	12594; 12843	1129
5128	<i>S. chrysomallus</i>	II	23209	478.68	12755	1020
5129	<i>S. collinus</i>	II	19743	482.68	12759	1024
5130	<i>S. felleus</i>	II	19752	491.68	12766	1033
5131	<i>S. limosus</i>	II	19778	531.68	12790	1058
5133	<i>S. resistomycificus</i>	II	19804	556.68	12814	1083
5134	<i>S. xanthophaeus</i>	II	19819	572.68	12829	1099
5135	<i>A. acrimycini</i>	II	19885 (19720)	459.68	12736	1001
5136	<i>A. albovinaceus</i>	II	15823 (19723; 23613)	256.66 (462.68)	12739	1004
5137	<i>A. atroolivaceus</i>	II	19725	464.68	12741	1006
5138	<i>A. aurantiogriseus</i>	III	19887 (23883)	663.68	12842	1130
5139	<i>A. badius</i>	II	19888 (19729)	468.68	12745	1010
5140	<i>A. bicolor</i>	II	23614 ^c (19730)	469.68	12746	1011
5141	<i>A. candidus</i>	III	19891 (19735; 23891)	677.68	12846	1131
5144	<i>A. coeruleofuscus</i>	II	23618 (19741)	480.68	12757	1022
5145	<i>A. coeruleorubidus</i>	III	13740 (23900)	796.68	12855	1132
5146	<i>A. coerulescens</i>	II	19896 (19742)	481.68	12758	1023
5147	<i>A. cremeus</i>	II	19897 (19744)	483.68	12760	1025
5148	<i>A. cyaneofuscatus</i>	II	23619 (19746)	485.68	13190	1027
5149	<i>A. daghestanicus</i>	II	23620 (19747)	486.68	12762	1028
5150	<i>A. flavidovirens</i>	IV	19900 (25451)	684.69	13039	1231
5152	<i>A. flavotricini</i>	II	23621 ^c (19757)	495.68	12770	1037
5153	<i>A. flavoviridis</i>	II	19903 (19759)	497.68	12772	1039
5154	<i>A. fumanus</i>	IV	19904 (25454)	687.69	13042	1235
5155	<i>A. glaucescens</i>	II	23622 (19761)	499.68	12774	1041

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5159	<i>A. griseomycini</i>	II	23625 (19765)	503.68	12778	1045
5160	<i>A. griseorubens</i>	II	19909 (19767)	505.68	12780	1047
5161	<i>A. griseostramineus</i>	II	23628 (19768)	506.68	12781	1048
5162	<i>A. kurssanovii</i>	II	15824 (19774; 23629)	512.68	13192	1054
5163	<i>A. lateritius</i>	II	19913 (19776)	514.68	12788	1056
5164	<i>A. litmocidini</i>	II	19914 (19780)	533.68	12792	1060
5165	<i>A. longisporus-flavus</i>	III	19915 (19781; 23932)	915.68	12886	1133
5166	<i>A. longisporus</i>	III	23931	916.68	12885	1134
5167	<i>A. malachiticus</i>	II	19918 (19784)	536.68	12795	1063
5169	<i>A. mutabilis</i>	II	19919 (19789)	541.68	12800	1068
5172	<i>A. roseofulvus</i>	II	19921 (19805)	557.68	13194	1084
5173	<i>A. roseolilacinus</i>	II	19922 (19806)	558.68	12815	1085
5174	<i>A. roseolus</i>	II	23210	559.68	12816	1086
5175	<i>A. roseoviridis</i>	III	23959	942.68	12911	1135
5176	<i>A. rubiginosohelvolus</i>	III	19926 (23960)	943.68	12912	1136
5177	<i>A. rubiginosus</i>	III	19927 (23961)	944.68	12913	1137
5178	<i>A. toxytricini</i>	II	19813	566.68	12823	1093
5179	<i>A. variabilis</i>	II	19930 (19815)	568.68	12825	1095
5181	<i>A. violaceochromogenes</i>	IV	19932 (25512)	654.69	13100	1292
5183	<i>A. violascens</i>	III	23968	951.68	12920	1138
5185	<i>S. bellus</i>	III	14925 (23886)	666.68	12844	1139
5186	<i>S. aminophilus</i>	III	14961 ^c (23878)	617.68	12837	1140
5187	<i>S. endus</i>	III	23904	800.68	12859	1141
5188	<i>S. matensis</i>	III	23935	919.68	12889	1142
5189	<i>S. cellostaticus</i>	III	23894	680.68	12849	1143
5190	<i>S. goshikiensis</i>	III	23914	835.68	12868	1144
5191	<i>S. griseofuscus</i>	III	23916	837.68	12870	1145
5192	<i>S. melanogenes</i>	III	23937	921.68	12890	1146
5194	<i>S. racemochromogenus</i>	III	23954	937.68	12906	1147
5195	<i>S. tanashiensis</i>	III	23967	950.68	12919	1148
5196	<i>S. zaomyceticus</i>	V	27482	649.72	13348	1309
5197	<i>A. albocyaneus</i>	III	15845 (23872)	611.68		1149
5198	<i>A. cyanoalbus</i>	III	15859 (23902)	798.68	12857	662; 1150
5199	<i>A. globisporus</i>	III	15864 (23913)	834.68	12867	335; 1151
5200	<i>A. streptomycini</i>	III	15886 (23966)	949.68	12918	333; 1152
5201	<i>A. vulgaris</i>	IV	15895 (25519)	661.69	13107	334; 1299
5202	<i>A. levoris</i>	III	15876 (23929)	913.68	12883	338; 1153
5203	<i>A. fluorescens</i>	III	15860 (23907)	803.68	12861	647; 1154
5205	<i>A. violarius</i>	IV	25516	658.69	13104	1296
5206	<i>A. janthinus</i>	III	15870 (23925)	909.68	12879	659; 1155
5207	<i>A. violochromogenes</i>	IV	15893 (25517)	659.69	13105	657; 1297
5209	<i>S. violatus</i>	V	15892	650.72	13349	708; 1310
5210	<i>A. fulvoviridis</i>	III	15863 (23909)	830.68	12863	660; 1156
5211	<i>S. olivoviridis</i>	III	15882 (23944)	928.68	12897	661; 1157
5212	<i>A. pseudovenezuelae</i>	III	23951	934.68	12904	1158
5213	<i>A. pseudolavendulae</i>	III	23950	515.68	12903	1159

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5216	<i>A. lavendocolor</i>	III	15871 (23927)	911.68	12881	749; 1160
5217	<i>A. lavendofoliae</i>	III	15872 (23928)	912.68	12882	750; 1161
5218	<i>A. finlayi</i>	III	23340 (23906)	802.68	13201	1162
5219	<i>S. amakusaensis</i>	III	23876	615.68	12835	1163
5220	<i>S. chibaensis</i>	III	23895	681.68	12850	1164
5221	<i>S. mashiensis</i>	III	23934	918.68	12888	1165
5222	<i>S. misakiensis</i>	III	23938	922.68	12891	1166
5223	<i>S. noboritoensis</i>	IV	25477	887.69	13065	1257
5224	<i>S. yokosukanensis</i>	IV	25520	662.69	13108	1300
5225	<i>S. capreolus</i>	III	23892	678.68	12847	1167
5226	<i>S. argenteolus</i>	III	11009 (23882)	662.68	12841	1168
5227	<i>S. thermotolerans</i>	IV	11416 (25500)	960.69	13088	1280
5228	<i>S. afghaniensis</i>	III	23871	610.68	12831	1169
5229	<i>S. griseoviridis</i>	III	23920	904.68	12874	1170
5230	<i>S. venezuelae</i>	IV	10712 (25508)	650.69	13096	1288
5231	<i>S. rochei</i>	III	10739 (19245; 23956)	939.68	12908	1171
5232	<i>S. baarnensis</i>	III	23885	306.55 (665.68)	13197	1172
5233	<i>S. coelicolor</i>	III	23899	210.27 (795.68)		1173
5234	<i>S. antibioticus</i>	III	8663 (23879)	659.68	12838	1174
5235	See <i>S. bikiniensis</i>	III; V		651.72		1175; 1311
5236	<i>S. griseus</i>	III	23345 (23921)	905.68	12875	1176
5237	<i>S. viridoflavus</i>	V	12631	652.72	13351	1312
5239	<i>S. viridifaciens</i>	V	11989	653.72	13352	1313
5240	<i>S. roseo-luteus</i>	III	23957	940.68	12909	1177
5241	<i>S. saraceticus</i>	IV	25496	641.68 (956.69)	13084	1276
5242	<i>S. umbrosus</i>	IV	25504	646.69	13092	1284
5243	<i>S. viridosporus</i>	V	27479	654.72	13353	1314
5244	<i>S. xantholiticus</i>	V	27481	655.72	13354	1315
5249	<i>A. virido-diastaticus</i>	IV	25518	660.69	13106	1298
5250	<i>S. olivoverticillatus</i>	IV	25480	890.69	13068	1260
5252	<i>S. arabicus</i>	III	23881	661.68	12840	1178
5253	<i>S. ehimensis</i>	III	23903	799.68	12858	1179
5254	<i>S. lilacinus</i>	III	23930	914.68	12884	1180
5255	<i>S. sindenensis</i>	III	23963	946.68	12915	1181
5256	<i>S. coralus</i>	III	23901	797.68	12856	1182
5257	<i>S. vinaceus</i>	IV	11861 (25510)	307.55 (652.69)	13098	1290
5258	<i>S. catenulae</i>	III	12476 (23893)	679.68	12848	1183
5259	<i>Stv. netropsis</i>	III	23940	924.68	12893	1184
5260	<i>S. rimosus</i>	III	10970 (23955)	938.68	12907	1185
5261	<i>S. tubercidicus</i>	IV	25502	644.69	13090	1282
5262	<i>S. bottropensis</i>	IV	25435	163.64 (667.69)	13023	1215
5263	<i>S. humidus</i>	III	12760 (23923)	907.68	12877	1186
5265	<i>A. citreofluorescens</i>	III	15858 (23898)	684.68	12853	1187
5266	<i>S. horton</i>	V	27437	656.72	13355	1316
5267	<i>S. somaliensis</i>	III	19437 (23964)	947.68	12916	1188
5268	<i>S. albofaciens</i>	III	25184 (23873)	612.68	12833	1189
5269	<i>S. sclerotialus</i>	V	15721	657.72	13356	1317
5270	<i>S. flaviscleroticus</i>	V	19347	658.72	13357	1318
5271	<i>S. purpurogeniscleroticus</i>	V	19348	659.72 (409.66)	13358	1319
5272	<i>A. biverticillatus</i>	III	23615 (23888)	668.68	12845	1190
5273	<i>A. chromofuscus</i>	III	23896	682.68	12851	1191

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5274	<i>A. griseocarnatus</i>	III	23623 (23917)	838.68	12871	1192
5275	<i>A. griseoruber</i>	III	23626 (23918)	839.68	12872	1193
5276	<i>A. nigrescens</i>	III	23941	925.68	12894	1194
5277	<i>A. roseoviolaceus</i>	IV	25493	953.69	13081	1273
5278	<i>A. umbrinus</i>	IV	19929 (25503)	645.69	13091	1283
5279	<i>A. violaceorectus</i>	IV	25514	656.69	13102	1294
5280	<i>A. viridiviolaceus</i>	V	27478	660.72	13359	1320
5281	<i>S. griseoruber</i>	III	23919	903.68	12873	1195
5282	<i>S. naganishii</i>	III	23939	923.68	12892	1196
5283	<i>S. purpeofuscus</i>	III	23952	935.68	12905	1197
5284	<i>S. antimycoticus</i>	III	23880	660.68	12839	1198
5285	<i>S. phaeoviridis</i>	III	23947	931.68	12900	1199
5292	<i>S. spheroides</i>	III	23965	948.68	12917	1200
5293	<i>S. arenae</i>	IV	25428	926.69	13016	1208
5294	<i>S. carnosus</i>	IV	25437	668.69	13025	1217
5296	<i>S. craterifer</i>	IV	25445	676.69	13033	1225
5297	<i>S. listeri</i>	V	27442	661.72	13360	1321
5300	<i>S. cavourensis</i>	IV	14889 (25438)	669.69	13026	1218
5301	<i>S. minutiscleroticus</i>	V	17757 (19346)	662.72	13361	1322
5302	<i>C. nigra</i>	V	17756	663.72	13362	1323
5303	<i>S. roseiscleroticus</i>	V	17755	664.72	13363	1324
5304	<i>C. rubra</i>	V	17754			
5306	<i>S. misionensis</i>	IV	14991 (25475)	885.69	13063	1255
5307	<i>S. ornatus</i>	IV	23265 (25481)	909.69 (253.65)	13069	1261
5309	<i>S. vastus</i>	IV	25506	648.69 (290.60)	13094	1286
5310	<i>S. purpurascens</i>	IV	25489	917.69	13077	1269
5313	<i>S. albus</i>	IV	3004 (25426)	924.69	13014	1206
5314	<i>S. nashvillensis</i>	IV	25476	886.69	13064	1256
5315	<i>S. paucisporogenes</i>	IV	12596 (25482)	910.69	13070	1262
5316	<i>S. polychromogenus</i>	IV	12595 ^c (25484)	311.56 (912.69)	13072	1264
5317	<i>S. lucensis</i>	IV	17804 (25468)	701.69	13056	1248
5318	<i>S. melanosporofaciens</i>	IV	25473	883.69	13061	1253
5319	<i>S. plicatus</i>	IV	25483	911.69	13071	1263
5320	<i>S. albidus</i>	IV	25423	100.34 (921.69)	13011	1203
5321	<i>S. krainskii</i>	IV	25465	342.35 (698.69)	13053	1245
5322	<i>S. fimicarius</i>	IV	25449	420.34 (682.69)	13037	1229
5323	<i>S. flavogriseus</i>	IV	25452	101.34 (685.69)	13040	1232
5324	<i>S. gougeroti</i>	IV	10975 (25455)	422.34 (688.69)	13043	1235
5326	<i>S. alboviridis</i>	IV	25425	923.69	13013	1205
5327	<i>S. flocculus</i>	IV	25453	686.69	13041	1233
5328	<i>S. heimi</i>	IV	25460	693.69	13048	1240
5329	<i>S. termitum</i>	IV	25499	959.69	13087	1279
5331	<i>S. microflavus</i>	IV	13231 (25474)	124.18 (884.69)	13062	1254
5332	<i>A. malachitofuscus</i>	IV	25471	881.69	13059	1251

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5333	<i>A. malachitorectus</i>	IV	25472	882.69	13060	1252
5334	<i>A. olivaceoviridis</i>	IV	23630 (25478)	888.69	13066	1258
5335	<i>A. prunicolor</i>	IV	25487	915.69	13075	1267
5336	<i>Stv. kashmirens</i>	V	27439	665.72	13364	1325
5337	<i>S. actuosus</i>	IV	25421	919.69	13009	1201
5338	<i>S. pristinaespiralis</i>	IV	25486	914.69	13074	1266
5340	<i>S. corchorusii</i>	IV	25444	677.69	13032	1224
5341	<i>S. psammoticus</i>	IV	25488	175.61 (916.69)	13076	1268
5345	<i>S. karnatakensis</i>	IV	25463	696.69	13051	1243
5346	<i>A. varsoviensis</i>	IV	14631c ^c (25505)	357.64 (647.69)	13093	1285
5347	<i>S. odorifer</i>	V	6246	666.72	13365	1326
5348	<i>S. parvus</i>	V	12433	427.61		
5350	<i>S. galtieri</i>	V	27433	368.49 (667.72)	13366	1327
5355	<i>S. lincolnsensis</i>	IV	25466	630.70 (699.69)	13054	1246
5356	<i>S. sparsogenes</i>	IV	25498	672.69 (958.69)	13086	1278
5357	<i>S. natalensis</i>	V	27448	668.72 (700.57)	13367	1328
5358	<i>S. novaecaesareae</i>	V	27452	669.72 (134.20)	13368	1329
5361	<i>S. anulatus</i>	V	27416	670.72	13369	1330
5362	<i>S. cellulosa</i>	IV	25439	122.18 (670.69)	13027	1219
5364	<i>S. citreus</i>	IV	25441	109.60 (704.69)	13029	1221
5365	<i>S. thermophilus</i>	V	19282	275.66 (671.72)	13370	1331
5366	<i>S. flavofungini</i>	V	27430	672.72 (411.59)	13371	1332
5367	<i>S. phaeofaciens</i>	V	15034	673.72 (426.64)	13372	1333
5372	<i>S. intermedius</i>	IV	3329 (25461)	101.21 (694.69)	13049	1241
5379	<i>S. vendargensis</i>	IV	25507	154.57 (649.69)	13095	1287
5381	<i>S. viridis</i>	V	15732	674.72	13373	1334
5383	<i>S. ipomoea</i>	IV	25462	695.69	13050	1242
5384	<i>S. chromogenus</i>	V	27424	675.72	13374	1335
5385	<i>S. griseolavendus</i>	IV	25457	690.69	13045	1237
5386	<i>A. aureocirculatus</i>	IV	19823 ^c (15851; 25430)	928.69	13018	682; 1210
5387	<i>A. aureoversales</i>	IV	15853 (25433)	664.69	13021	681; 1213

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5392	<i>S. griseoluteus</i>	V	12768	676.72	13375	1336
5393	<i>S. praecox</i>	IV	3374 (25485)	913.69 (104.27)	13073	66; 1265
5394	<i>S. sampsonii</i>	IV	25495	955.69	13083	1275
5395	<i>S. setonii</i>	IV	25497	957.69 (105.27)	13085	1277
5397	<i>S. kishiwadensis</i>	IV	25464	697.69	13052	1244
5398	<i>S. luteofluorescens</i>	IV	25469	702.69	13057	1249
5402	<i>S. capuensis</i>	IV	25436	113.63 (744.69)	13024	1216
5410	<i>A. albohelvatus</i>	IV	19820 (25424)	922.69	13012	1204
5412	<i>A. aurantiacus</i>	IV	19822 (25429)	927.69	13017	1209
5414	<i>A. aureofasciculus</i>	IV	19824 (25431)	666.69	13019	1211
5416	<i>A. aureomonopodiales</i>	IV	19825 (25432)	665.69	13020	1212
5417	<i>A. aurigineus</i>	IV	19827 ^c (25434)	663.69	13022	1214
5419	<i>S. caesius</i>	V	19828	677.72	13376	1337
5420	<i>S. chrysseus</i>	V	19829	678.72	13377	1338
5421	<i>S. coelescens</i>	V	19830	679.72	13378	1339
5422	<i>A. coeliatus</i>	IV	19833 (25442)	679.69	13030	1222
5424	<i>A. coerulatus</i>	IV	19834 (25443)	678.69	13031	1223
5425	<i>A. cyanocolor</i>	IV	19835 (25446)	675.69	13034	1226
5426	<i>A. cyanogenus</i>	IV	19836 (25447)	674.69	13035	1227
5427	<i>A. cyanoglomerus</i> subsp. <i>cellulose</i>	IV	19837 (25448)	681.69	13036	1228
5428	<i>A. flavescens</i>	IV	19838 (25450)	683.69	13038	1230
5429	<i>S. glomeroaurantiacus</i>	V	19839	681.72	13380	1341
5430	<i>S. griseoaurantiacus</i>	V	19840	682.72	13381	1342
5431	<i>S. helveticus</i>	V	19841	683.72	13382	1343
5432	<i>S. indigocolor</i>	V	19842	684.72	13383	1344
5433	<i>S. lazureus</i>	V	19843	685.72	13384	1345
5434	<i>S. lividans</i>	V	19844	686.72	13385	1346
5435	<i>A. longissimus</i>	IV	19850 (25467)	700.69	13055	1247
5436	<i>A. rectiverticillatus</i>	IV	19845 ^c (25491)	951.69	13079	1271
5438	<i>A. violaceolatus</i>	IV	19847 (25513)	655.69	13101	1293
5441	<i>S. nobilis</i>	V	19251	687.72 (197.65)	13386	1347
5443	<i>S. thermoviolaceus</i> subsp. <i>thermoviolaceus</i>	V	19283	688.72	13387	1348
5444	<i>S. thermovulgaris</i>	IV	19284 (25501)	643.69 (276.66)	13089	1281
5445	<i>S. subrutilus</i>	V	27467	689.72	13388	1349

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5447	<i>S. almquisti</i>	IV	618 (25427)	925.69	13015	1207
5449	<i>S. diastatochromogenes</i>	V	12309	690.72	3337; 13389	1350
5451	<i>S. olivochromogenes</i>	IV	3336 (25479)	889.69	13067	1259
5452	<i>S. rangoon</i>	IV	6860 (25490)	918.69	13078	1270
5454	<i>S. viridogenes</i>	V	3372	369.66 (691.72)	13390	1351
5455	<i>S. albidoflavus</i>	IV	25422	416.34 (920.69)	13010	1202
5456	<i>S. griseoflavus</i>	IV	25456	409.52 (689.69)	13044	1236
5459	<i>S. willmorei</i>	V	6867	692.72 (372.64)	13391	1352
5461	<i>S. lydicus</i>	IV	25470	703.69	13058	1250
5463	<i>S. roseochromogenes</i>	IV	13400 (25492)	952.69	13080	651; 1272
5464	<i>Stv. rubrreticuli</i>	IV	12629 ^c (25494)	954.69	13082	1274
5465	<i>A. alborubidus</i>	V	23612	693.72	13392	1353
5467	<i>A. cinnabarinus</i>	IV	23617 (25440)	671.69	13028	1220
5468	<i>A. griseoalbus</i>	IV	23624 ^c (25458)	691.69	13046	1238
5469	<i>A. griseorubiginosus</i>	IV	23627 (25459)	692.69	13047	1239
5470	<i>S. vinaceus-drappus</i>	IV	25511	653.69	13099	1291
5472	<i>S. salmonicida</i>	V	27463	694.72	13393	1354
5473	<i>Stv. parvisporogenes</i>	V	12568	695.72	13394	1355
5475	<i>S. atrofaciens</i>	V	27418	696.72	13395	1356
5476	<i>S. spadici</i>	V	19017	680.72	13379	1340
5477	<i>S. tenebrarius</i>	V	17920	697.72	13396	1357
5478	<i>S. albaduncus</i>	V	14698	698.72	13397	1358
5479	<i>S. cirratus</i>	V	14699	699.72	13398	1359
5480	<i>S. galbus</i>	V	14077	700.72	13399	1360
5481	<i>S. galilaeus</i>	V	14969	701.72	13400	1361
5482	<i>S. iakyrus</i>	V	15375	702.72	13401	1362
5483	<i>S. luteogriseus</i>	V	15072	703.72	13402	1363
5485	<i>S. coriofaciens</i>	V	14155	704.72	13403	1364
5486	<i>S. werraensis</i>	V	14424	705.72 (437.67)	13404	1365
5487	<i>S. lavenduligriseus</i>	V	13306	706.72	13405	1366
5488	<i>S. roseogriseus</i>	V	12414	707.72	13406	1367
5489	<i>S. rishiriensis</i>	V	14812	708.72	13407	1368
5490	<i>S. nigellus</i>	V	27450	709.72	13408	1369
5491	<i>S. versipellis</i>	V	27475	710.72	13409	1370
5492	<i>S. albulus</i>	V	12757	711.72	13410	1371
5494	<i>S. capoamus</i>	V	19006	712.72	13411	1372
5496	<i>S. diastaticus</i>	V	3315	713.72	1341	1373
5499	<i>S. griseochromogenes</i>	V	14511	714.72	13413	1374
5500	<i>S. kanamyceticus</i>	V	12853	715.72	13414	1375
5501	<i>S. mediterranei</i>	V	13685	716.72	13415	1376

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5503	<i>S. moro-okaensis</i>	V	19166	717.72	13416	1377
5504	<i>S. showdoensis</i>	V	15105	718.72	13417	1378
5505	<i>S. tuirus</i>	V	19007	719.72	13418	1379
5506	<i>S. prasinosporus</i>	V	17918	720.72	13419	1380
5507	<i>Stv. griseoverticillatum</i>	V	27436	721.72	13420	1381
5508	<i>S. naraensis</i>	V	13788	722.72	13421	1382
5509	<i>S. luteoreticuli</i>	V	27446	723.72	13422	1383
5511	<i>S. ostreogriseus</i>	V	27455	724.72	13423	1384
5512	<i>S. spectabilis</i>	V	27465	725.72	13424	1385
5515	<i>S. vinaceus</i>	V	27476	726.72	13425	1386
5517	<i>S. erythraeus</i>	V	11635	727.72	13426	1387
5518	<i>S. gedanensis</i>	V	4880	728.72	13427	1388
5520	<i>S. tropicalensis</i>	V	17963	729.72	13428	1389
5526	<i>S. avidinii</i>	V	27419	730.72	13429	1390
5527	<i>S. arduus</i>	V	27417	731.72	13430	1391
5528	<i>S. canarius</i>	V	27423	732.72	13431	1392
5529	<i>S. moderatus</i>	V	23443	733.72	13432	1393
5530	<i>S. pactum</i>	V	27456	734.72	13433	1394
5531	<i>S. pallidus</i>	V	27457	735.72	13434	1395
5532	<i>S. regalis</i>	V	27460	736.72	13435	1396
5533	<i>S. rosa</i>	V	27462	737.72	13436	1397
5534	<i>S. cyaneogriseus</i>	V	27426	738.72	13437	1398
5535	<i>S. anandii</i>	V	19388	739.72	13438	1399
5536	<i>S. roseoflavus</i>	V	13167	740.72	13439	1400
5537	<i>S. saprophyticus</i>	V	3351	741.72	13440	1401
5539	<i>S. durhamensis</i>	V	23194	742.72	13441	1402
5540	<i>S. acidoresistans</i>	V	27413	743.72	13442	1403
5541	<i>S. flavochromogenes</i>	V	14841	744.72	13443	1404
5545	<i>S. chrestomyceticus</i>	V	14947	745.72	13444	1405
5546	<i>S. nogalater</i>	V	27451	746.72	13445	1406
5547	<i>S. steffisburgensis</i> subsp. <i>steffisburgensis</i>	V	27466	747.72	13446	1407
5550	<i>S. katrae</i>	V	27440	748.72	13447	1408
5551	<i>S. regensis</i>	V	27461	749.72	13448	1409
5552	<i>S. omiyaensis</i>	V	27454	750.72	13449	1410
5553	<i>S. mirabilis</i>	V	27447	751.72	13450	1411
5554	<i>S. avellaneus</i>	V	23730	752.72	13451	1412
5555	<i>S. libani</i>	V	23732	753.72	13452	1413
5557	<i>S. alni</i>	V	27415	100.41 (754.72)	13453	1414
5558	<i>S. colombiensis</i>	V	27425	755.72	13454	1415
5559	<i>S. graminofaciens</i>	V	12705	756.72	13455	1416

TABLE 1. *Continued*

ISP	Name	ISP publication no.	ATCC	CBS	IFO	RIA
5560	<i>S. tauricus</i>	V	27470	757.72	13456	1417
5561	<i>A. cretaceus</i>	V	3005	137.21 (758.72)	13457	1418
5562	<i>S. griseosporeus</i>	V	27435	759.72	13458	1419
5563	<i>S. violaceoniger</i>	V	27477	760.72	13459	1420
5564	<i>S. bluensis</i>	V	27420	761.72	13460	1421
5565	<i>S. aspergilloides</i>	V	14808	762.72	13461	1422
5566	<i>S. pulcher</i>	V	13849	763.72	13462	1423
5567	<i>S. paraguayensis</i>	V	27458	104.48 (764.72)	13463	1424
5568	<i>S. lusitanus</i>	V	27444	765.72	13464	1425
5570	<i>S. albolongus</i>	V	27414	766.72	13465	1426
5571	<i>Stv. orinoci</i>	V	23202	767.72	13466	1427
5572	<i>S. gannmycicus</i>	V	27434	768.72	13467	1428
5573	<i>S. thermodiastaticus</i>	V	27472	769.72	13468	1429
5574	<i>S. thermoflavus</i>	V	27473			
5575	<i>S. xanthocidicus</i>	V	27480	770.72	13469	1430
5576	<i>S. takataensis</i>	V	27469	771.72	13470	1431
5577	<i>Stv. septatum</i>	V	27464	772.72	13471	1432
5578	<i>S. hygrosopicus</i>	V	27438	773.72	13472	1433
5579	<i>S. thermotritificans</i>	V	23385	774.72	13473	1434
5581	<i>S. bikiniensis</i>	V	11062			
5585	<i>S. tetanusemus</i>	V	27471	775.72	13474	1435
5586	<i>S. hydrogenans</i>	V	19631	776.72	13475	1436
5587	<i>Stv. ladakanus</i>	V	27441	777.72	13476	1437
5588	<i>S. neyagawaensis</i>	V	27449	778.72	13477	1438
5589	<i>A. oligocarophilus</i>	V	27453	101.18 (779.72)	13478	1439
5590	<i>S. bambergensis</i>	V	13879	780.72	13479	1440
5591	<i>A. ochroleucus</i>	V	3006	781.72 (138.21)	13480	1441
5592	<i>S. peruviansis</i>	V	27459	782.72	13481	1442
5593	<i>S. fulvissimus</i>	V	27431	783.72	13482	1443
5594	<i>S. ochraceiscleroticus</i>	V	15814	784.72	13483	710; 1444
5595	<i>S. olivaceiscleroticus</i>	V	15722	785.72	13484	1445
5596	<i>S. poonensis</i>	V	15723	786.72 (295.66)	13485	1446
5597	<i>S. violens</i>	V	15898	787.72 (451.65)	13486	565; 1447
5598	<i>S. bacillaris</i>	V	15855	788.72	13487	336; 1448
5599	<i>S. longispororuber</i>	V	27443	789.72	13488	1449
5600	<i>S. luteolutescens</i>	V	27445	790.72	13489	1450
5602	<i>S. humifer</i>	V	13748	643.72	13342	1303
5603	<i>S. caespitosus</i>	V	27422	791.72	13490	1451
5604	<i>Stv. eurocidicum</i>	V	27428	792.72	13491	1452
5605	<i>S. tumuli</i>	V	27474	793.72	13492	1453
5606	<i>S. alanosinicus</i>	V	15710	794.72	13493	1454

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