INTERNATIONAL JOURNAL OF
SYSTEMATIC BACTERIOLOGY

Vol. 18, No. 4

October 1968

pp. 279-392

Copyright 1968, Iowa State University Press

COOPERATIVE DESCRIPTION OF TYPE CULTURES OF
STREPTOMYCES III. ADDITIONAL SPECIES DESCRIPTIONS
FROM FIRST AND SECOND STUDIES**

Elwood B. Shirling and David Gottlieb

Department of Botany and Bacteriology
Ohio Wesleyan University, Delaware, Ohio, and
Department of Plant Pathology, University of Illinois, Urbana, Illinois

ABSTRACT. More than 40 cooperating laboratories representing 18 nations are joined in an international effort to assemble and redescribe authentic type strains or acceptable neotype strains for the named species in the genera Streptomyces and Streptoverticillium. Part II of this series included illustrated emendations to the descriptions for 100 type strains. Part III extends the report to include type strains for an additional 100 Streptomyces or Streptoverticillium species. Each new description is based upon data submitted by three cooperating laboratories, using the standardized criteria and methods officially adopted for this purpose. Emendations for additional species will be included in reports to follow. Type specimens for all redescribed species are deposited in the American Type Culture Collection, The Centraalbureau voor Schimmelcultures, The USSR Research Institute for Antibiotics, and in Japan.

- - - - -

Collaborators and authors of descriptions:

Group A-2*

Cross, T. and A. Maciver. Postgraduate School of Studies in Biological Sciences, Univ. of Bradford, Bradford 7/Yorkshire, England.

Johanides, Vera and Tea Blazekovic. Laboratorij za industrijsku mikrobiologiju, Tehnološki fakultet, Pierottijeve 6, Zagreb, Jugoslavija.

Trejo, W. E.R. Squibb and Sons, New Brunswick, New Jersey, U.S.A.

* A letter-number combination is assigned to each collaborating group. To conserve space, this code is used to indicate the author group for each emended description. The letter A indicates collaborating groups for the first 130 type strains distributed for study; B designates groups participating in the second study.

** Reprints of this article may be purchased from the International Microbiological Fund, 221 Science Hall, Iowa State University, Ames, Iowa 50010 U.S.A. Price for single copies: \$2.00.

Group A-3

- Crook, Kenneth E., Jr. and Carol S. Cassidy. Bristol Labs., Inc.
Syracuse, New York, U.S.A.
deVries, G.A. Centraalbureau voor Schimmelcultures, Baarn,
Netherlands.
Krasil'nikov, N.A. Inst. Microbiology. Academy of Sciences, Moscow
B-133, U.S.S.R.

Group A-8

- Oliver, T.J. Abbott Laboratories, N. Chicago, Illinois, U.S.A.
Spyvee, J. and J. Elliott, Boots Pure Drug Co., Ltd., Antibiot. and
Ferm. Div., Nottingham, England.
Nakazawa, K., M. Shibata, K. Yamamoto, E. Higashide, T. Iwasa and
T. Hasagawa. Takeda Chem. Ind., Ltd., Juso-Higashiyodogawaku,
Osaka, Japan.

Group A-9

- Nishimura, H., M. Mayama and K. Tawara. Shionogi Res. Lab.,
Shionogi and Co., Ltd., Fukushima-ku, Osaka, Japan.
Pridham, T.G. Northern Utilization Res. and Dev. Div., Peoria,
Illinois, U.S.A.
Woźnicka, Wanda. Państwowy Zakład Higieny, Warszawa 12, ul.
Chocimska 24, Poland.

Group A-12

- Margalith, P. Labor. of Microbiol., Dept. of Food and Biotechnology,
Technion, Haifa, Israel.
Vernon, T.R. Dept. Scientific and Ind. Res., Private Bag, Auckland
C1, New Zealand.
Williams, S.T. Hartley Botan. Labor., Univ. of Liverpool, Liverpool,
England.

Group A-13

- Řehaček, Z. and Alena Řičicová. Czech. Acad. of Science, Inst. of
Microbiol., Prague 4, Budejovicka No.1083, Czechoslovakia.
Sanchez-Marroquin, A. Miami 40, Mexico 18 /D.F., Mexico.
Williams, S.T. Hartley Botan. Labor., Univ. of Liverpool, Liverpool,
England.

Group B-1

- Sanchez-Marroquin, A. Miami 40, Mexico 18 /D.F., Mexico.
Baldacci, E., G. Farina and R. Locci. Ist. Patol. Vegetale, Univ.
Milano, Milano, Via Celoria N.2, Milano, Italy.
Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, T.S. Maximova
and M.A. Sveshnikova. Acad. Med. Sciences of U.S.S.R., Inst.
New Antibiotics, Bolshaia Pirogovskaia 11, Moscow, U.S.S.R.

Group B-2

- Anderson, Lucia E. and Sara Wold. Parke, Davis and Co., Detroit, Michigan, U.S.A.
- Cross, T. and A. Maciver. Postgraduate School of Studies in Biological Sciences, Univ. of Bradford, Bradford, 7, Yorkshire, England.
- Johanides, Vera and Tea Blazekovic. Laboratorij za Industrijsku mikrobiologiju, Tehnološki fakultet, Pierottijeva 6, Zagreb, Jugoslavija.

Group B-3

- Radziminska, Ina. Hoffman-LaRoche, Nutley, New Jersey, U.S.A.
- deVries, G.A. Centraalbureau voor Schimmelcultures, Baarn, Netherlands.
- Krasil'nikov, N.A. Inst. Microbiology. Academy of Sciences, Moscow B-133, U.S.S.R.

Group B-4

- Crook, Kenneth E., Jr. and Carol S. Cassidy. Bristol Labs., Inc., Syracuse, New York, U.S.A.
- Mach, F. Inst. für Mikrobiologie, Greifswald, Ludwig-Jahn-Str. 15, German Democratic Republic.
- Kuznetsov, V. D. USSR Research Inst. for Antibiotics, Moscow, U.S.S.R.

Group B-5

- Oliver, T. J. Abbott Laboratories, N. Chicago, Illinois, U.S.A.
- Prauser, H. Inst. Mikrobiol. Exptl. Therapie, Jena, Beuthenbergstr. 11, German Democratic Republic.
- Szabó, I. Magyar Tudományos Akadémia, Talajtana És Agrokémiai Kutató Intézet, Budapest, Hungary.

Group B-6

- Řehaček, Z. and Alena Říčivová. Czech. Acad. of Science, Inst. of Microbiol., Prague 4, Budejovicka No. 1083, Czechoslovakia.
- Mitchell, T. G. Torry Research Station, Aberdeen Scotland.
- Tsyganov, V. A. Res. Inst. of Antibiotics, Leningrad, L-20, U.S.S.R.

Group B-8

- McClung, Norvel M.* and Gene Michaels. Dept. Microbiol., Univ. Georgia, Athens, Ga., U.S.A. *(Present address: Dept. Bot. and Bact., Univ. South Florida, Tampa, Florida.)
- Spyvee, J. and J. Elliott. Boots Pure Drug Co., Ltd., Antibiot. and Ferm. Div., Nottingham, England.
- Nakazawa, K., M. Shibata, K. Yamamoto, E. Higashide, T. Iwasa and T. Hasegawa. Takeda Chem. Ind., Ltd., Juso-Higashiyodogawaku, Osaka, Japan.

Group B-9

- Dietz, Alma. Upjohn Co., Kalamazoo, Michigan, U.S.A.
Woźnicka, Wanda. Państwowy Zakład Higieny, Ul. Chocimska 24,
Warszawa 12, Poland.
Ohara, Y. and H. Nonomura. Faculty of Engineering, Yamanashi Univ.,
Kofu, Japan.

Group B-10

- Trejo, W. E. R. Squibb and Sons, New Brunswick, New Jersey, U.S.A.
Brinkmann, Rolf. Organic Chem. Inst., Univ. of Gottingen, Gottingen,
Germany.
Nishimura, H., M. Mayama and K. Tawara. Shionogi Res. Lab.,
Shionogi and Co., Ltd., Fukushima-ku, Osaka, Japan.

Group B-11

- Routien, J. B. and Corinne Clevenger. Charles Pfizer and Co., Inc.
Groton, Connecticut, U.S.A.
Falcão de Moraes, J. O. Inst. de Química da Univ. Fed. de Pernambuco,
Recife, Pernambuco, Brazil.
Okami, Y. Nat'l. Inst. of Health of Japan, Shinagawa, Tokyo, Japan.

Group B-12

- Higgins, Calvin E. and R. E. Kastner. Eli Lilly and Co., Indianapolis,
Indiana, U.S.A.
Williams, S. T. Hartley Botan. Labor., Univ. of Liverpool, Liverpool,
England.
Vernon, T. R. Dept. Scientific and Ind. Res., Private Bag, Auckland Cl,
New Zealand.

ACKNOWLEDGMENTS

The Subcommittee on Actinomycetes of the Committee on Taxonomy, ASM, participated in the planning of the project, preparation of descriptions and editing of the manuscript. Members of the Subcommittee (other than the authors) during the period covered by this report were: T. G. Pridham, E. J. Backus, and W. Grundy.

We are grateful to A. A. Ichida, Jann M. Ichida, Janet Stevens, Margaret Speer, and Louise Hoffhines of the Ohio Wesleyan ISP staff for technical services, for assistance in locating authentic type cultures and descriptive literature, and for help in collating data from cooperating laboratories.

C. W. Christensen of Difco Laboratories rendered valuable assistance in directing the formulation of dehydrated culture media according to ISP specifications. The technical and financial assistance of Difco Laboratories, Detroit, Michigan, in supplying these standardized media to collaborators throughout the world is gratefully acknowledged.

This research was supported by National Science Foundation Grant GB 509 and GB 4365. The Subcommittee on Actinomycetes of the Committee on Taxonomy, ASM, and the Subcommittee on Taxonomy of Actinomycetes of the International Committee on Nomenclature of Bacteria are co-sponsoring advisors.

INTRODUCTION

This is the third in a series of reports related to the comprehensive international effort to clarify taxonomy in the genera Streptomyces and Streptoverticillium through standardized collaborative study of the authentic type strain (or an acceptable neotype) for each of the named species. The cooperative study, known as the International Streptomyces Project (ISP), is sponsored by the Subcommittee on Actinomycetes of the Committee on Taxonomy, ASM and the corresponding subcommittee of the International Committee on Bacteriological Nomenclature. The rationale, scope, extensive background preparation and general plan for the project are explained in detail in the first paper of the series (Gottlieb and Shirling 1967); descriptive criteria and methods for ISP characterization of Streptomyces and Streptoverticillium species are given under the title, Methods for Characterization of Streptomyces Species (Shirling and Gottlieb 1966). Illustrated descriptions for 100 type strains or suggested neotypes are given in the second paper of the series (Shirling and Gottlieb 1968).

This report (Part III of the series) includes illustrated descriptions for an additional 100 type strains or suggested neotype strains from the genus Streptomyces (including Actinomyces sensu Krasil'nikov) and the genus Streptoverticillium. The second paper of the series (op. cit. pp. 73-79) should be consulted for analysis of a typical entry and guidance in interpretation of data submitted in each description.

The ISP description for each species is based upon data submitted by three independent collaborators. In rare instances where significant disagreement occurred in reports from the three laboratories, the culture was either submitted to a fourth collaborator or withdrawn for re-study. The ISP description is an emendation to previous descriptions. The collaborators who studied the species are to be regarded as the authors for the emendation. They are listed as cooperating groups at the beginning of this paper and identified by group number in each description. Earlier descriptions for each culture, including the description ascribed to the original author, are cited whenever possible to complete the characterization.

The 200 type strains included in Part II and Part III of this series are deposited as reference cultures in the American Type Culture Collection, the Centraalbureau voor Schimmelcultures and the USSR Research Institute for Antibiotics. They will also be deposited in an appropriate culture collection in Japan. Cooperative studies characterizing approximately 300 or more additional species are in progress or have been completed. Descriptions for these species will be included in subsequent reports and the type strains will be deposited in the culture collections as the descriptions are published.

ISP CHARACTERIZATIONS OF TYPE STAINS¹

Streptomyces aburaviensis Nishimura, Kimura, Tawara, Sasaki, Nakajima, Shimaoka, Okamoto, Shimohira and Isono. Description: Nishimura *et al.* 1957, 205-211. Type strain: S-66 (*ibid.*). ISP 5033 from Nishimura as S-66 = ISM 1083. ISP description by Group B-1.

Spore chain morphology: Section Retiflexibiles (Fig. 1). Mature spore chains moderately long with 10 to 50, or sometimes 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. 2).

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

Reverse side of colony: Yellowish brown on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; this 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 other than trace of yellow is found in medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: Growth on carbon utilization media is generally poor. D-Glucose and D-fructose and D-xylose are utilized for growth. Reports varied from no growth to traces of growth on L-arabinose, sucrose, i-inositol, D-mannitol, rhamnose and raffinose.

Streptomyces aerocolonigenes Shinobu and Kawato. Description: Shinobu and Kawato 1960a, 212-216. Type strain: 701 (*ibid.*). ISP 5034 from Shinobu as 701. ISP description by Group B-4.

Morphological characteristics: No aerial mycelium is formed on yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar. In addition to these media, cooperators found no aerial mycelium or spore formation on Langeron's weak potato-carrot medium, modified Bennett's medium, tomato-paste oatmeal agar, soil extract agar, modified Sabouraud maltose agar or Czapek's agar plus glucose. Spore surface: Not observed. The original description by Shinobu (*ibid.*) includes the following statement: "No. 701 had a tendency to become weak and lose its formation ability of aerial mycelia by successive cultures, . . .". Shinobu observed best aerial mycelium development on glucose-asparagine agar. On this medium he observed flexuous, cottony white aerial mycelium without whirls or spirals and with spherical to oval conidia.

Special morphological characteristics: Although ISP collaborators were unable to obtain aerial mycelium on any medium tried (see above), Shinobu's original description makes special mention of the formation of secondary colonies on the cottony aerial mycelium on glucose-asparagine agar. His illustrations suggest that these secondary colonies are similar to "sclerotia" reported by other authors (Waksman 1961, 292).

¹Type strains for 100 Streptomyces species are described here. An additional 100 strains were described in an earlier report (*op. cit.*); and descriptions for other species are in preparation.

Figure 1. *S. aburaviensis*. RF spore chains. (a) (X 100) on oatmeal agar, 24 days.^{1*} (b) (X 640) on salts-starch agar, 14 days.²
 Figure 2. *S. aburaviensis*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.²
 Figure 3. *S. afghaniensis*. Spiral spore chains (X 400). Short chains from incomplete spirals or hooks.³
 Figure 4. *S. afghaniensis*. Spiny spores; electron micrograph from 14 day culture on oatmeal agar.⁴

* Sources of illustrations are indicated by superscript number following legend for each figure, and are listed by number after the bibliography.

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

Color in medium: Melanoid pigments are not formed on peptone-yeast-iron agar, tyrosine agar or peptone-yeast broth. Pigments other than traces of yellow are not found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Streptomyces afghaniensis Shimo, Shiga, Tomosugi and Kamoi. Description: Shimo *et al.* 1959, 1-6. Type strain: 772 (*ibid.*). ISP 5528 from Shimo as 772. ISP description by Group B-5.

Spore chain morphology: Section *Spirales*, but short spore chains usually result in hooks, incomplete spirals or spirals with only one or two turns (Fig. 3). Short, straight and flexuous chains of only a few spores are common, but hooks and loops of wide diameter as found in typical *RA* cultures are not found. Spore chains are short, often with only 3 to 10 spores per chain, but more than 10 spores may be found on some chains. This morphology is best developed on oatmeal agar and salts-starch agar. Spore surface: Spiny (Fig. 4).

Color of colony: Aerial mass color in the Blue color-series on oatmeal agar. Immature aerial mycelium or mycelium producing few spores is in the Yellow color-series. Observers reported both Blue and Yellow color-series for yeast-malt agar and salts-starch agar. Mature spores are not usually found on glycerol-asparagine agar.

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

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and peptone-yeast broth. Orange to red or brown pigments are found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. These pigments are not pH sensitive when tested with 0.05 N HCl or NaOH.

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

Streptomyces albidofuscus Maeda, Kosaka, Okami and Umezawa 1953. *Streptomyces albidofuscus* Okami and Umezawa in Okami, Maeda and Umezawa 1954. The type strain is described under the name *Streptomyces pyridomyceticus* Okami and Umezawa, *q.v.*

Actinomyces albocyanus Krasil'nikov and Agre. Description: Krasil'nikov and Agre 1960, 272. Type strain: INMI 679 (*ibid.*). ISP 5197 from Krasil'nikov as INMI 679 = RIA-633. ISP description by Group B-9.

Spore chain morphology: Section *Retinaculiaperti* or *Spirales*. Spirals, when formed, are open and poorly developed. Long chains often show primitive spirals, terminal spirals, loops or hooks characteristic of *RA* cultures (Fig. 5). Flexuous chains are also common.

Figure 5. *A. albocyaneus*. RA or Spiral spore chains (X 1100).⁵

(a) Flexuous looped and spiraled chains on yeast-malt agar, 14 days.

(b) Open spirals, yeast-malt agar, 14 days. (c) Flexuous chains and terminal spirals, oatmeal agar, 21 days.

Figure 6. *A. albocyaneus*. Spiny spores, short spines; electron micrograph from 10 day culture on yeast-malt agar.⁶

Figure 7. *S. albofaciens*. Spiral spore chains (X 1100).⁵ (a) On oatmeal agar, 21 days. (b) On glycerol-asparagine agar, 14 days.

Figure 8. *S. albofaciens*. Smooth spores; electron micrograph from 14 day culture on glycerol-asparagine agar.⁷

Mature spore chains generally more than 10 but less than 50 spores per chain on yeast-malt agar, oatmeal agar and salts-starch agar. Spore surface: Spiny; spines are usually short and thick (Fig. 6).

Special morphological characteristics: Fragmentation of the substrate mycelium on salts-starch agar and glycerol-asparagine agar to form "oidiospores" is reported by one observer; a second observer records "chlamydospores" on oatmeal agar and glycerol-asparagine agar after 7 days.

Color of colony: Aerial mass color in the Green color-series on yeast-malt agar, oatmeal agar and salts-starch agar; aerial mycelium is poorly developed or white on glycerol-asparagine agar.

Reverse side of colony: Grayed yellow is modified by green or blue pigments on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Only one observer recorded a change in reverse color from pale green to pale violet by addition of 0.05 N HCl.

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, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: D-Glucose, L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose and raffinose are utilized for growth, although reports vary from slight growth to good growth for sucrose, i-inositol and raffinose.

Streptomyces albofaciens Thirumalachar and Bhatt. Description: Thirumalachar and Bhatt 1960, 61-63. Type strain: 27-A (*ibid.*). ISP 5268 from M. J. Thirumalachar as 27-A. ISP description by Group B-9.

Spore chain morphology: Section Spirales (Fig. 7). Open irregular spirals sometimes appear to arise from an axial hypha, but true whorls typical of verticillate cultures are not formed. Mature spore chains generally 10 to 50, or sometimes 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. 8).

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

Reverse side of colony: No distinctive pigments on yeast-malt agar, oatmeal agar, salts-starch agar or 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 trace of yellow pigment, found in 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. No growth or only trace of growth on rhamnose. Utilization of sucrose and D-xylose is doubtful.

Streptomyces alboflavus (Waksman and Curtis) Waksman and Henrici. Descriptions: Actinomyces albo-flavus Waksman and Curtis 1916, 120 and 128; Actinomyces alboflavus Waksman 1919, 90-91; Streptomyces alboflavus (Waksman and Curtis) Waksman and Henrici 1948, 954. Type strain: IMRU 3008 (Waksman 1961, 169 and 170). ISP 5045 from S. A. Waksman as IMRU 3008. ISP description by Group B-5.

Morphological characteristics: Typical aerial mycelium is not formed on yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar. Spore chain morphology, spore surface and aerial mass color of colony cannot be observed on ISP media. Loss of ability to produce sporulating aerial mycelium was noted in an early description of this culture (Waksman 1919, 90). Early descriptions of the culture describe white or yellowish white aerial mycelium on synthetic agar or Czapek's agar only.

Special morphological characteristics: Coremia formation on salts-starch agar and glycerol-asparagine agar was recorded by two observers. This same phenomenon was recorded in the original description on Czapek's agar (Waksman 1916, 120): "... aerial mycelium was found to have a tendency to produce . . . a mass of hyphae massed together into a rope, and from this rope fine filaments coming out in the shape of side branches. The structure looks like the root of a tree and fine rootlets coming out on the side." One ISP observer found straight spore chains within the coremia on glycerol-asparagine agar.

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

Color in medium: Melanoid pigments formed weakly in peptone-yeast-iron agar and tryptone-yeast broth but not in tyrosine agar. Pigments other than melanoids not formed 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. No growth or only trace of growth on rhamnose. Utilization of sucrose is doubtful.

Streptomyces albogriseolus Benedict, Shotwell, Pridham, Lindenfelter and Haynes. Description: Benedict *et al.* 1954, 653-656. Type strain: 7-A = NRRL B-1305 (*ibid.*). ISP 5003 from T. Pridham as 7-A = NRRL B-1305. Note: The authenticity of this strain as the type strain deposited by Dr. R.G. Benedict in the ARS Culture Collection in August, 1951, as NRRL B-1305 has been verified by C.W. Hesseltine and T. Pridham of the ARS Culture Collection, Peoria, Ill. (personal communication). No authentic subcultures from the type strain have hairy spores. At some time the culture with hairy spores was apparently mislabelled as NRRL B-1305 and given limited distribution. The warty to smooth spored ISP 5003 (7-A = NRRL B-1305) corresponds to the original description in all details. The hairy spored culture was also studied by ISP collaborators as ISP 5344. In addition to the difference in spore surface, it differs from the type strain and the original description in carbon utilization. The type strain, in agreement with the description by Benedict *et al.*, uses all ISP carbon sources except raffinose and cellulose. The hairy spored strain is unable to utilize any of the ISP carbon sources except D-glucose and possibly fructose. ISP description by Group A-2.

Spore chain morphology: Section *Spirales*. Spirals are open (Fig. 9); flexuous or RA spore chains are also common. Mature spore chains generally 10 to 50 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar and salts-starch agar, but not on glycerol-asparagine agar. Spore surface: Warty. Warts are not prominent or regular and some smooth spores may be found (Fig. 10).

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

Reverse side of colony: No distinctive pigments are formed (colorless or yellowish gray on oatmeal agar, salts-starch agar and glycerol-asparagine agar; grayed yellowish brown or 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. No pigment is found in medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Streptomyces amakusaensis Nagatsu, Ansai, Ohkuma and Suzuki.

Description: Nagatsu *et al.*, 1963, 207-210. Type strain: 10-101 (*ibid.*). ISP 5219 from S. Suzuki, Inst. Phys. and Chem. Res., Tokyo as 10-101. ISP description by Group B-3.

Spore chain morphology: Section Spirales (Fig. 11). Mature spore chains 10 to 50 or more spores per chain on yeast-malt agar and salts-starch agar. Sporulating aerial mycelium is poorly developed or absent on oatmeal agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 12).

Color of colony: Aerial mass color of mature aerial mycelium is in the Blue color-series on salts-starch agar and the Green or Blue color-series on yeast-malt agar; younger mycelium may be in the Gray color-series. Mature aerial mycelium is usually not formed on oatmeal agar or glycerol-asparagine agar.

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

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

Carbon utilization: This culture does not show good growth with any of the carbon sources tested on Pridham and Gottlieb carbon utilization medium. D-Glucose is utilized for growth. No significant growth occurs on D-xylose, L-inositol, D-mannitol, D-fructose, rhamnose or raffinose and only doubtful trace is seen on L-arabinose and sucrose.

Streptomyces ambofaciens Pinnert-Sindico. Description: Pinnert-Sindico 1954, 702-707. Type strain: 3486 (*ibid.*). ISP 5053 from R. Despois, Société Rhône-Poulenc as 3486. ISP description by Group B-8.

Spore chain morphology: Section Spirales (Fig. 13). Open terminal spirals on long spore chains also suggest RA morphology. Mature spore chains generally 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, although sporulating aerial mycelium is not abundant on glycerol-asparagine agar. Spore surface: Smooth to warty; surface irregularities suggesting warts are small (Fig. 14).

Figure 9. *S. albogriseolus*. (a, b) Spiral spore chains (X 500) on glycerol-asparagine agar, 7 days.⁸

Figure 10. *S. albogriseolus*. Warty and smooth spores; electron micrograph from 21 day culture on yeast-malt agar.⁹

Figure 11. *S. amakusaensis*. (a) Open and tight spirals (X 300) on yeast-malt agar, 14 days.¹⁰ (b) Tight spirals, yeast-malt agar, 15 days.¹¹

Figure 12. *S. amakusaensis*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.¹²

Figure 13. *S. ambofaciens*. Spiral spore chains (X 800) on salts-starch agar, 14 days.¹³

Figure 14. *S. ambofaciens*. Smooth spores with minor surface irregularities suggesting small warts or spines; electron micrograph from 14 day culture on yeast-malt agar.¹⁴

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

Reverse side of colony: No distinctive pigments (colorless to grayed yellow) on yeast-malt agar, oatmeal agar and glycerol-asparagine agar. Dark brown, dark blue or almost black substrate mycelium pigment is found on salts-starch agar. This pigment is not pH sensitive.

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 medium in salts-starch agar; no pigment is in the medium in yeast-malt agar, oatmeal 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 on raffinose. Utilization of sucrose is doubtful.

Streptomyces aminophilus Wooldridge. Description: The name and original identification for this species is credited to J. W. Foster by Oswald *et al.* 1956, 236. This publication contains no description and the original characterizations by Foster have been lost (J. W. Foster, personal communication). The first available description is in Wooldridge 1957, German Patent Notation DAS 1000966; see also Wooldridge 1960a, British Patent 828,792 and Wooldridge 1960b, U. S. Patent 2,956,925 (Streptomyces coelicolor var. aminophilus). Type strain: NRRL 2390 (*ibid.*; L. E. Arnow, Warner-Lambert Res. Inst., personal communication). ISP 5186 from C. W. Hesseltine as NRRL 2390. ISP description by Group A-13.

Spore chain morphology: Section Spirales (Fig. 15). Mature spore chains 3 to 10 or sometimes more than 10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar, but formation of sporulating aerial mycelium is poor on oatmeal agar. Spore surface: Smooth (Fig. 16).

Color of colony: Aerial mass color in the Yellow color-series on yeast-malt agar, salts-starch agar and glycerol-asparagine agar; aerial mycelium poorly developed on oatmeal agar.

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

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigments, or only traces of yellow pigment, are 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 and D-fructose are utilized for growth. No growth or only trace of growth on i-inositol and rhamnose. Reports vary on utilization of sucrose and raffinose.

Streptomyces antibioticus (Waksman and Woodruff) Waksman and Henrici. Description: Actinomyces antibioticus Waksman and Woodruff 1941, 246-249; Streptomyces antibioticus (Waksman and Woodruff) Waksman and Henrici 1948, 942. Type strain: IMRU 3435 (Waksman 1961; R. Gordon, Personal Communication). ISP 5234 from S. A. Waksman as IMRU 3435. ISP description by Group B-10.

Figure 15. *S. aminophilus*. Spiral spore chains (X 500) on salts-starch agar, 23 days.¹⁵

Figure 16. *S. aminophilus*. Smooth spores; electron micrograph from 15 day culture on yeast-malt agar.³

Figure 17. *S. antibioticus*. RF spore chains (X 600).¹⁶

Figure 18. *S. antibioticus*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.¹⁷

Figure 19. *S. antimycoticus*. Compact clusters of closed spirals on salts-starch agar, 14 days (X 200).¹⁸

Figure 20. *S. antimycoticus*. Spiny to warty spores in spiral spore chains; electron micrograph from 14 day culture on salts-starch agar.¹⁸

Spore chain morphology: Section Rectiflexibiles (Fig. 17). Mature spore chains are short, often with only 3 to 10 spores per chain, longer chains are also found. This morphology is observed on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 18).

Color of colony: Aerial mass color in the Gray color-series on yeast-malt agar, salts-starch agar and glycerol-asparagine agar; mature aerial mycelium poorly developed on oatmeal agar.

Reverse side of colony: No distinctive pigments (grayed yellow-brown on yeast-malt agar, grayed yellow or dark greyish greenish yellow on oatmeal agar, salts-starch agar, glycerol-asparagine agar); substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar, tyrosine agar and peptone-yeast broth. No pigment in medium, or only trace of yellow, 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. No growth or only trace of growth on sucrose and raffinose. Utilization of D-xylose is doubtful.

Streptomyces antimycoticus Waksman. Descriptions: Streptomyces sp Leben, Stessel and Keitt 1952, 159-168; Streptomyces antimycoticus Waksman 1957, 799. Type strain: A158 (*ibid.*). ISP 5284 from C. W. Hesseltine as NRRL 2421 = A158. ISP description by Group B-11.

Spore chain morphology: Section Spirales; compact clusters of closed spirals on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar (Fig. 19); mature spore chains of generally 10 to 50 spores per chain on these media. Spore surface: Spiny to warty. Surface irregularities on spores are intermediate between very short, thick spines and warts (Fig. 20).

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

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

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

Carbon utilization: D-Glucose, L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose and raffinose are utilized for growth. Growth on L-arabinose and D-xylose is generally less abundant than on the other carbon sources.

Streptomyces arabicus Shibita, Nakazawa, Miyake, Inoue and Okabori. Description: Shibita *et al.* 1957, 32-37. Type strain: 6762 (*ibid.*). ISP 5252 from K. Nakazawa as IFO 3406 = 6762. ISP description by Group B-8.

Spore chain morphology: Section Spirales on oatmeal agar and salts-starch agar (Fig. 21a). Short spore chains on yeast-malt agar and glycerol-asparagine agar may appear to be RF morphology or may

show only incomplete spirals or hooks (Fig. 21b). Mature spore chains on oatmeal agar and salts-starch agar generally 10 to 50 or more spores per chain; shorter spore chains are found on yeast-malt agar and glycerol-asparagine agar. Spore surface: Warty to spiny. Surface irregularities are short and blunt (Fig. 22a); smooth spores may also be found (Fig. 22b).

Color of colony: Aerial mass color in the Gray color-series on yeast-malt agar, oatmeal agar and salts-starch agar; Red color-series on glycerol-asparagine agar. Observers selected color tabs representing neutral grays to light grayish reddish brown (5fe) for the Gray color-series and grayish yellowish pink (5dc) from the Red color-series for glycerol-asparagine agar.

Reverse side of colony: Grayish yellowish brown on yeast-malt agar; colorless to pale yellowish gray or brown on oatmeal agar, salts-starch agar and glycerol-asparagine agar. Substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigment is not produced in peptone-yeast-iron agar, tyrosine agar, or tryptone-yeast broth. Trace of yellow pigment may be found in the medium in oatmeal agar or salts-starch agar or may be absent. 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 trace of growth on raffinose. Utilization of sucrose is doubtful.

Streptomyces argenteolus Fried, Perlman, Langlykke and Titus. Descriptions: Actinomycete species ATCC 11,009 Perlman et al. U.S. Patent 2,709,705, 1955; *Streptomyces argenteolus* ATCC 11,009, Fried et al. U.S. Patent 2,855,343 Oct., 1958; *Streptomyces argenteolus* (name only) Tresner et al. 1961, 74. Type strain: ATCC 11,009 (ibid.). ISP 5226 from F. Arnow, Squibb Culture Collection as MD 2428 = ATCC 11,009. ISP description by Group B-3.

Spore chain morphology: Section Spirales (Fig. 23). This culture is described as "not forming loops or spirals" in the original descriptions appearing in the patents cited above. However, the type strain was observed to produce spirals in subsequent studies by Pridham et al., 1958 and by Tresner et al., 1961. Mature spore chains generally 10 to 50 or more spores per chain 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 Gray color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Reverse side of colony: Colorless to grayish yellowish green or gray on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigment found in 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 on sucrose, i-inositol and raffinose.

Figure 21. *S. arabicus*. (a) Spiral spore chains (X 300) on salts-starch agar, 7 days.¹⁴ (b) Short, flexuous chains with some hooks and incomplete spirals (X 800) on yeast-malt agar, 14 days.¹³

Figure 22. *S. arabicus*. (a) Spiny to warty spores; surface irregularities are thick and blunt or rounded.¹⁹ (b) Smooth spores of *S. arabicus*; electron micrograph from 14 day culture on yeast-malt agar.¹⁴

Figure 23. *S. argenteolus*. Spiral spore chains (X 600) on yeast-malt agar, 14 days.²⁰

Figure 24. *S. argenteolus*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.¹⁰

Actinomyces aurantiogriseus Preobrazhenskaya. Description: Preobrazhenskaya in Gauze et al. 1957, 74. Type strain: 10369/58 (G.F. Gauze, cited by Gottlieb 1968, 20). Streptomyces aurantiogriseus (Preobrazhenskaya) Pridham et al. 1958, 67. ISP 5138 from T.P. Preobrazhenskaya as 10369/58. ISP description by Group B-6.

Spore chain morphology: Section Retinaculiaperti or Spirales. Spirals are open and often are irregular and poorly developed (Fig. 25a, b). Long spore chains of the RA type and flexuous chains are common (Fig. 25c). Mature spore chains may be slow to develop; they are moderately long with more than 10 spores per chain on oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 26).

Color of colony: Aerial mass color is in both the Red and the Gray color-series on yeast-malt agar, salts-starch agar and glycerol-asparagine agar; both colors may appear on the same medium. One observer noted an increase in gray aerial color between 14 and 21 days on glycerol-asparagine agar; this tendency to change from red to gray was also included in the original description. The color tabs most frequently chosen were 2ec (yellowish gray) from the Gray color-series and 5ge (light grayish reddish brown) from the Red color-series.

Reverse side of colony: No distinctive pigment (grayed yellow on oatmeal agar and glycerol-asparagine agar to orange-yellow or brown on yeast-malt agar and salts-starch agar). Substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Pigments other than melanoids are not found in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Streptomyces aureofaciens Duggar. Description: Duggar 1948, 177-181; U.S. Patent 2,482,055 Sept. 1949. Type strain: A-377 = NRRL 2209 (ibid.). ISP 5127 from E. Backus, Lederle Labs., Amer. Cyanamid Co. as A-377 = NRRL 2209. ISP description by Group A-12.

Spore chain morphology: Section Retinaculiaperti but chains representative of Section RF are also common (Fig. 27). Mature spore chains generally 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. 28).

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

Reverse side of colony: No distinctive pigments (grayed yellow, orange-yellow or brown on yeast-malt agar, and grayed yellow or greenish yellow on oatmeal agar, salts-starch agar and glycerol-asparagine agar). Substrate mycelium pigment is not a pH indicator.

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

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

Figure 25. *A. aurantiogriseus*. (a) Incomplete spirals or hooks (X 500) on yeast-malt agar, 23 days.¹⁵ (b) Spirals (X 700) on yeast-malt agar, 21 days.²¹ (c) Flexuous spore chains (X 350) on yeast-malt agar, 18 days.²¹

Figure 26. *A. aurantiogriseus*. Smooth spores; electron micrograph from 18 day culture on yeast-malt agar.²¹

Figure 27. *S. aureofaciens*. RA spore chains (X 240) on oatmeal agar, 14 days.²²

Figure 28. *S. aureofaciens*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.²²

Figure 29. *S. baarnensis*. Smooth spores; electron micrograph from 14 day culture on glycerol-asparagine agar.²

Streptomyces baarnensis (Duché) Pridham, Hesseltine and Benedict. Descriptions: Actinomyces viridis Duché 1934, 311-317; Actinomyces baarnensis Duché 1934 = Actinomyces viridis Gougerot, Blum and Duché 1934, 376. Type strain: Dreyfus 472 (G.A. deVries, CBS, personal communication). ISP 5232 from G.A. deVries as Dreyfus 472. ISP description by Group B-1.

Spore chain morphology: This strain has apparently lost the ability to produce good sporulating aerial mycelium. Spore chains, when found, were straight (Section Rectiflexibiles) and usually contained more than 10 spores per chain. Spore surface: Smooth (Fig. 29).

Color of colony: Aerial mycelium on yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar is inadequate for determination of aerial mass color. The original description of Duché (op. cit.) describes early appearance of abundant greenish aerial mycelium on comparable media.

Reverse side of colony: No distinctive pigment; yellow-brown on yeast-malt agar, light grayish yellow on oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Color in medium: Melanoid pigment is 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. No growth or only trace of growth on raffinose. Utilization of sucrose and i-inositol is doubtful.

Streptomyces bellus Margalith and Beretta. Description: Margalith and Beretta 1960, 189-195. Type strain: A/870 (ibid.). ISP 5185 from L.G. Silvestri, Lepetit S.p.A. as Lep. M. A/870. ISP description by Group A-13.

Spore chain morphology: Section Spirales. Short spore chains may form incomplete spirals, hooks, and loops of small diameter or flexuous chains (Fig. 30). Spirals are best developed on salts-starch agar. Hooks and loops are of small diameter and therefore are not typical of RA cultures. Mature spore chains with 3 to 10, or sometimes more than 10, spores per chain on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Spiny (Fig. 31).

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

Reverse side of colony: Substrate color is modified by red (orange) pigment on yeast-malt agar and glycerol-asparagine agar and by red or blue pigments on oatmeal agar and salts-starch agar. These pigments are not pH indicators.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Trace of red pigment may be found in the medium in glycerol-asparagine agar; it is not a pH indicator. Pigments are not found in the medium in yeast-malt agar, oatmeal agar or salts-starch agar.

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

Streptomyces bikiniensis Johnstone and Waksman. Descriptions: Johnstone and Waksman 1947, 294; Johnstone and Waksman 1948, 317-326. Type strain: IMRU 3514 (S.A. Waksman and R. Gordon, personal communication). ISP 5235 from S.A. Waksman as IMRU 3514. ISP description by Group B-9.

Spore chain morphology: Section Rectiflexibiles (Fig. 32). Mature spore chains 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. 33).

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

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

Color in medium: Melanoid pigment is not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Trace of yellow pigment, or no pigment may be found in medium in tryptone-yeast broth, yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; this pigment is not a pH indicator.

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

Actinomyces biverticillatus Preobrazhenskaya. Description: Preobrazhenskaya in Gauze et al. 1957, 75-76. Type strain: 10204/54 (G.F. Gauze, personal communication; G.F. Gauze cited by Gottlieb, 1968, 20). ISP 5272 from G.F. Gauze as 10204/54. *Streptomyces biverticillatus* (Preobrazhenskaya) Pridham et al., 1958, 72; *Streptoverticillium biverticillatus* (sic) (Preobrazhenskaya) Baldacci 1958, 25; *Streptoverticillium biverticillatum* (Preobrazhenskaya) Baldacci, Farina and Locci 1966, 157. The original authors now consider this to be identical with *Streptomyces hirosimensis* Shinobu 1955, personal communication, 1964. ISP description by Group B-3.

Spore chain morphology: Section Verticillati with umbellate-monoverticillate (biverticillate) spore chains (Fig. 34). Mature spore chains generally contain 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. 35).

Color of colony: Aerial mass color in the Red color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. (One observer, only, placed this culture in the Violet color-series on yeast-malt agar and salts-starch agar).

Reverse side of colony: Reverse color is red on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; this pigment is pH sensitive, changing from red to orange-red with addition of 0.05 N NaOH and from red to violet-red or blue with addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in less than 2 days in peptone-yeast-iron agar and tryptone-yeast broth, but more slowly in tyrosine agar. Pigments other than melanoids are not formed in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Figure 30. *S. bellus*. (a) Spiral spore chains on salts-starch agar, 21 days.²³ (b) Incomplete spirals, hooks and loops (X 550) on salts-starch agar, 24 days.¹⁵

Figure 31. *S. bellus*. Spiny spores, chromium shadowed; electron micrograph from 24 day culture on yeast-malt agar.²⁴

Figure 32. *S. bikiniensis*. RF spore chains (X 240) on yeast-malt agar, 14 days.²⁵

Figure 33. *S. bikiniensis*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.⁷

Figure 34. *A. biverticillatus*. BIV (umbellate monoverticillate) morphology (X 600). (a) On yeast-malt agar, 7 days; (b) On glycerol-asparagine agar, 14 days.²⁰

Figure 35. *A. biverticillatus*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar.¹⁰

Carbon utilization: D-Glucose and possibly i-inositol and D-fructose are utilized for growth; growth on i-inositol and D-fructose is much less abundant than on D-glucose. No growth or only trace of growth on L-arabinose, sucrose, D-xylose, D-mannitol, rhamnose and raffinose.

Streptomyces bobili (Waksman and Curtis) Waksman and Henrici. Descriptions: Actinomyces bobili Waksman and Curtis 1916, 121 and 127; Waksman 1919, 100-102; Streptomyces bobiliae (sic) (Waksman and Curtis) Waksman and Henrici 1948, 937. Type strain: IMRU 3310 (Waksman 1961, 182). ISP 5056 from S.A. Waksman as IMRU 3310. ISP description by Group B-11.

Spore chain morphology: Section Spirales. Sporulating aerial mycelium is not produced at 27°C or 37°C on yeast-malt agar, oatmeal agar or glycerol-asparagine agar, or on supplementary media (Czapek's agar and potato-glucose agar) used by one observer. Two observers found some spots of sporulating aerial mycelium on salts-starch agar. One collaborator (J.B. Routien) found spiral spore chains with 10 to 30 or more spores per chain on Pridham and Gottlieb's basal salts medium for carbon utilization enriched with xylose, raffinose or glucose (Fig. 36). Incubation was at 37°C. Spirals were most abundant when xylose was the carbon source. The first description by Waksman (1916 op. cit.) notes the absence of true aerial mycelium or spores on Czapek's medium. The description published in 1919 (Waksman, op. cit.) notes spiral formation on scant white aerial mycelium on glycerin-synthetic agar and traces of aerial mycelium in spots only on starch agar plate and potato plug. Aerial mycelium was not produced on 7 other solid media used by Waksman. The present culture seems to conform well to the early descriptions. Spore surface: Smooth (Fig. 37).

Color of colony: Aerial mass color cannot be observed on yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar. Sparse aerial mycelium, when produced, is white.

Reverse side of colony: Substrate mycelium color may be grayish yellow, or may be modified with red to reddish gray or pink, reddish brown, or reddish orange. The substrate mycelium color is dependent on pH, changing from yellowish pink to violet pink with addition of 0.05 N NaOH and from yellowish pink to yellow orange with 0.05 N HCl.

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

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

Streptomyces calvus Backus, Tresner and Campbell. Description: Backus, Tresner and Campbell 1957, 532-541. Type strain: T-3018 (ibid.). ISP 5010 from H. Tresner as T-3018. ISP description by Group B-10.

Spore chain morphology: Section Spirales on salts-starch agar. (Fig. 38). Spore chains are short and poorly developed or absent on yeast-malt agar, oatmeal agar and glycerol-asparagine agar. The original description by Backus, Tresner and Campbell (op. cit.) also indicates that aerial mycelium is poorly developed on most media with

Figure 36. *S. bobili*. Spiral spore chains (X 50) on Pridham and Gottlieb carbon utilization medium plus raffinose.³⁶

Figure 37. *S. bobili*. Smooth spores; electron micrograph (X 2,700) from 13 day culture on Pridham and Gottlieb carbon utilization medium plus raffinose.³⁶

Figure 38. *S. calvus*. Spiral spore chains on salts-starch agar.¹⁶

Figure 39. *S. calvus*. Spiny to hairy spores; electron micrograph from 21 day culture on salts-starch agar.¹⁷

Figure 40. *A. candidus*. RF spore chains (X 875). (a) Flexuous aerial chains on yeast-malt agar, 22 days; (b) Long chains on glycerol-asparagine agar surface, 22 days.²⁷

Figure 41. *A. candidus*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.¹²

best sporulation and spiral development on starch containing inorganic salts media. Spore surface: Spiny to hairy (Fig. 39).

Color of colony: Aerial mycelium is inadequate for color determination on most media. When mature sporulating aerial mycelium is formed on yeast-malt agar or salts-starch agar, it is in the Gray color-series.

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

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

Actinomyces candidus Krasil'nikov. Descriptions: Krasil'nikov 1941, 49; Krasil'nikov 1949, 100. Type strain: 5855/54 (neotype, Preobrazhenskaya, personal communication; Krasil'nikov, personal communication). Streptomyces candidus (Krasil'nikov) Waksman 1953, 94. ISP 5141 from T.P. Preobrazhenskaya as 5855/54. ISP description by Group A-3.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains generally long and flexuous, often with more than 50 spores per chain (Fig. 40). This morphology is seen on salts-starch agar and glycerol-asparagine agar. Sporulation may be poor on yeast-malt agar and oatmeal agar. Spore surface: Smooth (Fig. 41).

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

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

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Pigments are not formed in 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 rhamnose are utilized for growth. No growth or only trace of growth on sucrose, i-inositol and raffinose.

Streptomyces capreolus Higgens. Description: Higgens in Stark et al. 1962, 596-606. Type strain: M48-E2655 = NRRL 2773 (D.H. Lively, Lilly Res. Labs., personal communication). ISP 5225 from D.H. Lively as M48-E2655 = NRRL 2773. ISP description by Group B-2.

Spore chain morphology: Section Rectiflexibiles with long spore chains of 50 or more spores per chain on mature cultures (Fig. 42) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 43).

Color of colony: Aerial mass color is usually in the Red or Yellow color-series after 14 to 21 days. Immature aerial mycelium is in the White color-series. Color tabs selected by observers for 21 day cultures

included 2ba (pale yellow) from the Yellow color-series and 3ca (pale orange yellow) to 5cb (grayish yellowish pink) from the Red color-series. These colors are observed on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Reverse side of colony: Grayed yellow to orange yellow or orange on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; this 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 or yellow orange pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and usually glycerol-asparagine agar; this pigment is not a pH indicator.

Carbon utilization: D-Glucose, L-arabinose and i-inositol are utilized for growth. Reports vary on utilization of D-xylose, D-mannitol and D-fructose, although in each case, two or three observers reported utilization. A trace of growth is found on the carbon free control and on sucrose, rhamnose and raffinose; these sugars are not utilized.

Streptomyces catenulae (sic) Davisson and Finlay. Description: Davisson and Finlay 1959, U.S. Patent 2,895,876; see also Waksman 1961, 190-191. Type strain: ATCC 12,476 (*ibid.*) = Pfizer 6563 (J. Routien, Chas. Pfizer and Co., personal communication). ISP 5258 from J. Routien as 6563 = ATCC 12,476. ISP description by Group B-5.

Spore chain morphology: Section Rectiflexibiles. Very short spore chains of 3 to 10 spores occur in dense clusters so that morphology is difficult to determine (Fig. 44a). Short chains often form hooks or incomplete spirals (Fig. 44b). Tight spirals may occur in the dense clusters but most chains are too short to form true spirals (Fig. 44c). Short chains are also not typical of RA cultures. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. It is representative of morphology described by Davisson and Finlay (*op. cit.*). Spore surface: Smooth (Fig. 45).

Color of colony: Aerial mass color in the Green color-series on yeast-malt agar, oatmeal agar and glycerol-asparagine agar; Gray or Green color-series on salts-starch agar. The color on all media is medium gray to olive gray or grayish olive (see tabs 2ih or 2ge in Gray color-series and 1 1/2ge in Green color-series).

Reverse side of colony: Colorless or grayish yellow to light grayish olive or olive brown on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Substrate mycelium pigment is not pH sensitive.

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

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

Streptomyces cellostacticus Hamada. Description: Hamada 1958, 173-179. Type strain: E-150 (*ibid.*). ISP 5189 from N. Ishida, Tohoku Univ. as E-150. ISP description by Group A-13.

Figure 42. *S. capreolus*. Long RF spore chains (X 380) on Waksman starch agar B, 21 days.²⁸

Figure 43. *S. capreolus*. Smooth spores; electron micrograph from 21 day culture on salts-starch agar.²⁹

Figure 44. *S. catenulae*. (a) Large, dense clusters of spore chains (X 400) on salts-starch agar, 14 days.³ (b) Clusters of short spore chains, some of which appear to be bent into hooks or partial spirals (X 400) on salts-starch agar, 14 days.³ (c) Short, twisted spore chains (X 300) on salts-starch agar, 14 days.⁴

Figure 45. *S. catenulae*. Smooth spores; electron micrograph from 32 day culture on yeast-malt agar.³⁰

Spore chain morphology: Section *Spirales* (Fig. 46). Mature spore chains 10 to 50 spores per chain; longer chains are often observed. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Spiny (Fig. 47).

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. Characteristic color is usually between 3ge (light grayish yellowish brown) and 5ge or 5dc (grayish yellowish pink) color tabs of Tresner-Backus color wheels.

Reverse side of colony: No distinctive pigment (characteristic grayed yellow or light yellow 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, tyrosine agar and tryptone-yeast broth. Pigments other than melanoids or faint traces of yellow pigment not formed in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Streptomyces chibaensis Suzuki, Nakamura, Okuma and Tomiyama.

Description: Suzuki et al. 1958, 81-83. Type strain: 77-SN-2 (Suzuki, personal communication). ISP 5220 from S. Suzuki as 77-SN-2. ISP description by Group B-4.

Spore chain morphology: Section *Spirales* or *Rectiflexibiles*. Spirals, when formed, are open and poorly developed (Fig. 48a). Some spore chains are straight and many are flexuous or curved to form hooks or partial spirals (Fig. 48b). Most spore chains are too short (3 to 10 or 20 spores per chain) for this culture to be placed in section *RA* (Fig. 48b). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 49).

Color of colony: Mature aerial mass color is usually in the Gray color-series on yeast-malt agar, oatmeal agar and salts-starch agar; Gray or Yellow color-series on glycerol-asparagine agar. Color tabs selected from the Gray color-series were yellowish gray or grayish yellowish brown.

Reverse side of colony: No distinctive pigments (grayed greenish yellow, yellow or rarely orange-yellow) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not found in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Yellow pigment may or may not be found in the medium in yeast-malt agar, oatmeal agar and glycerol-asparagine agar; this pigment is not pH sensitive.

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

Actinomyces chromofuscus Preobrazhenskaya, Ryabova and Blinov.

Description: Preobrazhenskaya et al. in Gauze et al. 1957, 176-177. Type strain: 13638/58 (G.F. Gauze, personal communication; G.F.

Figure 46. *S. cellostaticus*. Spiral spore chains forming tight coils.

(a) On yeast-malt agar, 21 days.²³ (b) On salts-starch agar, 22 days (X 500).¹⁵

Figure 47. *S. cellostaticus*. Spiny spores; electron micrograph from 13 day culture on Gauze's medium No. 1.³

Figure 48. *S. chibaensis*. Spore chains (X 800) on oatmeal agar, 14 days:

(a) Spiral chains; (b) Flexuous chains.²⁷

Figure 49. *S. chibaensis*. Smooth spores; electron micrograph from 21 day culture on oatmeal agar.³¹

Gauze cited by Gottlieb 1968, 20). Streptomyces chromofuscus (Preobrazhenskaya, Ryabova and Blinov) Pridham et al. 1958, 68. ISP 5273 from G.F. Gauze as 13638/58. ISP Description by Group B-4.

Spore chain morphology: Section Spirales (Fig. 50). Mature spore chains moderately 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: Spiny (Fig. 51).

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

Reverse side of colony: No distinctive pigment (grayed yellow to 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. Pigments other than melanoids or faint traces of yellow are not 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 utilization of raffinose and i-inositol. No growth or only trace of growth on sucrose.

Streptovercillium cinnamoneum (Benedict, Dvorch, Shotwell, Pridham and Lindenfelser) Baldacci, Farina, Locci. Streptomyces cinnamoneus Benedict et al. 1952, 591-594; Dvorch et al. 1954, 1135-1142; Streptomyces cinnamomeus Pridham et al. 1956, 576 (orthographic variant); Streptovercillium cinnamoneus (sic) (Benedict et al.) Baldacci 1958, 25; Streptovercillium cinnamoneum (Benedict et al.) emend. nobis Baldacci, Farina, Locci 1966, 158. Type strain: NRRL B-1285 (T. Pridham, personal communication). ISP 5005 from T. Pridham as NRRL B-1285. ISP description by Group B-1.

Spore chain morphology: Umbellate Monoverticillate (= Streptomyces section Verticillati, biverticillate) (Fig. 52). Mature spore chains generally 3 to 10, or often 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. 53).

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

Reverse side of colony: No distinctive pigment (grayish yellow to yellow-brown or 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 is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: Vegetative growth is generally poor on Pridham and Gottlieb's carbon utilization medium plus D-glucose. Reports from collaborators varied from no growth to slight growth with other carbon sources, but good growth was not observed on any of the following: L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose,

Figure 50. A. chromofuscus. Spiral spore chains. (X 400) on oatmeal agar, 18 days.³¹

Figure 51. A. chromofuscus. Spiny spores; electron micrograph from 14 day culture on oatmeal agar.³¹

Figure 52. Streptoverticillium cinnamoneum. BIV (umbellate monoverticillate) spore chains (X 1000) on oatmeal agar, 14 days.²

Figure 53. Streptoverticillium cinnamoneum. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.²

rhamnose or raffinose. Poor growth on all carbon sources including D-glucose may indicate a requirement for a growth factor not present in the basal medium.

Actinomyces citreofluorescens Korenyako, Krasil'nikov, Nikitina and Sokolova. Description: Korenyako et al. 1960, 133-159. Type strain: INMI 2292 (ibid.). ISP 5265 from N.A. Krasil'nikov as USSR-RIA 648 = INMI 2292. ISP description by Group B-2.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains long, often with more than 50 spores per chain (Fig. 54). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 55).

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

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

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Yellow pigment is found in medium in glycerol-asparagine agar and yellow or green pigment is found in medium in yeast-malt agar, oatmeal agar and salts-starch agar. This pigment is not a pH indicator.

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 on sucrose, i-inositol or raffinose.

Streptomyces coelicolor (Müller) Kutzner and Waksman. Descriptions: Müller 1908, 197-213; Kutzner and Waksman 1959, 528-538. Not Actinomyces coelicolor (Müller) Lieske 1921, 28; not Streptomyces coelicolor (Müller) Waksman and Henrici 1948, 935; not Actinomyces violaceus Waksman and Curtis 1916, 110 (see Kutzner and Waksman 1959, 528-538). Type strain: CBS-R. Müller strain (G.A. deVries, CBS personal communication). ISP 5233 from G.A. deVries as CBS-R Müller strain. ISP description by Group B-2.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains usually 10 to 50, or often more than 50, spores per chain. (Fig. 56). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 57).

Special morphological characteristics: One observer reports substrate conidia on oatmeal agar, Emerson's potato dextrose agar and potato carrot agar. Sclerotia formation on yeast-malt agar and oatmeal agar was reported by one observer.

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

Reverse side of colony: Light olive brown to strong brown or very dark brown on yeast-malt agar, salts-starch agar and glycerol-asparagine agar; brown substrate mycelium pigment on oatmeal agar is pH sensitive changing from brown to green with addition of 0.05 N NaOH. Potato plug is pigmented dark blue in 4-7 days.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Reddish, yellowish brown, or greenish pigments are found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; yellowish brown pigment is changed to green with addition of 0.05 N NaOH. Liquid surrounding dark blue potato plug is pigmented greenish brown in 4-7 days.

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

Actinomyces coeruleorubidus Preobrazhenskaya. Description: Preobrazhenskaya in Gauze *et al.* 1957, 123 and 125. Type strain: 12531/54 (*ibid.*; see also Gauze in Gottlieb 1968). Streptomyces coeruleorubidus (Preobrazhenskaya) Pridham *et al.* 1958, 67. ISP 5145 from T.P. Preobrazhenskaya as 12531/54. ISP description by Group A-13.

Spore chain morphology: Section Spirales. Salts-starch agar shows best spiral morphology (Fig. 58a); incomplete spirals and hooks may also be common, especially on yeast-malt agar, oatmeal agar and glycerol-asparagine agar (Fig. 58b). Mature spore chains generally 10 to 50 spores per chain. Spore surface: Spiny (Fig. 59).

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

Reverse side of colony: Grayish yellow to yellowish brown on yeast-malt agar; grayed yellow to yellowish green on oatmeal agar and salts-starch agar; both grayed yellowish green and grayed red or orange on glycerol-asparagine agar. These substrate mycelium pigments are not pH indicators when tested with 0.05 N NaOH or HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Red pigment may be found in medium in yeast-malt agar, salts-starch agar and glycerol-asparagine agar after 14 days; it is not pH sensitive.

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

Streptomyces coralus Dietz (unpublished data). Description: Not published (Alma Dietz, Upjohn Co., personal communication, Sept. 1964). Type strain: UC 2098 = NRRL 2442 (Dietz, personal communication). ISP 5256 from A. Dietz, Upjohn Co. as UC 2098 = NRRL 2442. ISP description by Group B-2.

Spore chain morphology: Section Rectiflexibiles (Fig. 60). Some long spore chains form open loops suggesting RA morphology. Mature spore chains are usually very 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. 61).

Color of colony: Mature aerial mass color is usually in the Red color-series on salts-starch agar and in the Red, Yellow or White color-series on yeast-malt agar and glycerol-asparagine agar. Aerial mycelium is poorly developed on oatmeal agar.

Figure 54. *A. citreofluorescens*. RF spore chains (X 500) on oatmeal agar, 7 days.⁸

Figure 55. *A. citreofluorescens*. Smooth spores; electron micrograph from 21 day culture on glycerol-asparagine agar.²⁹

Figure 56. *S. coelicolor*. RF spore chains (X 380) on Waksman's starch agar B.²⁸

Figure 57. *S. coelicolor*. Smooth spores; electron micrograph from 7 day culture on yeast-malt agar.²⁹

Figure 58. *A. coeruleorubidus*. Spiral spore chains (X 500): (a) Coils of many turns on salts-starch agar, 24 days; (b) Spirals on oatmeal agar, 24 days.¹⁵

Figure 59. *A. coeruleorubidus*. Spiny spores; electron micrograph from 18 day culture on oatmeal agar.³

Reverse side of colony: Pale or light grayish yellow to orange-yellow on yeast-malt agar, oatmeal agar and glycerol-asparagine agar; light yellow to grayish red on salts-starch agar. Substrate mycelium pigment is a pH indicator changing from yellow or yellowish brown to red with addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Red pigment is found in the medium in salts-starch agar; traces of yellow pigment are found in the medium in yeast-malt agar and oatmeal agar. This pigment is changed from yellow to pink with the addition of 0.05 N NaOH.

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

Actinomyces cyanoalbus Krasil'nikov and Agre. Description: Krasil'nikov and Agre 1960, 273-274. Type strain INMI-414 (*ibid.*, Krasil'nikov personal communication). ISP 5198 from N.A. Krasil'nikov as INMI-414 = RIA 662. ISP Description by Group A-13.

Spore chain morphology: Section Spirales or Rectiflexibiles. Distinct spirals are rare. Moderately short chains often with only 10 to 20 spores may form strongly wavy chains to open spirals of 1 to 4 turns (Fig. 62). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Spiny (Fig. 63).

Color of colony: Mature aerial mass color (14 to 21 days) is in the Green color-series on yeast-malt agar and salts-starch agar; Green, Gray or White color-series on oatmeal agar and glycerol-asparagine agar. Aerial mycelium is usually poorly developed on oatmeal agar.

Reverse side of colony: Grayed yellow to grayed yellow-green on yeast-malt agar and oatmeal agar; grayed yellow-green to blue on salts-starch agar and glycerol-asparagine agar. Substrate 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, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose and rhamnose are utilized for growth. No growth or only trace of growth on raffinose.

Streptomyces ehimensis Nakazawa. Description: Japanese Patent 2125, Feb. 4, 1954; Japanese Patent 8148, Nov. 10, 1955 (see also Shibata, Honjo, Tokui and Nakazawa 1954, 168 for publication of name and antibiotic production only). Type strain: 138 = IFO 3398 (Nakazawa, personal communication; Shibata *et al.* 1954, 168). ISP 5253 from K. Nakazawa, Takeda Chem. Ind., Ltd. as 138 = IFO 3398. ISP description by Group B-9.

Spore chain morphology: Section Verticillati. Mature aerial mycelium is usually umbellate-monoverticillate (biverticillate), but sporulating aerial mycelium is very sparse or absent on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Biverticillate spore chains can be seen on Pridham and Gottlieb carbon utilization medium plus D-xylose or L-arabinose and sometimes can be found on oatmeal agar after 21 days (Fig. 64). Spore chains are short, usually

Figure 60. *S. coralus*. RF, very long spore chains (X 500) on oatmeal agar, 7 days.⁸

Figure 61. *S. coralus*. Smooth spores; electron micrograph from 21 day culture on oatmeal agar.²⁹

Figure 62. *A. cyanoalbus*. (a) Open spirals and imperfect spirals (X 500) on glycerol-asparagine agar, 21 days.¹⁵ (b) Flexuous chains on yeast-malt agar, 21 days.²³

Figure 63. *A. cyanoalbus*. Spiny spores; electron micrograph from 18 day culture on oatmeal agar.³

Figure 64. *S. ehimensis*. BIV (umbellate monoverticillate) morphology (X 1100) on oatmeal agar, 21 days.⁵

Figure 65. *S. ehimensis*. Smooth spores; electron micrograph from 10 day culture on yeast-malt agar.⁶

with 3 to 10 spores per chain. Spore surface: Smooth (Fig. 65).

Color of colony: Aerial mass color for mature sporulating aerial mycelium cannot be determined accurately because of poor sporulation on yeast-malt agar, salts-starch agar or glycerol-asparagine agar. When sporulating aerial mycelium occurs on oatmeal agar, it is in the Gray color-series. (The spore surface of poorly sporulating growth is generally in the Yellow or Red color-series on yeast-malt agar, salts-starch agar and glycerol-asparagine agar or sparse aerial mycelium may be white.)

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

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar and tryptone-yeast broth, but only weakly or not at all on tyrosine agar. Yellow or grayish yellowish brown 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, i-inositol, D-Mannitol and D-fructose are utilized for growth. Traces of growth occur on the carbon free control and on other ISP carbon sources.

Streptomyces endus Anderson and Gottlieb 1952. Descriptions: Streptomyces 9-20 Gottlieb et al. 1951, 393-394; Streptomyces endus Gottlieb and Carter 1950, U.S. Patent 2,746,902; Upjohn Co. 1954, British Patent Spec. 705,622. See also: Anderson and Gottlieb 1952, 294-308. Type strain: 9-20 = NRRL 2339 (*ibid.*). ISP 5187 from D. Gottlieb as 9-20 = NRRL 2339. ISP description by Group A-13.

Spore chain morphology: Section Spirales with tightly closed spirals (Fig. 66). Individual spores are not easily detached from the spiral chain and compact coils may become hygroscopic (coalesce in black moist droplets). Spore surface: Warty (Fig. 67).

Color of colony: Aerial mass color in the Gray color-series after 21 days on yeast-malt agar, oatmeal agar and salts-starch agar. Aerial mycelium on glycerol-asparagine agar and young aerial mycelium on other media may be white. Older colonies sometimes become moist and black.

Reverse side of colony: No distinctive pigments (grayed yellow to yellowish brown or gray) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. In older cultures the substrate mycelium sometimes becomes moist and black. Substrate color is not affected by pH change.

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigments are 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 on sucrose, i-inositol and raffinose.

Streptomyces filipinensis Ammann, Gottlieb, Brock, Carter and Whitfield. Description: Ammann et al. 1955, 559-563. Type strain: 114-8 (*ibid.*). ISP 5112 from D. Gottlieb as NRRL 2437 = 114-8. ISP description by Group B-3.

Figure 66. *S. endus*. Spiral spore chains; tight spirals (X 550) on glycerol-asparagine agar, 23 days.¹⁵

Figure 67. *S. endus*. Warty spores in tight spirals; electron micrograph from 13 day culture on Gauze's medium No. 1.³

Figure 68. *S. filipinensis*. Spiral spore chains. (a) Tight spirals at end of spore chain on yeast-malt agar, 15 days; (b) Open coils (X 500) on yeast-malt agar, 11 days.²⁰

Figure 69. *S. filipinensis*. Spiny spores; electron micrograph from 14 day culture on yeast-malt agar.¹⁰

Figure 70. *A. finlayi*. (a) Flexuous chains, hooks and imperfect spirals (X 625) on salts-starch agar, 14 days.²² (b) Irregular spirals on yeast-malt agar, 21 days.²³

Figure 71. *A. finlayi*. Hairy spores.²²

Spore chain morphology: Section Spirales. Tight spirals (Fig. 68a) or open coils, usually of several turns (Fig. 68b), occur at the end of moderately long spore chains of 10 to 50 or more spores per chain on yeast-malt agar, oatmeal agar and salts-starch agar. Spirals may be replaced by RA morphology on glycerol-asparagine agar. Spore surface: Spiny (Fig. 69).

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

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

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar, tyrosine agar and peptone-yeast broth. Pigments other than melanoids are not found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Actinomyces finlayi Szabó, Marton, Buti and Pártai. Description: Szabó *et al.* 1963, 207-214. Type strain: R-1-30 = FBUA 1869 (*ibid.*). ISP 5218 from I. Szabó as R-1-30 = FBUA 1869. ISP description by Group B-12.

Spore chain morphology: Section Rectiflexibiles to Spirales. Short spore chains of 10 or more spores per chain are generally flexuous, crooked, hooked or in imperfect spirals of only one or two turns (Fig. 70a); longer chains may form open spirals of three or four turns (Fig. 70b). Hooks and loops on short spore chains are not characteristic of RA morphology. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; spirals are best developed on yeast-malt agar and oatmeal agar. Spore surface: Hairy (Fig. 71).

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

Reverse side of colony: Grayed yellow to yellow-brown modified by green (grayish yellow to olive brown on yeast-malt agar and oatmeal agar; pale greenish yellow or yellow-green to moderate or dark olive green on salts-starch agar or glycerol-asparagine agar). Substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigments are 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. Significant growth also occurs on L-arabinose, D-xylose and rhamnose, although growth on these carbon sources is less than on D-glucose. Utilization of sucrose is doubtful. No growth or only trace of growth on i-inositol, D-mannitol, D-fructose and raffinose.

Actinomyces fluorescens Korenyako, Krasil'nikov, Nikitina and Sokolova. Description: Korenyako *et al.* 1960, 133-159 (see also Engl. Trans., 128-156). Type strain: INMI 592 (*ibid.*). ISP 5203 from N.A. Krasil'nikov as INMI 592 = RIA 647. ISP Description by Group B-6.

Spore chain morphology: Section Rectiflexibiles (Fig. 72). Mature spore chains generally 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. 73).

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

Reverse side of colony: No distinctive pigments (colorless to grayish yellow on oatmeal agar, salts-starch agar and glycerol-asparagine agar; grayed orange-yellow to olive brown on yeast-malt agar). Reverse pigment is not pH sensitive or is changed only slightly from yellow-brown to yellow-green, with addition of 0.05 N NaOH.

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. A small amount of yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and tryptone-yeast broth. This pigment when present is only slightly pH sensitive, changing from yellow-brown to yellow-green with addition of 0.05 N NaOH.

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 on sucrose, i-inositol or raffinose. The original description for this species (op. cit.) states that rhamnose is not utilized, noting that this is one difference between A. fluorescens and other species in the fluorescent group. However, all of the 3 ISP observers recorded good growth on rhamnose, equivalent to growth on D-glucose.

Streptomyces fragilis Anderson, Ehrlich, Sun and Burkholder. Description: Anderson *et al.* 1956, 100-105 and 114-115. Type strain: isolate C 1437 = P-D 04926 = NRRL 2424 (*ibid.*). ISP 5044 from L. Anderson, Res. Lab., Parke, Davis and Co. as P-D 04926 = NRRL 2424. ISP description by Group B-2.

Spore chain morphology: Section Spirales to Rectiflexibiles. Short spore chains in many straight to flexuous chains (Fig. 74a), but hooks or loops of small diameter and incomplete spirals are also common (Fig. 74b). Spirals of two or more complete turns are also present, but are not common. Spore chains are generally short, but usually contain 10 or more spores per chain. Spore surface: Smooth with some tendency toward warty surface on spores near the terminal part of the chain (Fig. 75).

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 on salts-starch agar and glycerol-asparagine agar.

Reverse side of colony: Grayed yellow to yellow-brown modified by red (light to moderate yellow or orange-yellow on salts-starch agar; light grayish reddish brown to dark brown on yeast-malt agar, oatmeal agar and glycerol-asparagine agar). Reddish brown pigment may change to yellow brown with addition of 0.05 N HCl.

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Medium may remain unpigmented or may contain small amounts of yellow or red-brown pigment in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar. This pigment, when present,

Figure 72. *A. fluorescens*. RF spore chains (X 500) on salts-starch agar, 23 days.¹⁵

Figure 73. *S. fluorescens*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.³²

Figure 74. *S. fragilis*. (X 380) on Waksman's starch agar B, 21 days: (a) Straight to flexuous chains; (b) Loops, incomplete spirals and short spirals on the same medium.²⁸

Figure 75. *S. fragilis*. Smooth spores, with some surface irregularities on terminal spores; electron micrograph from 14 day culture on yeast-malt agar.²⁹

is pH sensitive changing from red-brown to yellow with addition of 0.05 N HCl.

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

Actinomyces fulvoviridis Kuchaeva, Krasil'nikov, Skryabin and Tapykova. Description: Kuchaeva *et al.* 1960, 251 (see also Engl. transl., 222-251). Type strain: INMI 16-3 (*ibid.*; type strain selected by N.A. Krasil'nikov, personal communication). ISP 5210 from N.A. Krasil'nikov as INMI 16-3 = RIA 660. ISP description by Group B-12.

Spore chain morphology: Section Rectiflexibiles (Fig. 76). Mature spore chains moderately short 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. 77).

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

Reverse side of colony: Yellow to yellow-brown plus traces of green (pale yellow, yellow or grayed greenish yellow to olive brown or dark olive on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar). Reverse pigment is not a pH indicator.

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 on i-inositol or raffinose.

Streptomyces galbus Frommer. Description: Frommer 1959, 187-206. Not S. galbus Okami and Umezawa 1959. Type strain: Wind 731 (*ibid.*; type selected by W. Frommer, personal communication). ISP 5089 from C.W. Hesseltine as NRRL B-2283 = Wind 731 from W. Frommer. ISP description by Group B-5.

Spore chain morphology: Section Spirales or Retinaculiaperti. Spirals may be open coils of several turns, tight spirals at the ends of flexuous spore chains or imperfect spirals and loops at the ends of spore chains suggesting RA morphology (Fig. 78). Spore chains moderately long with 10 to 50, or often more than 50, spores per chain. Spore surface: Smooth to warty. Surface irregularities suggesting very small warts are characteristic (Fig. 79).

Color of colony: Aerial mass color in the Gray color-series on yeast-malt agar and oatmeal agar and in the Yellow color-series or Gray color-series on salts-starch agar and glycerol-asparagine agar. Gray color is represented by tabs 2fe (medium gray) or 3fe (light brownish gray) on all media; and 1ba or 2ba (pale yellow) or 1 l/2db (pale grayish yellow) on salts-starch agar and glycerol-asparagine agar.

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

Figure 76. *A. fulvoviridis*. RF spore chains on yeast-malt agar, 21 days.²³

Figure 77. *A. fulvoviridis*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar.²²

Figure 78. *S. galbus*. Spiral or RA spore chains; (a) On oatmeal agar, 14 days (X 400).³ (b) On glycerol-asparagine agar, 16 days.³³

Figure 79. *S. galbus*. Smooth spores with surface irregularities suggesting very small warts; electron micrograph from 16 day culture on yeast-malt agar.⁴

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar and tryptone-yeast broth, but not in tyrosine agar. Yellow soluble pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. This pigment is not a pH indicator.

Carbon utilization: D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol and D-fructose are utilized for growth. Only a trace of growth comparable to growth on the carbon-free control is found on sucrose, rhamnose and raffinose.

Streptomyces gardneri (Waksman 1942) Waksman 1961. Descriptions: Proactinomyces sp. Gardner and Chain 1942, 123-127; Proactinomyces gardneri Waksman in Waksman, Horning, Welsch and Woodruff 1942, 289-290; Nocardia gardneri (Waksman) Waksman and Henrici 1948, 914; Streptomyces gardneri (Waksman) Waksman 1961, 215-216. Type strain: IMRU 3834 (Waksman 1961, 216). ISP 5064 from S.A. Waksman as IMRU 3834. ISP description by Group B-3.

Spore chain morphology: Section Rectiflexibiles (Fig. 80). Spore chains moderately long, usually 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, although aerial mycelium may be poorly developed on oatmeal agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 81).

Color of colony: Aerial mass color in the Gray color-series on salts-starch agar in 14 to 21 days. Mature aerial mycelium may be inadequate for determination of aerial mass color on yeast-malt agar, oatmeal agar and glycerol-asparagine agar. One observer obtained good sporulating aerial growth in the Gray color-series on . potato agar (potato 200 gm; agar 18 gm; tap water 1 L; pH 6.9-7.1).

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

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar and tryptone-yeast broth, but not in tyrosine agar (or only in trace amounts) in 2 to 4 days. No pigments are found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Streptomyces gelaticus (Waksman) Waksman and Henrici. Description: Actinomyces 104 Waksman 1919, 165-166; Streptomyces gelaticus (Waksman) Waksman and Henrici 1948, 952 (see also Anderson et al. 1956, 100-115; and Hütter 1967, 319). Type strain: IMRU 3323 (Waksman 1961, 217). ISP 5065 from S.A. Waksman as IMRU 3323. ISP description by Group B-6.

Spore chain morphology: Section Rectiflexibiles (Fig. 82). Aerial mycelium is not produced on most media. Absence of aerial mycelium on most media was also noted in the original description (Waksman 1919 op. cit.) which, however, records open spirals on the scant growth on synthetic agar. ISP observers found wavy spore chains, but no spirals in the thin aerial mycelium on yeast-malt agar and glycerol-asparagine

agar. The absence of spirals has also been noted by Anderson *et al.* (1956 *op. cit.*), by Waksman in a later description (1961 *op. cit.*), and by Hütter (1967 *op. cit.*). Spore surface: Smooth (Fig. 83).

Color of colony: Aerial mycelium is poorly developed on most media. When an adequate spore mass is produced it is in the Gray color-series. This was observed on yeast-malt agar and glycerol-asparagine agar. Additional media used unsuccessfully by collaborators in an effort to get good sporulating growth included Bennett's agar, Anderson's agar, blood agar, Lemco agar and milk agar.

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

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

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

Actinomyces globisporus Krasil'nikov. Description: Krasil'nikov 1941, 48. Streptomyces globisporus (Krasil'nikov) Waksman 1953, 39. Type strain: INMI 2302 = RIA 335 (N.A. Krasil'nikov, personal communication). ISP 5199 from N.A. Krasil'nikov as INMI 2302 = RIA 335. ISP description by Group B-2.

Spore chain morphology: Section Rectiflexibiles (Fig. 84). Mature spore chains predominantly flexuous and moderately 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. 85).

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

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

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

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 on sucrose, i-inositol or raffinose.

Streptomyces goshikiensis Niida. Description: Niida, Japanese Patent 425909, Japan Official Gazette 38-26948 (Engl. Transl. from T. Niida, personal communication). Name without description: Streptomyces goshikiensis Niida in Kondo, Sakamoto and Yumoto 1961, 365 and in Kondo *et al.* 1962, 157. Type strain: ISP 5190 received from M. Oda, Meiji Seika Co. as holotype strain. ISP description by group A-13.

Spore chain morphology: Section Spirales, with open spirals of 4 to

- Figure 80. *S. gardneri*. RF spore chains (X 600) on salts-starch agar, 16 days.²⁰
- Figure 81. *S. gardneri*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.¹⁰
- Figure 82. *S. gelaticus*. RF spore chains on salts-starch agar, 23 days.¹⁵
- Figure 83. *S. gelaticus*. Smooth spores, Au/Pd shadowed; electron micrograph from 21 day culture on oatmeal agar.³⁴
- Figure 84. *A. globisporus*. RF spore chains on: (a) Oatmeal agar, 7 days (X 1000). (b) Waksman's starch agar B, 21 days (X 380).²⁸
- Figure 85. *S. globisporus*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.²⁹

10 convolutions at the end of long spore chains (Fig. 86). Mature spore chains 10 to 50 spores per chain; longer chains are often observed. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth with minor surface irregularities, but no true spines (Fig. 87).

Color of colony: Aerial mass color in the Red (or Gray) color-series on yeast-malt agar, oatmeal agar and salts-starch agar. Characteristic color on these media is between 3ge (light grayish yellowish brown) and 5dc or 6ec (grayish yellowish pink) color tabs of Tresner-Backus Color Wheels. Aerial mycelium may be poorly developed on glycerol-asparagine agar.

Reverse side of colony: No distinctive pigments (characteristic grayed yellow on oatmeal agar, salts-starch agar and glycerol-asparagine agar to light 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. Pigments other than melanoids or faint traces of yellow are not produced in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Carbon utilization: D-Glucose and possibly D-fructose are utilized for growth. Only a trace of growth comparable to growth on carbon-free basal medium on L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, rhamnose and raffinose.

Streptomyces griseinus Waksman. Description: Grisein-producing strain of Streptomyces griseus, Reynolds and Waksman 1948, 739-752; Streptomyces griseinus Waksman 1959, 1043-1046. Type strain: IMRU 3478 (Waksman 1959, 1045). ISP 5047 from S.A. Waksman as IMRU 3478. ISP description by Group B-3.

Spore chain morphology: Section Rectiflexibles (Fig. 88). Mature spore chains predominantly flexuous and moderately long with 10 to 50, or often more than 50, spores per chain on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 89).

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

Reverse side of colony: No distinctive pigments (grayish yellow to yellowish brown or light olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. The substrate mycelium pigment may be changed slightly from pale yellow to pale yellow-brown or pale violet with addition of 0.05 N NaOH, or from yellowish brown to pale yellow with 0.05 N HCl.

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. A trace of yellow to reddish brown pigment may be found in the medium in oatmeal agar. This pigment, when present, is slightly pH sensitive changing from pale yellow to pale violet with addition of 0.05 N NaOH.

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 on sucrose, i-inositol or raffinose.

Streptomyces griseofuscus Sakamoto, Kondo, Yumoto and Arishima. Description: Sakamoto et al. 1962, 98-101. Type strain: 1068 (*ibid.*).

Figure 86. *S. goshikiensis*. Spiral spore chains (X 500) on oatmeal agar, 22 days.¹⁵

Figure 87. *S. goshikiensis*. Smooth spores with minor surface irregularities, but no true spines. chromium shadowed. Electron micrograph from 22 day culture on oatmeal agar.²⁴

Figure 88. *S. griseinus*. RF spore chains on yeast-malt agar, 15 days.¹¹

Figure 89. *S. griseinus*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.¹⁰

ISP 5191 from M. Oda, Meiji Seika Co. as 1068. ISP description by Group A-13.

Spore chain morphology: Section Spirales (Fig. 90). Mature spore chains generally 10 to 50 spores per chain. This morphology is observed on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 91).

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. Characteristic color is between 4ge or 5ge (light grayish reddish brown) and 4ig (light grayish brown) color tabs of Tresner-Backus color wheels.

Reverse side of colony: No distinctive pigments on yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigment found in 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. No growth or only trace of growth on sucrose, i-inositol, rhamnose and raffinose.

Actinomyces griseoincarnatus Preobrazhenskaya, Ryabova and Blinov. Description: Preobrazhenskaya et al. in Gauze et al. 1957, 169-171. Type strain: 9673/55 (G.F. Gauze, personal communication: G.F. Gauze, cited by Gottlieb 1968, 20). Streptomyces griseoincarnatus (Preobrazhenskaya et al.) Pridham et al. 1958, 69. ISP 5274 from G.F. Gauze as 9673/55. ISP description by Group B-12.

Spore chain morphology: Section Spirales. Spirals are generally open with 5 to 7 or more turns (Fig. 92a); flexuous spore chains and imperfect spirals suggesting RA morphology are also common (Fig. 92b). Spirals are best developed on oatmeal agar and salts-starch agar. Spore chains are moderately long, especially on oatmeal agar and salts-starch agar with 10 to 50, or often more than 50, spores per chain. Spore surface spiny (Fig. 93).

Color of colony: Aerial mass color in the Gray color-series on salts-starch agar after 14-21 days; younger aerial mycelium may be in the Red color-series. Aerial mass color in the Gray or Red color-series on yeast-malt agar, oatmeal agar and salts-starch agar. Observers did not agree on the selection of individual color tabs representing the aerial color, but all chose tabs ranging from grayish yellowish pink or grayish reddish brown to medium gray.

Reverse side of colony: Yellow to yellow-brown plus red (grayish yellow on salts-starch agar; orange-yellow to reddish brown on yeast-malt agar, oatmeal agar and glycerol-asparagine agar). Substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Red or orange pigment is found in the medium in yeast-malt agar in 7 days and in oatmeal agar in 14-21 days. Red or orange pigment may or may not be found in glycerol-asparagine agar. This pigment is not a pH indicator.

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

Figure 90. *S. griseofuscus*. Spiral spore chains (X 500) on glycerol-asparagine agar, 22 days.¹⁵

Figure 91. *S. griseofuscus*. Smooth spores; electron micrograph from 18 day culture on oatmeal agar.³

Figure 92. *A. griseoincarnatus*. Spiral spore chains; (a) Open spirals on oatmeal agar, 21 days.²³ (b) Imperfect spirals (X 600) on salts-starch agar, 14 days.²²

Figure 93. *A. griseoincarnatus*. Spiny spores; electron micrograph from 14 day culture on oatmeal agar.²²

Actinomyces griseoruber Ryabova and Preobrazhenskaya. Description: Ryabova and Preobrazhenskaya in Gauze et al. 1957, 186 and 195. *Streptomyces griseoruber* (Ryabova and Preobrazhenskaya) Pridham et al. 1958, 69. Not *Streptomyces griseoruber* Yamaguchi and Saburi 1955. Type strain: 2022/55 (G.F. Gauze, personal communication 1964; G.F. Gauze in Gottlieb 1968, 20). ISP 5275 from G.F. Gauze as 2022/55. ISP description by Group B-5.

Spore chain morphology: Section Spirales (Fig. 94). Spore chains moderately 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: Spiny (Fig. 95).

Color of colony: Aerial mass color in the Gray color-series on yeast-malt agar, oatmeal agar or salts-starch agar. One observer placed aerial mass color in both the Gray and Red color-series on these media. Good aerial mass growth is not found on glycerol-asparagine agar. Color tabs selected by observers indicate a range from light or medium gray to yellowish or brownish gray in the Gray series, to grayish yellowish pink in the Red series; gray is the predominant color.

Reverse side of colony: Yellow to yellow-brown plus red (moderate orange to grayish red or grayish reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. The substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Pigments are not found in the medium in yeast-malt agar, oatmeal agar or salts-starch agar. A trace of yellow pigment is found in glycerol-asparagine agar after 14-21 days; it is not pH sensitive.

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

Streptomyces griseoruber Yamaguchi and Saburi. Description: Yamaguchi and Saburi 1955, 203 and 219-231. Not *Streptomyces griseoruber* (Ryabova and Preobrazhenskaya) Pridham et al. 1958, 69. Type strain: H-4650 (*ibid.*). ISP 5281 from T. Yamaguchi as H-4650. ISP description by Group B-10.

Spore chain morphology: Section Spirales or Retinaculiaperti. Open or tight spirals are produced at the ends of moderately long spore chains of 10 to 50 or more spores per chain (Fig. 96a). Spirals are often incomplete, forming only 1 or 2 turns or a hook at the end of the spore chain. Straight to flexuous chains without hooks or spirals are also present (Fig. 96b). This morphology is usually best on glycerol-asparagine agar, but may also be observed on yeast-malt agar, oatmeal agar and salts-starch agar. Spore surface: Smooth (Fig. 97).

Color of colony: Aerial mass color is in the Red or Gray color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. The color is represented by tab 5fe (light grayish reddish brown) from the Gray color-series and tab 5ge (also light grayish reddish brown) from the Red color-series.

Reverse side of colony: Yellow to yellow-brown plus red (reddish orange or reddish brown on yeast-malt agar, oatmeal agar and salts-starch agar; light yellowish pink on glycerol-asparagine agar). Substrate mycelium pigment is a pH indicator changing from reddish orange

Figure 94. *A. griseoruber* Ryabova and Preobrazhenskaya. Spiral spore chains (X 400) on yeast-malt agar, 14 days.³

Figure 95. *A. griseoruber* Ryabova and Preobrazhenskaya. Spiny spores; electron micrograph from 16 day culture on yeast-malt agar.⁴

Figure 96. *S. griseoruber* Yamaguchi and Saburi. Spiral or RA spore chains on glycerol-asparagine agar, 14 days: (a) Open and tight spirals at ends of long chains (X 580); (b) Straight to glaucous chains and some terminal hooks or spirals (X 230).¹⁶

Figure 97. *S. griseoruber* Yamaguchi and Saburi. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.¹⁷

to purple with addition of 0.05 N NaOH and from reddish orange to yellowish orange with addition of 0.05 N HCl.

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Yellow to red pigment (depending upon pH) may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. This pigment is pH sensitive, changing from orange to purple with addition of 0.05 N NaOH and from orange to yellow with addition of 0.05 N HCl.

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

Streptomyces griseoviridis Anderson, Ehrlich, Sun and Burkholder. Description: Streptomyces griseoviridis (sic) Anderson et al. 1956, 109-115. (Spelling changed to S. griseoviridis by Waksman 1961, 225, and by L. E. Anderson, personal communication, Sept., 1967.) Type strain: A 9071 = P-D 04955 = NRRL 2427 (ibid.). ISP 5229 from L. E. Anderson as P-D 04955 = NRRL 2427, IMRU 3735. ISP description by Group B-6.

Spore chain morphology: Section Spirales (Fig. 98). Some open spirals have only one or two turns or are poorly developed suggesting RA morphology. Spore chains moderately long with 10 to 50 spores per chain. Spore surface: Smooth (Fig. 99).

Color of colony: Aerial mass color in the Red color-series (grayish yellowish pink to pale orange yellow) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. One observer placed this culture in the Yellow color-series. The original description (Anderson et al., 1956) included the following statement: "Aerial mycelium is white to pink-tan, pink-gray, or brown or occasionally greenish". The greenish color was not observed on ISP media.

Reverse side of colony: Grayed yellow to olive brown or dark brown on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Substrate mycelium pigment is not a pH indicator or is changed only slightly by 0.05 N NaOH or HCl.

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

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

Streptomyces griseus (Krainsky) Waksman and Henrici. Descriptions: Actinomyces griseus Krainsky 1914, 682; Actinomyces griseus (Krainsky) Waksman 1916, 119 and 128; Waksman 1919, 123-125; Streptomyces griseus (Krainsky) Waksman and Henrici 1948, 948. (See also Actinomyces globisporus var. streptomycini Krasil'nikov 1949, 100; Actinomyces streptomycini Krasil'nikov 1957, 598). Type strain: IMRU 3463 (neotype, Waksman 1961, 226). ISP 5236 from S.A. Waksman as IMRU 3463. ISP description by Group B-10.

Spore chain morphology: Section Rectiflexibiles (Fig. 100). Mature

Figure 98. *S. griseoviridis*. Spiral spore chains (X 500) on oatmeal agar, 22 days.¹⁵

Figure 99. *S. griseoviridis*. Smooth spores, Au/Pd shadowed; electron micrograph from 21 day culture on oatmeal agar.³⁴

Figure 100. *S. griseus*. RF spore chains (X 230) on yeast-malt agar, 14 days.¹⁵

Figure 101. *S. griseus*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.¹⁶

spore chains 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. 101).

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

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

Color in medium: Melanoid pigments are formed in tyrosine agar, but not in peptone-yeast-iron agar or tryptone-yeast broth. No pigments other than traces of yellow are 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 and D-fructose are utilized for growth. No growth or only trace of growth on L-arabinose, sucrose, i-inositol, rhamnose or raffinose.

Streptomyces herbaricolor Kawato and Shinobu. Description: Kawato and Shinobu 1959, 114-119. Type strain: 608 (*ibid.*) ISP 5123 from R. Shinobu as 608. ISP description by Group B-12.

Spore chain morphology: Section Rectiflexibiles (Fig. 102). Mature spore chains generally 10 to 50 spores per chain on yeast-malt agar and glycerol-asparagine agar. Sporulating aerial mycelium is poorly developed or absent on oatmeal agar and salts-starch agar. Spore surface: Smooth (Fig. 103).

Color of colony: Aerial mass color in the Gray color-series on glycerol-asparagine agar and yeast-malt agar. Aerial mycelium is poorly developed on all ISP media; mass color cannot be determined on oatmeal agar or salts-starch agar.

Reverse side of colony: Substrate mycelium may be grayish yellow to olive brown or brown or it may contain an additional pH sensitive pigment with a color range from pale purple or pale purplish pink to green or greenish blue. When this pigment is present, addition of 0.05 N NaOH changes color from violet-red to green or blue and this change is reversed by addition of 0.05 N HCl. The pH sensitive mycelial pigment was found by one observer in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Color in medium: Melanoid pigments are not formed or occur only in trace amounts in peptone-yeast-iron agar and tyrosine agar. Pigment may or may not be formed in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar. When formed, this pigment shows the same pH range found in the transient substrate pigment.

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

Streptomyces humidus Nakazawa, Shibata, Tanabe and Yamamoto. Descriptions: Nakazawa et al. 1958, 321-324; also Nakazawa et al. 1960, U.S. Patents 2,931,756 and 2,950,277. Name and antibiotic production only, without description: Nakazawa and Shibata in Imamura et al. 1956, 648-653. Type strain: 23572 (Nakazawa et al., *ibid.*).

Figure 102. *S. herbaricolor*. RF spore chains (X 625) on yeast-malt agar, 14 days.²²

Figure 103. *S. herbaricolor*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.²²

Figure 104. *S. humidus*. Spiral spore chains (X 600) on oatmeal agar, 14 days.¹⁶

Figure 105. *S. humidus*. Smooth spores; electron micrograph from 21 day culture on oatmeal agar.¹⁷

Figure 106. *S. indigoferus*. Portion of colony (X 400) showing RF spore chains at edge of colony (top) and coremia on colony surface (bottom).³

Figure 107. *S. indigoferus*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.³⁰

ISP 5263 from E. Lessel, Amer. Type Cult. Col. as ATCC 12760 from Takeda Pharm. Ind., LTD. as 23572 = IFO 3520. ISP description by Group B-10.

Spore chain morphology: Section Spirales with many incomplete spirals resembling RA morphology (Fig. 104). Spore chains short to 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. 105).

Special morphological characteristics: Although the original description reports production of black, moist (hygroscopic) areas on mature aerial mycelium, this was not recorded on ISP reports.

Color of colony: Aerial mass color in the Gray or Red color-series (3fe or 3li, brownish gray, from the Gray color-series to 5dc or 5cb, grayish yellowish pink, in the Red color-series).

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

Color in medium: Melanoid pigments not produced in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigment, or only trace of yellow 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 on sucrose and raffinose.

Streptomyces indigoferus Shinobu and Kawato. Descriptions: Shinobu and Kawato 1960b, 49-53. Type strain: 709 (ibid.). ISP 5124 from R. Shinobu as 709. ISP description by Group B-5.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains moderately long with 10 to 50, or sometimes more than 50, spores per chain. Aerial mycelium is poorly developed on all ISP media and is obscured by extensive coremia formation on yeast-malt agar, salts-starch agar and glycerol-asparagine agar (Fig. 106). Spore surface: Smooth (Fig. 107).

Color of colony: Aerial mass color often cannot be determined because of inadequate aerial growth on oatmeal agar or because of extensive coremia formation on yeast-malt agar, salts-starch agar and glycerol-asparagine agar. When adequate aerial mycelium is formed, it is in the Gray color-series on yeast-malt agar and oatmeal agar. Aerial mass color in the Gray color-series was also found on glycerol-urea agar and soil extract agar by one observer.

Reverse side of colony: Substrate mycelium is usually nearly colorless, grayish yellow or dark brown on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. A transient blue to red pigment (depending on pH) may also be found in the mycelium on these media. This pigment changes from blue or colorless to red with addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but are not formed in tyrosine agar. Pigments other than melanoids were not found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: D-Glucose and L-arabinose are utilized for

growth. Utilization of D-xylose is doubtful. No growth or only trace of growth on sucrose, i-inositol, D-mannitol, D-fructose, rhamnose or raffinose.

Actinomyces janthinus Artamonova and Krasil'nikov. Description: Artamonova and Krasil'nikov 1960, 334 (see also English translation, 3-7 and 300-306). Type strain: 117 (ibid.); type strain selected by N.A. Krasil'nikov, personal communication. ISP 5206 from N.A. Krasil'nikov as INMI 117 = RIA 659. ISP description by Group B-8.

Spore chain morphology: Section Spirales (Fig. 108). Spore chains moderately long with 10 to 50, or sometimes 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. 109).

Color of colony: Aerial mass color in the Red or White color-series on yeast-malt agar and salts-starch agar; White color-series on oatmeal agar and White or Gray color-series on glycerol-asparagine agar. The nearest color tabs in the Red color-series are 5dc, 5ca, 5cb and 6ec (all grayish yellowish pink).

Reverse side of colony: No distinctive pigments (colorless to grayed yellow or pale yellow) 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 and tryptone-yeast broth, but not in tyrosine agar. Yellow pigment is found in the medium in salts-starch agar. This pigment is not pH sensitive when tested with 0.05 N NaOH or HCl.

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

Streptovercillium kentuchense (sic) (Barr and Carman) Baldacci, Farina and Locci. Descriptions: Streptomyces kentuchensis Barr and Carman 1956, 286-289; Streptovercillium kentuchense Baldacci, Farina and Locci, 1966, 161. Type strain: 5XI RCV as Streptomyces kentuckensis Barr and Carman (ibid.). ISP 5052 from F.S. Barr as ATCC 12691 = 5XI RCV. ISP description by Group B-1.

Spore chain morphology: Umbellate Monoverticillate (= Streptomyces Section Verticillati, biverticillate) (Fig. 110). Mature spore chains 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. 111).

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

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

Color in medium: Melanoid pigments are produced 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 fructose are utilized for growth; utilization of D-xylose is doubtful. No growth or only trace

Figure 108. *A. janthinus*. Spiral spore chains (X 1000) on oatmeal agar, 14 days.¹³

Figure 109. *A. janthinus*. Spiny spores; electron micrograph from 14 day culture on oatmeal agar.¹⁹

Figure 110. *Streptoverticillium kentuchense*. BIV (umbellate-monoverticillate) morphology (X 640) on yeast-malt agar, 14 days.²

Figure 111. *Streptoverticillium kentuchense*. Smooth spores; electron micrograph from 21 day culture on oatmeal agar.²

of growth on L-arabinose, sucrose, D-mannitol, rhamnose and raffinose.

Actinomyces lavendocolor Kuchaeva, Krasil'nikov, Taptikova and Gesheva. Description: Kuchaeva *et al.* 1962, 103-124. Type strain: INA 4518 (*ibid.*). ISP 5216 from N.A. Krasil'nikov as INA 4518 = RIA 749. ISP description by Group B-12.

Spore chain morphology: Section Retinaculiaperti or RF. Spore chains are long, often with more than 50, spores per chain (Fig. 112). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 113).

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

Reverse side of colony: No distinct pigments (nearly colorless to pale yellow or very pale yellowish pink) 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 usually in tyrosine agar and tryptone-yeast broth. Pigments other than melanoids are not 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 i-inositol are utilized for growth. Trace of growth on sucrose, D-mannitol, D-fructose, rhamnose and raffinose resembles growth on the carbon-free control.

Actinomyces lavendofoliae Kuchaeva, Krasil'nikov, Taptikova and Gesheva. Description: Kuchaeva *et al.* 1962, 103-124. Type strain: INA 3613 (*ibid.*). ISP 5217 from N.A. Krasil'nikov as INA 3613 = RIA 750. ISP description by Group B-12.

Spore chain morphology: Section Retinaculiaperti. Long, flexuous spore chains often terminate in spirals or hooks and loops of wide diameter (Fig. 114). Mature spore chains have 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. 115).

Color of colony: Aerial mass color in the Red color-series (Grayish yellowish pink or yellowish pink) on yeast-malt agar, oatmeal agar and salts-starch agar.

Reverse side of colony: No distinctive pigment (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 and usually in tyrosine agar and tryptone-yeast broth. Pigments other than melanoids are not formed 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 i-inositol are utilized for growth. Utilization of fructose is doubtful. No growth or only trace of growth on sucrose, D-mannitol, rhamnose or raffinose.

Figure 112. *A. lavendocolor*. Very long flexuous chains of more than 50 spores (X 485) on salts-starch agar.³⁷ Loops and hooks, representative of RA cultures are also reported for this strain.

Figure 113. *A. lavendocolor*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar.²²

Figure 114. *A. lavendofoliae*. RA spore chains with terminal spirals or loops on oatmeal agar, 21 days: (a) (X 300); (b) (X 1200).²³

Figure 115. *A. lavendofoliae*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar.²²

Actinomyces levoris Nikitina. Descriptions: Nikitina 1958, 142; Korenyako, Krasil'nikov and Nikitina 1960, 116-132 (see also Engl. Transl., 111-127). Type strain: INMI 2725 (*ibid.*; type strain selected by N.A. Krasil'nikov, personal communication). ISP 5202 from N.A. Krasil'nikov as INMI 2725 = RIA 338. ISP description by Group B-5.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains generally long with 10 to 50, or often more than 50, spores per chain (Fig. 116). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 117).

Color of colony: Aerial mass color in Yellow color-series on yeast-malt agar, salts-starch agar and glycerol-asparagine agar. Aerial mycelium may be inadequate for color observation on oatmeal agar.

Reverse side of colony: No distinctive pigment (Grayish yellow or grayish greenish yellow to orange-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 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. No growth or only trace of growth on sucrose, i-inositol, rhamnose and raffinose.

Streptomyces lilacinus Nakazawa, Tanabe, Shibata, Miyake and Takewaka. Descriptions: Nakazawa *et al.* 1956, 81; Nakazawa *et al.* 1957, 111-115. Type strain: 2305 (*ibid.*). ISP 5254 from K. Nakazawa as IFO 3944 = 2305. ISP description by Group B-10.

Spore chain morphology: Section Verticillati, umbellate monoverticillate (biverticillate), (Fig. 118). Spore chains are short, usually with 3-10 spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 119).

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

Reverse side of colony: Yellow-brown plus red (grayish reddish brown to strong brown) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; this pigment is somewhat pH sensitive changing from brown to reddish brown with addition of 0.05 N NaOH and from brown to yellowish brown with addition of 0.05 N HCl.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Red pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. This pigment is pH sensitive when tested with 0.05 N NaOH or HCl, showing the same change noted for substrate color.

Carbon utilization: D-Glucose is utilized for growth; reports vary on positive utilization of i-inositol. No growth or only trace of growth on L-arabinose, sucrose, D-xylose, D-mannitol, D-fructose, rhamnose and raffinose.

Actinomyces longisporus Krasil'nikov. Description: Krasil'nikov 1941, 47. Streptomyces longisporus (Krasil'nikov) Waksman 1953, 39. Type strain: 4417/56 (neotype, Preobrazhenskaya, personal communication: N.A. Krasil'nikov, personal communication, January, 1968). ISP 5166 from T.P. Preobrazhenskaya as 4417/56. ISP description by Group B-1.

Spore chain morphology: Section Spirales (Fig. 120). Mature spore chains moderately short, usually 10 to 50 spores per chain. Spore surface: Spiny (Fig. 121). (One observer found smooth spores.)

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

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

Color in medium: Melanoid pigments are produced in peptone-yeast iron agar, tyrosine agar and tryptone-yeast broth. Pigments other than melanoids are not found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

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

Actinomyces longisporus-flavus Krasil'nikov. Descriptions: Krasil'nikov 1941, 30. Type strain: 81/53 (neotype, Preobrazhenskaya, personal communication; Krasil'nikov, personal communication). Streptomyces longisporoflavus Waksman 1953, 94; Streptomyces longisporus flavus (Krasil'nikov) Pridham et al. 1958, 66. ISP 5165 from T.P. Preobrazhenskaya as 5165. ISP description by Group A-9.

Spore chain morphology: Section Spirales. Open spirals; spore chains resembling RA morphology are also common (Fig. 122). Mature spore chains are long with 10 to 50 spores per chain; longer chains are often observed. This morphology may be observed on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 123).

Color of colony: Aerial mass color is in Yellow color-series on salts-starch agar. Aerial mycelium is poorly developed or absent on other ISP media.

Reverse side of colony: No distinct pigments (colorless, grayish yellow or light grayish 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 found in 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 rhamnose are utilized for growth. No growth or only trace of growth on sucrose and raffinose. Utilization of i-inositol and D-mannitol is doubtful.

Streptomyces luteovorticillatus Shinobu. Description: Shinobu 1956, 84-93. Type strain: 486 (ibid.). ISP 5038 from R. Shinobu as 486. ISP description by Group A-8.

Figure 116: *A. levoris*. RF spore chains (X 300) on glycerol-asparagine agar, 5 days.³³

Figure 117. *A. levoris*. Smooth spores; electron micrograph from 32 day culture on salts-starch agar.³⁰

Figure 118. *S. lilacinus*. BIV (umbellate monovercillate) morphology (X 400) on salts-starch agar, 14 days.³⁸

Figure 119. *S. lilacinus*. Smooth spores; electron micrograph from 21 day culture on oatmeal agar.¹⁷

Figure 120. *A. longisporus*. Spiral spore chains (X 640) on oatmeal agar, 21 days.²

Figure 121. *A. longisporus*. Spiny spores; electron micrograph from 14 day culture on salts-starch agar.²

Spore chain morphology: Section Verticillati, umbellate monoverticillate (biverticillate, Fig. 124). Mature spore chains generally 10 to 20 or more spores per chain after 21 days on salts-starch agar or yeast-malt agar. Aerial mycelium is poorly developed or absent on yeast-malt agar, oatmeal agar and glycerol-asparagine agar. Absence of good aerial mycelium on various media was also noted by Shinobu in his original description (op. cit.). Spore surface: Smooth.

Color of colony: Mature aerial mycelium in the Red or Yellow color-series on salts-starch agar; it is absent or poorly developed (White or Yellow) on other ISP media.

Reverse side of colony: No distinctive pigments (light brown to grayed yellow) 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, tyrosine agar and tryptone-yeast broth. Yellow pigment is found in medium in yeast-malt agar, oatmeal agar and salts-starch agar after 14-21 days; it is not a pH indicator.

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

Streptomyces mashuensis Sawazaki, Susuki, Nakamura, Kawasaki, Yamashita, Isono, Anzai, Serizawa and Sekiyama. Description: Sawazaki et al. 1955, 44-45. Type strain: 449 (S. Susuki, personal communication). ISP 5221 from S. Susuki as 449. ISP description by Group B-5.

Spore chain morphology. Section Verticillati, umbellate monoverticillate (biverticillate, Fig. 125). Spore chains are short with 3 to 10, or sometimes more than 10, spores per chain. Spore surface: Smooth (Fig. 126).

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

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

Color in medium: Melanoid pigments are produced 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, sucrose and D-fructose are utilized for growth. Utilization of i-inositol is doubtful. No growth or only trace of growth on L-arabinose, D-xylose, D-mannitol, rhamnose and raffinose.

Streptomyces matensis Margalith, Beretta and Timbal. Description: Margalith et al. 1959, 71-75. Type strain: ME/17 (ibid.). ISP 5188 from L.G. Silvestri, Lepetit S.p.A. as Lep. M-ME/17. ISP description by Group A-13.

Spore chain morphology: Section Spirales. Open spirals are the dominant forms (Fig. 127); spore chains suggesting primitive spirals of RA cultures or flexuous chains of RF are also present. Mature spore chains moderately long with 10 to 50 or more spores per chain.

Figure 122. *A. longisporus-flavus*. (a) Spiral spore chains (X 400) on oatmeal agar, 14 days.³⁸ (b) Terminal spirals and hooks on yeast-malt agar, 14 days.³⁸

Figure 123. *A. longisporus-flavus*. Smooth spores; electron micrograph from 21 day culture on salts-starch agar.¹⁷

Figure 124. *S. luteoverticillatus*. BIV (umbellate monoverticillate) morphology on yeast-malt agar.³⁵

Figure 125. *S. mashuensis*. BIV (umbellate monoverticillate) morphology (X 400) on oatmeal agar, 14 days.³

Figure 126. *S. mashuensis*. Smooth spores; electron micrograph from 10 day culture on yeast-malt agar.³

This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Spiny. Spines are short and inconspicuous (Fig. 128); some smooth spores may be seen.

Color of colony: Mature aerial mass color in the Gray color-series (color tab 3ge, light grayish yellowish brown; to 5fe, light grayish reddish brown) on salts-starch agar; Gray or White color-series on yeast-malt agar and glycerol-asparagine agar. One observer reports tab 5dc (grayish yellowish pink) from the Red color-series for growth on yeast-malt agar, oatmeal agar and salts-starch agar. This trace of red (or violet) pigment in aerial color is also noted in the original description (Margalith *et al.*, 1959).

Reverse side of colony: Red pigments in mycelium modify characteristic substrate colors to dark reddish brown on yeast-malt agar and salts-starch agar, light grayish brown or yellowish pink on oatmeal agar and glycerol-asparagine agar. The substrate mycelium pigment is not a strong pH indicator. (One observer reports change from violet to pink with addition of 0.05 N HCl.)

Color in medium: Melanoid pigments are not found in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Red or violet pigments are found in yeast-malt agar, oatmeal agar and glycerol-asparagine agar. One observer reports a change from violet to red by addition of 0.05 N 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 trace of growth on raffinose. Utilization of sucrose is doubtful.

Streptomyces mediocidicus Okami, Utahara, Nakamura and Umezawa. Description: Okami *et al.*, 1954, 98-100. Type strain: 535-A1 (*ibid.*). ISP 5021 from Y. Okami as 535-A1 = NIHJ 266. ISP description by Group B-2.

Spore chain morphology: Sporulating aerial mycelium is not produced on any ISP media or on 15 additional media tested by cooperators. Single conidia were observed on the substrate mycelium on glucose-asparagine agar and Waksman's starch agar B (Fig. 129). Masses of crystals formed on the substrate growth on yeast-malt agar (Fig. 130). The original description (Okami *et al.*, 1954) indicates that aerial mycelium was only poorly developed or absent on most media. Spore surface: not observed.

Color of colony: No sporulating aerial mycelium was found on any of the media tried by the cooperators.

Reverse side of colony: Yellow to greenish yellow on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. This pigment is not pH sensitive.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth, but may not be formed in tyrosine agar. Trace of 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.

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

Figure 127. *S. matensis*. Spiral spore chains on yeast-malt agar.²⁵

Figure 128. *S. matensis*. Spiny spores; spines are short and sparse.

Electron micrograph from 13 day culture on Gauze medium No. 1.³

Figure 129. *S. mediocidicus*. Single spores on substrate mycelium:

(a) On Waksman's starch agar B, 21 days.²⁸ (b) On glucose-asparagine agar, 10 days (X 1000).⁸

Figure 130. *S. mediocidicus*. Crystalline masses on surface of substratal growth (X 380) on yeast-malt agar, 21 days.²⁸

Streptomyces melanogenes Sugawara and Onuma. Description: Sugawara and Onuma 1957, 138-142. Type strain: KITA V-1179 (T. Hata, personal communication). ISP 5192 from Y. Yagisawa from T. Hata, Kitasato Inst. as KITA V-1179. ISP description by Group B-2.

Spore chain morphology: Section Rectiflexibiles (Fig. 131). Mature spore chains 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. 132).

Color of colony: Aerial mass color in the Red color-series (5cb, grayish yellowish pink) on oatmeal agar and salts-starch agar; White or Gray color-series on yeast-malt agar and salts-starch agar. Mature sporulating aerial mycelium may be poorly developed on yeast-malt agar and salts-starch agar.

Reverse side of colony: Grayed yellow to yellow-brown is usually modified by red (becoming dark brown to reddish brown) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; this pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Yellow or red 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 raffinose are utilized for growth. Reports vary on utilization of sucrose. No growth or only trace of growth with rhamnose.

Streptomyces misakiensis Nakamura. Description: Nakamura 1961, 86-89; name and antibiotic production, without description, in Isono, Anzai and Suzuki 1958, 264-267. Type strain: 1755 (Nakamura, *ibid.*). ISP 5222 from S. Suzuki, Inst. Phys. and Chem. Res., Tokyo as 7617 = 1755. ISP description by Group B-6.

Spore chain morphology: Section Rectiflexibiles (Fig. 133). Mature spore chains generally long with 10 to 50, or sometimes 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. 134).

Color of colony: Aerial mass color in the Gray color-series on salts-starch agar and glycerol-asparagine agar; Gray or Red color-series on yeast-malt agar and oatmeal agar. The most representative color tab from the Gray color-wheel is 2dc (yellowish gray) for all ISP media. One observer selected tab 5dc (grayish yellowish pink) from the Red color-wheel as the most representative color on yeast-malt agar and oatmeal agar.

Reverse side of colony: Yellow to yellow-brown is modified by red, becoming brown to strong brown on yeast-malt agar, salts-starch agar and glycerol-asparagine agar and orange to light brown on oatmeal agar; this 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. Red pigment is found in the medium in yeast-malt agar, oatmeal agar and salts-starch agar. This pigment is not pH sensitive when tested with 0.05 NaOH or HCl.

Figure 131. *S. melanogenes*. RF spore chains. (a) (X 380), Waksman's starch agar B, 21 days.²⁸ (b) (X 500), oatmeal agar, 7 days.⁸

Figure 132. *S. melanogenes*. Smooth spores; electron micrograph from 21 day culture on oatmeal agar.²⁹

Figure 133. *S. misakiensis*. RF spore chains (X 350) on yeast-malt agar, 21 days.²¹

Figure 134. *S. misakiensis*. Smooth spores; electron micrograph (Au/Pd shadowed) from 21 day culture on oatmeal agar.³⁴

Carbon utilization: D-Glucose, sucrose, D-fructose and raffinose are utilized for growth. No growth or only trace of growth with L-arabinose, D-xylose, i-inositol, D-mannitol and rhamnose. In the original description (Nakamura, loc. cit.) L-arabinose and D-mannitol were also reported as supporting growth with Czapek's agar as basal medium.

Streptomyces naganishii Yamaguchi and Saburi. Description: Yamaguchi and Saburi 1955, 216-219 and 226. Type strain: H-4871 (ibid.). ISP 5282 from T. Yamaguchi as H-4871. ISP description by Group B-11.

Spore chain morphology: Section Spirales (Fig. 135a,b). Mature spore chains short to moderately long, usually with more than 10 spores per chain. This morphology is best developed on yeast-malt agar. Short spore chains on salts-starch agar and glycerol-asparagine agar may form incomplete spirals or hooks (Fig. 135c). Sporulation on oatmeal agar is especially poor. Aerial hyphae may terminate in atypical club-like swellings instead of spores (Fig. 136). Spore surface: Smooth (Fig. 137).

Color of colony: Aerial mass color in the Gray or Red color-series on yeast-malt agar and on carbon utilization medium plus D-Glucose. The sporulated aerial growth on oatmeal agar, salts-starch agar and glycerol-asparagine agar is usually white.

Reverse side of colony: Pale or grayish yellow to yellow-brown modified in spots or at margins by red (dark pink, purplish pink or grayish reddish brown). Substrate pigment is not a pH indicator.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar and tryptone-yeast broth in two days, but are produced slowly or not at all in tyrosine agar. A transient red pigment is found in the medium in oatmeal 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-mannitol, D-fructose and rhamnose are utilized for growth. Utilization of raffinose is doubtful. No growth or only trace of growth with sucrose.

Streptoverticillium netropsis (Finlay, Hochstein, Sobin and Murphy) Baldacci, Farina and Locci. Description: Streptomyces netropsis, U.S. Patent 2,586,762, Feb. 19, 1952; name and antibiotic production, without description, in Finlay, Hochstein, Sobin and Murphy 1951, 341-343. Streptoverticillium netropsis, Baldacci, Farina and Locci 1966, 161-162. Type strain: Isolate 2937-6 = Pfizer F.D. 4779 = NRRL 2268. ISP 5259 from J. Routien, Chas. Pfizer and Co., Inc. as F.D. 4779 = NRRL 2268. ISP description by Group B-6.

Spore chain morphology: Umbellate monoverticillate (= Streptomyces Section Verticillati, biverticillate). Whorls may be composed of straight (BIV), flexuous, or spiral (BIV-S) spore chains (Fig. 138a,b,c). Mature spore chains generally 10 to 20 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 on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

Figure 135. *S. naganishii*. (a) Spiral spore chains (X 200) on glycerol-asparagine agar, 14 days.¹⁸ (b) Spiral chains (X 400) on yeast-malt agar.³⁹ (c) Short chains with incomplete spirals and hooks, yeast-malt agar, 14 days.³⁶

Figure 136. *S. naganishii*. Aerial hyphae terminating in club-like swellings (X 500) on yeast-malt agar.³⁶

Figure 137. *S. naganishii*. Smooth spores; electron micrograph from 14 day culture on glycerol-asparagine agar.¹⁸

Figure 138. *Streptoverticillium netropsis*. (a) BIV (umbellate monoverticillate) morphology with straight chains forming the umbels (X 500) on oatmeal agar, 24 days.¹⁵ (b) BIV with flexuous spore chains, (X 500) on salts-starch agar, 24 days.¹⁵ (c) BIV-S (X 350); spore chains terminate in coils of one to two turns; salts-starch agar, 20 days.²¹

Figure 139. *Streptoverticillium netropsis*. Smooth spores; electron micrograph (Au/Pd shadowed) from 21 day culture on oatmeal agar.³⁴

Reverse side of colony: No distinctive pigments (grayish yellow to olive brown or 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, but not in tyrosine agar. No pigment or only a trace of yellow or brown pigment, is found in the medium in yeast-malt agar, oatmeal agar and salts-starch agar. Pigment, if present, may be slightly pH sensitive changing from pale yellow to pale pink when tested with 0.05 N NaOH.

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

Actinomyces nigrescens Sveshnikova. Description: Sveshnikova in Gauze *et al.* 1957, 146-148. Type strain: 1800/54 (*ibid.*; selected by G.F. Gauze and regarded by him as identical with Streptomyces hygroscopicus, personal communication, Sept., 1964). Streptomyces nigrescens (Sveshnikova) Pridham *et al.* 1958, 70. ISP 5276 from G.F. Gauze as 1800/54. ISP description by Group B-6.

Spore chain morphology: Section Spirales (Fig. 140). Mature spore chains moderately long with 10 to 50, or sometimes 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 to warty (Fig. 141).

Color of colony: Aerial mass color in the Gray color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. In the original description (Sveshnikova *op. cit.*) emphasis is placed on an autolytic change of gray aerial mycelium to a black shiny mass in aging cultures. This phenomenon was not observed by ISP cooperators.

Reverse side of colony: No distinctive pigments (colorless to 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, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose and raffinose are utilized for growth. No growth or only trace of growth with L-arabinose and rhamnose.

Streptomyces nodosus Trejo. Description: Trejo in Waksman 1961, 250; Trejo and Bennett 1963, 436-439. Type strain: SC 2388 = ATCC 14899 (Trejo, personal communication). ISP 5109 from W. H. Trejo as SC 2388. ISP description by Group A-12.

Spore chain morphology: Section Spirales. Spirals on short spore chains may be poorly developed showing only a few turns or hooks of small diameter; or tightly knotted spirals may be formed (Fig. 142). Spore chains are short, often with only 3 to 10 spores per chain. This morphology is seen on yeast-malt agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth, but some wrinkles or folds are found on the spore surface (Fig. 143).

Figure 140. *A. nigrescens*. Spiral spore chains (X 300) on salts-starch agar, 21 days.¹⁵

Figure 141. *A. nigrescens*. Smooth spores (Au/Pd shadowed) with small surface irregularities suggesting warts.³⁴

Figure 142. *S. nodosus*. Spirals on short chains, some forming tight "knots" (X 400); salts-starch agar, 21 days.²³

Figure 143. *S. nodosus*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar.²²

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

Reverse side of colony: Grayed yellow or grayed greenish yellow to dark olive brown or near black on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast extract broth. Traces of red or yellow orange pigment may be found in the medium in yeast-malt agar, oatmeal agar and glycerol-asparagine agar. One observer reports this pigment is pH sensitive changing from red to green by addition of 0.05 N NaOH and from green to blue-red by 0.05 N HCl.

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

Streptovercillium olivoreticuli (Arai, Nakada and Suzuki) Baldacci, Farina and Locci. Descriptions: *Streptomyces olivoreticuli* Arai *et al.* 1957, 435-441; *Streptovercillium olivoreticuli* (Arai *et al.*) Baldacci, Farina and Locci 1966, 162. Type strain: 100 (*ibid.*) = IFM 1018, Arai, personal communication. ISP 5105 from T. Arai as IFM 1018 = 100. ISP description by Group B-1.

Spore chain morphology: Umbellate monovercillate (= *Streptomyces* Section *Verticillati*, biverticillate, Fig. 144). Mature spore chains generally short with 3 to 10 spores per chain. This morphology may be observed on Pridham and Gottlieb carbon utilization medium with glucose or inositol, but good sporulation is usually not seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 145).

Color of colony: Aerial mass color in the White color-series on media supporting sporulating aerial growth. In the absence of sporulation, the surface is pale yellow on yeast-malt agar, oatmeal agar and glycerol-asparagine agar and white on salts-starch agar.

Reverse side of colony: No distinctive pigments (colorless to grayish 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 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: Carbon utilization appears to be unusually variable. Reports from three observers differ on utilization of each carbon source tested and results vary on duplicate dishes in the same laboratory. The original description (Arai, *et al.* 1957) directs attention to fluctuation of carbon utilization by ultra-violet irradiated strains. This fluctuation appears also to be a characteristic of the type strain.

Streptomyces olivoviridis Kuchaeva, Krasil'nikov, Skryabin and Tapykova. Description: Kuchaeva *et al.* 1960, 251 (see also Engl. transl., 222-251). Type strain: INMI 1475 = RIA 661 (*ibid.*; type strain selected by N.A. Krasil'nikov, personal communication). ISP 5211 from N.A. Krasil'nikov as INMI 1475 = RIA 661. ISP description by Group B-8.

Figure 144. *Streptovercillium olivoreticuli*. BIV (umbellate mono-verticillate) morphology (X 640) on Pridham and Gottlieb carbon utilization medium plus inositol, 14 days.²

Figure 145. *Streptovercillium olivoreticuli*. Smooth spores; electron micrograph from 28 day culture on salts-starch agar.²

Figure 146. *S. olivoviridis*. (a) RF spore chains (X 300) on yeast-malt agar, 7 days.¹⁴ (b) Flexuous and wavy chains with some tendency toward hooks and spirals; 14 day culture on oatmeal agar.¹³

Figure 147. *S. olivoviridis*. Spiny spores; electron micrograph from 14 day culture on oatmeal agar.¹⁹

Spore chain morphology: Section Rectiflexibiles (Fig. 146a). The predominantly flexuous or wavy spore chains may also form occasional hooks and open spirals (rare) resembling RA or S morphology (Fig. 146b). Mature spore chains generally 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. 147).

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

Reverse side of colony: Yellow to yellow brown is usually modified by green (olive brown to yellow green or grayish green) on yeast-malt agar, oatmeal agar and salts-starch agar; no distinctive substrate mycelium pigment on glycerol-asparagine agar. Substrate mycelium pigment is not a pH indicator.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar or tyrosine agar. Some coloration may appear in medium in tryptone-yeast broth. Yellow or green pigment is found in the medium in yeast-malt agar, oatmeal 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, D-mannitol, D-fructose and rhamnose are utilized for growth. No growth or only trace of growth with sucrose, i-inositol or raffinose.

Streptomyces phaeochromogenes (Conn) Waksman. Descriptions: Actinomyces phaeochromogenus (sic) Conn 1917a, 3, 16 (also reprinted in Conn 1917b, 157, 170); Streptomyces phaeochromogenus (Conn) Waksman and Henrici 1948, 943; Streptomyces phaeochromogenes (Conn) Waksman 1957, 778. Type strain: IMRU 3338 (Waksman, 1961). ISP 5073 from S.A. Waksman as IMRU 3338. ISP description by Group B-4.

Spore chain morphology: Section Rectiflexibiles (Fig. 148). Mature spore chains generally straight chains of 10 to 50, or sometimes more than 50, spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spirals were reported in Waksman's 1919 description, but not in Conn's original description (1917, op. cit.). Subsequent observations reported in Waksman, 1961, note frequent occurrence of straight spore chains and absence of spirals. Spore surface: Smooth (Fig. 149).

Color of colony: Aerial mass color usually in the Red color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Most representative color tabs from the Red color-series were 3ca (pale orange yellow) and 5ca or 5cb (light yellowish pink to grayish yellowish pink). Aerial mass color may also be white or pale yellow on oatmeal agar and pale yellow on salts-starch agar and glycerol-asparagine agar.

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

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. No pigment other than 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, sucrose, D-xylose,

D-inositol, D-mannitol, D-fructose and rhamnose are utilized for growth. Reports vary on utilization of raffinose.

Streptomyces phaeopurpureus Shinobu. Description: Shinobu 1957, 63-67. Type strain: 146 (ibid.). ISP 5125 from R. Shinobu as 146. ISP description by Group B-9.

Spore chain morphology: Section Rectiflexibiles (Fig. 150). Aerial mycelium is usually poorly developed or absent on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Mature spore chains may be observed on other media including Gauze's medium No. 1 where chains of 10 to 50 or more spores may be formed. Spore surface: Smooth (Fig. 151).

Color of colony: Aerial mass color probably in the Gray or Red color-series, but aerial sporulation on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar is usually inadequate for accurate spore mass color determination.

Reverse side of colony: Yellow to yellow brown is modified by red (light brown, strong brown, or grayish reddish brown on oatmeal agar, salts-starch agar or glycerol-asparagine agar; moderate to strong reddish brown on yeast-malt agar). Substrate mycelium pigment is not a pH indicator (or is changed only slightly from brown to yellow brown by 0.05 N HCl).

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. Yellow, orange, or red pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. This pigment is slightly pH sensitive changing from reddish orange or brown to yellow brown with 0.05 N HCl.

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

Streptomyces phaeoviridis Shinobu. Description: Shinobu 1957, 67-73. Type strain: 503 (ibid.). ISP 5285 from A. Seino, Kakken Kagaku Co., Tokyo as 503. ISP description by Group B-12.

Spore chain morphology: Section Rectiflexibiles (Fig. 152). Mature spore chains generally 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 with mature spore chains is not formed on glycerol-asparagine agar. Spore surface: Smooth (Fig. 153).

Color of colony: Aerial mass color in the Gray color-series on yeast-malt agar, oatmeal agar and salts-starch agar. (White also may be seen on these media and on the poorly sporulated surface of glycerol-asparagine agar.)

Reverse side of colony: Yellow to yellow brown is modified slightly by red or orange (light yellowish brown to strong brown, yellowish pink, or grayish reddish orange). Substrate 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. Orange or reddish pigment is found 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.

Figure 148. *S. phaeochromogenes*. RF spore chains. (a) (X 400) on yeast-malt agar, 17 days.³¹ (b) (X 800) on glycerol-asparagine agar, 14 days.²⁷

Figure 149. *S. phaeochromogenes*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.³¹

Figure 150. *S. phaeopurpureus*. Long RF spore chains (X 1100) on yeast-malt agar, 21 days.⁵

Figure 151. *S. phaeopurpureus*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.⁵

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

Streptomyces platensis Pittenger and Gottlieb. Descriptions: McGuire, British Pat. Specification 713,795, Jan. 31, 1954; Pittenger and Gottlieb in Waksman 1961, 258-259. Type strain: M5-5353 (Pittenger, personal communication). ISP 5041 from R.C. Pittenger as M5-5353. ISP description by Group B-4.

Spore chain morphology: Section Spirales (Fig. 154). Mature spore chains generally 10 to 50, or sometimes 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. 155).

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

Special morphological characteristic: Spores frequently coalesce to form black, moist (hygroscopic) masses of spores (Fig. 156). Sometimes much of the aerial growth will be converted to a black, moist surface.

Reverse side of colony: Grayish yellow on oatmeal agar and salts-starch agar; sometimes modified by red to grayish yellowish pink or light reddish brown on yeast-malt agar and glycerol-asparagine agar. Reddish substrate mycelium pigment may be changed to colorless or pale yellow by 0.05 N HCl.

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Traces of red or yellow pigments are found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. The reddish pigment is somewhat pH sensitive, changing from grayed red to nearly colorless with 0.05 N HCl.

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

Streptomyces pseudogriseolus Okami and Umezawa. Description: Okami and Umezawa in Okami, Utahara, Oyagi, Nakamura and Umezawa. 1955, 127-128. Type strain: 534 (*ibid.*). ISP 5026 from Y. Okami as H-16C = 534 = NIHJ 224. ISP description by Group B-2.

Spore chain morphology: Section Spirales (Fig. 157). Spore chains suggesting RA morphology may also be common. Mature spore chains moderately short, often with 3 to 10 spores per chain, but longer chains are formed on suitable media. This morphology is seen on yeast-malt agar and salts-starch agar but aerial mycelium is poorly developed on oatmeal agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 158).

Color of colony: Aerial mass color in the White color-series on yeast-malt agar and salts-starch agar; poor sporulation on oatmeal agar and glycerol-asparagine agar. The aerial mycelium is described as grayish buff in the original description by Okami and Umezawa (1955).

Figure 152. *S. phaeoviridis*. RF spore chains: (a) (X 485) on oatmeal agar, 14 days.³⁷ (b) (X 1200) on salts-starch agar.²³
 Figure 153. *S. phaeoviridis*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.²²
 Figure 154. *S. platensis*. Spiral spore chains (X 800) on glycerol-asparagine agar, 14 days.²⁷
 Figure 155. *S. platensis*. Smooth spores; electron micrograph from 7 day culture on salts-starch agar.³¹ Tangled masses of spirals are associated with hygroscopic droplets.
 Figure 156. *S. platensis*. Hygroscopic droplets containing coalesced masses of spores. (a) (X 400) on yeast-malt agar, 18 days (cf. Fig. 155).³¹ (b) (X 400) on oatmeal agar, 18 days.³¹ (c) (X 200) on oatmeal agar, 14 days.²⁶

Reverse side of colony: No distinctive pigments (colorless to 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 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 and rhamnose are utilized for growth. No growth or only trace of growth with sucrose and raffinose.

Actinomyces pseudolavendulae Kuchaeva, Krasil'nikov, Taptikova and Gesheva. Description: Kuchaeva *et al.* 1962, 103-124. Type strain: USSR RIA-744 = IMRU 3440 (*ibid.*; Krasil'nikov, personal communication). ISP 5213 from N.A. Krasil'nikov as RIA 744 = IMRU 3440. ISP description by Group B-10.

Remarks: The characterization by ISP study-group B-10 for Actinomyces pseudolavendulae Kuchaeva *et al.*, ISP strain 5213 is identical in all details with the characterization by study-group A-6 for Streptomyces lavendulae (Waksman and Curtis) Waksman and Henrici, ISP 5069. The characterization for Streptomyces lavendulae, ISP 5069 was reported in our previous paper (Shirling and Gottlieb 1968, 138). A personal communication from N.A. Krasil'nikov (April, 1964) gives IMRU 3440 = RIA-744 as the type strain for Actinomyces pseudolavendulae. IMRU 3440 is given as the type strain for Streptomyces lavendulae by Waksman (1961) and was used as the type strain for the ISP study of this species. Actinomyces pseudolavendulae Kuchaeva *et al.* 1962 is regarded here as an objective synonym for Streptomyces lavendulae (Waksman and Curtis) Waksman and Henrici 1948; and ISP strain 5213 is equivalent to ISP 5069 Streptomyces lavendulae g. v.

Actinomyces pseudovenezuelae Kuchaeva, Krasil'nikov, Taptikova and Gesheva. Description: Kuchaeva *et al.* 1962, 103-124. Type strain: USSR RIA-742 = IMRU 3774 (*ibid.*; Krasil'nikov, personal communication). ISP 5212 from N.A. Krasil'nikov as RIA-742 = IMRU 3774. ISP description by Group B-9.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains generally long, often with more than 50 spores per chain (Fig. 159). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 160).

Color of colony: Aerial mass color in the Red color-series (5dc, grayish yellowish pink) on yeast-malt agar, oatmeal agar and salts-starch agar; Gray or White color-series on glycerol-asparagine agar. (Gray or White is also sometimes reported for yeast-malt agar, oatmeal agar and salts-starch agar.)

Reverse side of colony: No distinctive pigments (light grayish yellow to orange yellow or 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, tyrosine agar and tryptone-yeast broth. Trace of grayish yellow pigment may be found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. This pigment is

Figure 157. *S. pseudogriseolus*. Spiral spore chains (X 380) on Waksman's starch agar B, 21 days.²⁸

Figure 158. *S. pseudogriseolus*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.²⁹

Figure 159. *A. pseudovenezuelae*. RF spore chains (X 1100) on glycerol-asparagine agar, 14 days.⁵

Figure 160. *A. pseudovenezuelae*. Smooth spores; electron micrograph from 14 day culture on glycerol-asparagine agar.⁷

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

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

Streptomyces purpeofuscus Yamaguchi and Saburi. Description: Yamaguchi and Saburi 1955, 203-207. Type strain: H-5080 (*ibid.*). ISP 5283 from T. Yamaguchi as H-5080. ISP description by Group B-12.

Spore chain morphology: Section Rectiflexibiles (Fig. 161). Mature spore chains 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. 162).

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

Reverse side of colony: Distinctive pigments are usually not produced (grayish yellow to olive brown) on yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar, but dark brown to reddish brown substrate mycelium pigment may be produced. The original description (Yamaguchi and Saburi, 1955) describes purple to brown reverse mycelium color but notes that this coloration may be lost on repeated transfer.

Color in medium: Melanoid pigments are formed in peptone-yeast-iron agar, but only as traces of brownish black color in tyrosine agar or tryptone-yeast broth. Traces of red, violet or yellow pigment may be found in the medium in yeast-malt agar, oatmeal 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 and D-xylose are utilized for growth. Utilization of D-fructose is doubtful. No growth or only trace of growth with sucrose, i-inositol, D-mannitol, rhamnose and raffinose.

Streptomyces pyridomyceticus Okami and Umezawa. Descriptions and nomenclature: Tentative name with incomplete and tentative description in Maeda, Kosaka, Okami and Umezawa 1953, 140; Streptomyces albidofuscus Okami and Umezawa in Okami, Maeda and Umezawa 1954, 55-56; authors' rejection of Streptomyces albidofuscus with assignment of the name Streptomyces pyridomyceticus Okami and Umezawa in Umezawa and Okami 1957, 172. Type strain: 451-A8 (Okami and Umezawa in Okami, Maeda and Umezawa 1954, 55). ISP 5024 from Y. Okami as 451-A8 = NIHJ 284. ISP description by Group B-3.

Spore chain morphology: Section not determined (possibly Spirales or RF). Mature spore chains are generally difficult to find on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar and other ISP media as well as on Hickey and Tresner's amidex agar. Rare spore chains were short with 3 to 10 spores per chain and were generally twisted or curved into hooks resembling incomplete spirals. (Fig. 163), although RF spore chains were also sometimes found (Fig. 164). The original descriptions (Maeda et al., 1963 and Okami and Umezawa, 1954) also note the general absence of good aerial mycelium on most media. In the original description loose spirals are described as occurring on the sparse aerial mycelium of synthetic media. Spore surface: Smooth (Fig. 165). Spores were irregular in size and were often interspersed with imperfect spores. This characteristic is also

Figure 161. *S. purpeofuscus*. RF spore chains on yeast-malt agar, 21 days (a, X 300; b, X 1200).²³

Figure 162. *S. purpeofuscus*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.²²

Figure 163. *S. pyridomyceticus*. Isolated spore chains forming hooks, incomplete spirals or spirals of only one or two turns (X 600): (a) On glycerol-asparagine agar, 14 days; (b, c) On yeast-malt agar, 14 days; (d) On glycerol-asparagine agar, 18 days.²⁰ Aerial mycelium is difficult to find on this strain.

Figure 164. *S. pyridomyceticus*. RF spore chains (X 600) on glycerol-asparagine agar, 12 days (see also, Figure 163).²⁰

Figure 165. *S. pyridomyceticus*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.¹⁰

mentioned in the first description.

Color of colony: Aerial mycelium is poorly developed or absent on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar as well as on other ISP media. When present on yeast-malt agar or oatmeal agar, aerial mycelium is thin and white. The original description describes the aerial mycelium as thin and white, sometimes with gray or brownish gray tinge on Czapek's agar.

Reverse side of colony: No distinctive pigments (colorless or grayish yellow or 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. No pigment is found in the medium in yeast-malt agar, oatmeal agar, salts-starch agar or glycerol-asparagine agar.

Carbon utilization: No growth or only trace of growth with D-Glucose, L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose or raffinose. Absence of growth with D-glucose and all other carbon sources tested, suggests that Pridham and Gottlieb's basal medium will not support growth of this strain. The original description (Okami and Umezawa 1954) indicates that D-glucose, L-arabinose, sucrose, D-xylose and D-fructose can be utilized for growth with Czapek's agar as the basal medium.

Streptomyces racemochromogenus Sugai. Description: Sugai 1956, 170-179. Type strain: 229 (*ibid.*). ISP 5194 from M. Oda, Meiji Seika Co. ISP description by Group B-4.

Spore chain morphology: Section Retinaculiaperti including many RF spore chains (Fig. 166a), and some long chains with terminal hooks or primitive spirals of wide diameter (Fig. 166b). Mature spore chains generally 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. 167).

Color of colony: Aerial mass color in the Red color-series (5ec and 5cb, grayish yellowish pink) on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Areas of gray or white sporulation may also be seen.

Reverse side of colony: No distinctive pigments on oatmeal agar, but yellow to yellow brown substrate mycelium color may be modified in some areas by blue pigment (dark olive green, grayish green or grayish blue) on yeast-malt agar, salts-starch agar and glycerol-asparagine agar. The blue pigment is not always present. When present, it can be intensified from grayish green to grayish blue or violet by 0.05 N NaOH or from gray green to reddish gray by 0.05 N HCl.

Color in medium: Melanoid pigments are produced in peptone-yeast-iron agar, tyrosine agar and tryptone-yeast broth. No pigment other than 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 and sucrose are utilized for growth. Only a trace of growth is found on D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose and raffinose.

Figure 166. *S. racemochromogenus*. RA morphology including both straight spore chains and terminal spirals: (a) RF chains (X 400) on yeast-malt agar, 17 days.³¹ (b) Typical RA terminal hooks and spirals (X 200) on oatmeal agar, 14 days.²⁷

Figure 167. *S. racemochromogenus*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.⁴⁰

Figure 168. *S. rimosus*. Spiral spore chains (X 1100) from 14 day cultures on: (a) Yeast-malt agar, (b) oatmeal agar, (c) glycerol-asparagine agar.⁵

Figure 169. *S. rimosus*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.⁷

Streptomyces rimosus (Sobin, Finlay and Kane) Waksman. Descriptions: Sobin, Finlay and Kane, U.S. Pat. 2,516,080 July 18, 1950. Waksman in Waksman and Lechevalier 1953, 47. Type strain: Pfizer F.D. 10326 = NRRL 2234, IMRU 3558, ATCC 10970 (Routien, personal communication). ISP 5260 from J.B. Routien, Chas. Pfizer and Co., Inc. as FD 10326. ISP description by Group B-9.

Spore chain morphology: Section Spirales (Fig. 168), but many imperfect spirals, hooks, and loops suggesting RA morphology are also present. Mature spore chains short to moderately long with 3 to 10, or often more than 10, spores per chain. This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar, glycerol-asparagine agar and on carbon utilization medium plus D-glucose. Spore surface: Smooth (Fig. 169).

Color of colony: Aerial mass color in the Red or White color-series on yeast-malt agar and in the Yellow or White color-series on oatmeal agar, salts-starch agar and glycerol-asparagine agar. Representative color tabs are 3ca (pale orange yellow), 5cb (grayish yellowish pink) and 2ca (pale yellow) from the Red color-wheel; 2db and 2ba (pale yellow) from the Yellow color-wheel; and a (white) from the White color-wheel.

Reverse side of colony: Grayish yellow on oatmeal agar and salts-starch agar; grayish yellow modified slightly by red (moderate to dark orange-yellow) on yeast-malt agar and glycerol-asparagine agar. Substrate 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. Trace of 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, i-inositol, D-mannitol, D-fructose and raffinose are utilized for growth. Utilization of D-xylose is doubtful. No growth or only trace of growth with sucrose and raffinose.

Streptomyces rochei Berger, Jampolsky and Goldberg. Description: Name only, without description is found in Berger, Jampolsky and Goldberg 1949, 476-478. Description is given in Waksman and Lechevalier 1953, 40-41 and by Preobrazhenskaya et al. in Gauze et al. 1957, 133 (Engl. transl., 106). Type strain: X 15 (Berger, personal communication). ISP 5231 from J. Berger, Hoffman-LaRoche, Inc. as X 15. ISP description by Group B-8.

Spore chain morphology: Section Spirales (Fig. 170a). Spirals are usually open, sometimes almost flexuous (Fig. 170 b, c). Mature spore chains moderately 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 to warty (Fig. 171).

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

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

Figure 170. *S. rochei*. (a) Spiral spore chains (X 300) on glycerol-asparagine agar, 7 days.¹⁴ (b, c) Open spirals to flexuous chains (X 400) on oatmeal agar, 14 days.⁴¹

Figure 171. *S. rochei*. Smooth to warty spores; electron micrograph from 14 day culture on oatmeal agar.¹⁹

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 trace of growth on sucrose and raffinose.

Streptomyces roseo-luteus Bessell. Description: Bessell, U.S. Patent 3,013,947 Dec. 19, 1961). Type strain: NRRL 2776 = NCIB 8984 (*ibid.*). ISP 5240 from C.W. Hesseltine (NRRL) as NRRL 2776. ISP description by Group B-6.

Spore chain morphology: Section Spirales. Tight spirals of one to many turns occur at ends of long spore chains (Fig. 172). These sometimes suggest RA morphology. Mature spore chains generally 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. 173).

Color of colony: Aerial mass color in the Red color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. One observer placed this strain in the Gray color-series with color tab 5fe (light grayish reddish brown) as the nearest matching color from the Gray color wheel. Nearest matching tabs in the Red color-series were 5ge and 4ge (light grayish reddish brown).

Reverse side of colony: Yellow to orange yellow on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar; substrate 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 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-mannitol, D-fructose and raffinose are utilized for growth. No growth or only trace of growth with L-arabinose, sucrose, i-inositol and rhamnose.

Streptomyces roseosporus Falcão de Moraes and Daliá Maia. Description: *Streptomyces venezuelae* var. *roseospori* Falcão de Moraes, Daliá Maia and Genn 1958, 102-103. Change in name (rank): *Streptomyces roseosporus* Moraes and D. Maia (*sic*) *nom nov* 1961, 43. Type strain: 4192 (Falcão de Moraes and Daliá Maia 1961, 43). ISP 5122 from J.O. Falcão de Moraes as 4192. ISP description by Group B-3.

Spore chain morphology: Section Rectiflexibiles. Mature spore chains generally long, often with more than 50 spores per chain (Fig. 174). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 175).

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

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

Figure 172. *S. roseo-luteus*. Spiral spore chains (X 500) on salts-starch agar, 3 days.¹⁵

Figure 173. *S. roseo-luteus*. Smooth spores (Au/Pd shadowed); electron micrograph from 21 day culture on salts-starch agar.³⁴

Figure 174. *S. roseosporus*. RF spore chains. (a) (X 300) on oatmeal agar, 14 days.¹⁰ (b) (X 600) on glycerol-asparagine agar, 21 days.²⁰

Figure 175. *S. roseosporus*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar.¹⁰

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. Utilization of D-fructose is doubtful. No growth or only trace of growth with sucrose, i-inositol, D-mannitol and raffinose.

Actinomyces roseoviridis Preobrazhenskaya. Description: Preobrazhenskaya in Gauze et al. 1957, 57. Type strain: 3617 (Preobrazhenskaya, personal communication; G. F. Gauze, cited by Gottlieb 1968, 20). Streptomyces roseoviridis (Preobrazhenskaya) Pridham et al. 1958, 61. ISP 5175 from T.P. Preobrazhenskaya as 3617. ISP description by Group A-12.

Spore chain morphology: Section Rectiflexibiles (Fig. 176). Mature spore chains generally 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. 177).

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

Reverse side of colony: No distinctive pigment 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, tyrosine agar and tryptone-yeast broth. Pigments other than melanoids are not formed 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 trace of growth on sucrose, i-inositol, D-mannitol, rhamnose and raffinose. Utilization of D-fructose is doubtful.

Actinomyces rubiginosohelvolus Kudrina. Description: Kudrina in Gauze et al. 1957, 78 and 89. Type strain: 10/53 (ibid.; see also Gauze in Gottlieb 1968). Streptomyces rubiginosohelvolus (Kudrina) Pridham et al. 1958, 59. ISP 5176 from T.P. Preobrazhenskaya as 10/53. ISP description by Group A-12.

Spore chain morphology: Section Rectiflexibiles (Fig. 178). Aerial mycelium is sometimes poorly developed on ISP media. Mature spore chains, when formed, contain 10 to 50 or more spores per chain on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 179).

Color of colony: Aerial mass color in the Yellow color-series on yeast-malt agar, salts-starch agar and glycerol-asparagine agar. Aerial mycelium is poorly developed on oatmeal agar. One observer also recorded tabs 2ca (pale yellow) and 3ca (pale orange yellow) from the Red color-series as a second color on yeast-malt agar and glycerol-asparagine agar.

Reverse side of colony: Colorless to pale yellow or grayed yellow on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. However, yellowish reverse pigment is a pH indicator changing from yellow to pink with addition 0.05 N NaOH.

Figure 176. *A. roseoviridis*. RF spore chains: (a) (X 240) on oatmeal agar, 14 days.²² (b) (X 400) on yeast-malt agar, 21 days.²³
 Figure 177. *A. roseoviridis*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.²³
 Figure 178. *A. rubiginosohelvolus*. RF spore chains (X 400) on yeast-malt agar, 21 days.²³
 Figure 179. *A. rubiginosohelvolus*. Smooth spores; electron micrograph from 21 day culture on yeast-malt agar.²³

Color in medium: Melanoid pigments not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigments or only trace of yellow pigment found 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 on sucrose, i-inositol and raffinose.

Actinomyces rubiginosus Preobrazhenskaya, Blinov and Ryabova.

Description: Preobrazhenskaya et al. in Gauze et al. 1957, 132 and 134. Type strain: 11852 (Gauze in Gottlieb, 1968). Streptomyces rubiginosus (Preobrazhenskaya, Blinov and Ryabova) Pridham et al. 1958, 70. ISP 5177 from T.P. Preobrazhenskaya as 11852. ISP description by Group A-12.

Spore chain morphology: Section Spirales. Spirals are best developed on salts-starch agar. Aerial mycelium and spore chains may be poorly developed and atypical on yeast-malt agar, oatmeal agar and glycerol-asparagine agar (Fig. 180). Mature spore chains generally 10 to 50 spores per chain. Spore surface: Spiny (Fig. 181).

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

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

Color in medium: Melanoid pigments not formed in peptone yeast-iron agar, tyrosine agar or tryptone-yeast broth. No pigment is found in medium in yeast-malt agar, salts-starch agar or glycerol-asparagine agar. There may be a trace of red soluble pigment in oatmeal agar; this pigment is not pH sensitive.

Carbon utilization: D-Glucose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose and rhamnose are utilized for growth. Growth on sucrose is less abundant than on other carbon sources. No growth or only trace of growth on raffinose.

Streptomyces scabies (Thaxter) Waksman and Henrici. Descriptions:

Oospora scabies Thaxter 1892, 159-160. Actinomyces scabies (Thaxter) Güssow 1914, 433; Millard and Burr 1926, 628-629. Streptomyces scabies (Thaxter) Waksman and Henrici 1948, 957. Type strain: IMRU 3018 (Waksman 1961, 274-275). ISP 5078 from S.A. Waksman as IMRU 3018. ISP description by Group B-4.

Spore chain morphology: Section Rectiflexibiles (Fig. 182). Mature spore chains moderately short with 3 to 10, or sometimes 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. 183).

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

Reverse side of colony: Yellow to yellow brown is usually modified by green to light grayish olive, olive, or olive brown on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Substrate mycelium pigment is not a pH indicator.

Figure 180. *A. rubiginosus*. Spiral spore chains; imperfect spirals (X 400) on yeast-malt agar, 21 days.²³

Figure 181. *A. rubiginosus*. Spiny spores; electron micrograph from 21 day culture on oatmeal agar.²²

Figure 182. *S. scabies*. RF spore chains: (a) (X 400) on yeast-malt agar, 17 days.³¹ (b) (X 800) on salts-starch agar, 14 days.²⁷

Figure 183. *S. scabies*. Smooth spores; electron micrograph from 14 day culture on oatmeal agar.³¹

Figure 184. *S. sindenensis*. RF spore chains (X 200) on oatmeal agar, 14 days.¹⁸

Figure 185. *S. sindenensis*. Long chains of smooth spores; electron micrograph (X 2700) from 16 day culture on yeast-malt agar.³⁶

Figure 186. *S. sindenensis*. Smooth spores (X 20,000); electron micrograph from 14 day culture on yeast-malt agar.¹⁸

Color in medium: Melanoid pigments are not formed in peptone-yeast-iron agar, tyrosine agar or tryptone-yeast broth. Yellow or greenish yellow pigment may be found in the medium in yeast-malt agar and oatmeal agar, but not in 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, D-mannitol, D-fructose and rhamnose are utilized for growth. No growth or only trace of growth with sucrose, i-inositol and raffinose.

Streptomyces sindenensis Nakazawa and Fujii. Descriptions: Nakazawa and Fujii 1957, 109-110; Nakazawa 1964, 69-70. Name only, without description, in Nakazawa, Fujii, Inoue, Hitomi, Miyake and Kaneko 1954, 168. Type strain: 1071 (*ibid.*). ISP 5255 from K. Nakazawa as 1071 = IFO 3399. ISP description by Group B-11.

Spore chain morphology: Section Rectiflexibiles (Fig. 184). Mature spore chains short, often with only 3 to 10 spores per chain (longer chains may be found on impression mounts or electron micrographs.

Fig. 185). This morphology is seen on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar. Spore surface: Smooth (Fig. 186).

Color of colony: Aerial mass color is difficult to determine because sporulating aerial mycelium is poorly developed on ISP media. When sporulation occurs, it is usually in the White or Red (5cb, grayish yellowish pink) color-series on yeast-malt agar and in the White or yellow color-series on oatmeal agar. When present, sporulating aerial mycelium is in the White color-series on salts-starch agar and 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, D-mannitol and D-fructose are utilized for growth. No growth or only trace of growth with sucrose, i-inositol, rhamnose and raffinose.

Streptomyces somaliensis (Brumpt) Waksman and Henrici. Description: Indiella somaliensis Brumpt 1906, 555 and 561-562. See also: Actinomyces somaliensis Erikson 1935, 17-18; Streptomyces somaliensis (Brumpt) Waksman and Henrici 1948, 965. Type strain: 3236 (Erikson 1935, 17, neotype). ISP 5267 from S. T. Cowan, NCTC as NCTC 3236. ISP description by Group B-11.

Spore chain morphology: Section Rectiflexibiles; flexuous chains are most common (Fig. 187). Mature spore chains generally 10 to 50, or sometimes 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. 188).

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

Figure 187. *S. somaliensis*. RF spore chains on oatmeal agar, 14 days. ³⁶

Figure 188. *S. somaliensis*. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar. ¹⁸

Figure 189. *S. spheroides*. Spiral spore chains (X ca 900) on salts-starch agar, 14 days. ²³

Figure 190. *S. spheroides*. Smooth spores; electron micrograph from 14 day culture on salts-starch agar. ²²

3ca, pale orange yellow, from the Red color wheel as the most representative color.) Aerial mycelium is often poorly developed on much of the culture surface on ISP media. Good sporulation in the Yellow color-series was observed on Czapek's agar.

Reverse side of colony: No distinctive pigments (grayish yellow to grayish greenish yellow and 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. 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, sucrose, D-xylose, D-mannitol and D-fructose are utilized for growth. No growth or only trace of growth with i-inositol, rhamnose or raffinose.

Streptomyces spheroides Wallick, Harris, Reagan, Ruger and Woodruff. Description: Wallick *et al.* 1956, 909-917. Type strain: MA 319 (Woodruff, personal communication 1964). ISP 5292 from H.B. Woodruff, Merck, Sharp and Dohme as MA 319 (=NRRL 2449). ISP description by Group B-12.

Spore chain morphology: Section Spirales (Fig. 189). Mature spore chains 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. 190).

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

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 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, sucrose, D-xylose, D-mannitol, D-fructose and rhamnose are utilized for growth. Only a trace of growth is found on i-inositol and raffinose. A trace of growth also occurs on the carbon-free basal medium.

Actinomyces streptomycini Krasil'nikov. Descriptions: Actinomyces globisporus streptomycini Krasil'nikov 1949, 100; Actinomyces streptomycini Krasil'nikov 1955, 12-18; see also Nikitina *et al.* 1960, 85-103 (Engl. transl. 80-98). Type strain: RIA 333 = INMI 1448 (Krasil'nikov, personal communication, 1964). ISP 5200 from N.A. Krasil'nikov as RIA 333 = INMI 1448 (=ATCC 15886). Note: This is a subjective synonym for Streptomyces griseus (Kraus) Waksman and Henrici, ISP 5236 = IMRU 3463 *q.v.* ISP description by Group B-3.

Spore chain morphology: Section Rectiflexibiles, flexuous chains are most common (Fig. 191). Mature spore chains 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. 192).

Figure 191. A. streptomycini. RF spore chains (X 300) on yeast-malt agar, 15 days.¹¹

Figure 192. A. streptomycini. Smooth spores; electron micrograph from 14 day culture on yeast-malt agar.¹²

Figure 193. S. tanashiensis. RF spore chains (X 312) on glycerol-asparagine agar, 14 days.³⁵

Figure 194. S. tanashiensis. Smooth spores; electron micrograph from 10 day culture on oatmeal agar.³

Color of colony: Aerial mass color in the Yellow color-series on yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar (sometimes in the White color-series on glycerol-asparagine agar).

Reverse side of colony: No distinctive pigments (colorless, grayish yellow or light 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. 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 and D-fructose and utilized for growth. No growth or only trace of growth with L-arabinose, sucrose, i-inositol, rhamnose and raffinose.

Streptomyces tanashiensis Hata, Ohki and Higuchi. Descriptions: Hata, Ohki and Higuchi 1952a, 529-534; 1952b, 67-77 (448-457); 1952c, 188-189. Type strain: 144 (*ibid.*). ISP 5195 from Y. Yagisawa from T. Hata, Kitasato Inst., as 144. ISP description by Group B-5.

Spore chain morphology: Section Rectiflexibiles (Fig. 193). Mature spore chains generally 10 to 50, or sometimes 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. 194).

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

Reverse side of colony: No distinctive pigments (pale yellow to light 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 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 and D-xylose are utilized for growth. Reports vary on utilization of D-fructose. Only a trace of growth is found with sucrose, i-inositol, D-mannitol, rhamnose and raffinose.

Actinomyces violascens Preobrazhenskaya and Sveshnikova. Description: Preobrazhenskaya and Sveshnikova *in* Gauze *et al.* 1957, 32 and 41. Type strain: 3959/54 (*ibid.*; see also Gauze *in* Gottlieb 1968). Streptomyces violascens (Preobrazhenskaya and Sveshnikova) Pridham *et al.* 1958, 68. ISP 5183 from T.P. Preobrazhenskaya as 3959/54. ISP description by Group A-13.

Spore morphology: Section Spirales (Fig. 195). Mature spore chains 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. 196).

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

Figure 195. *A. violascens*. Spiral spore chains (X 500) on yeast-malt agar, 24 days.¹⁵

Figure 196. *A. violascens*. Spiny spores; electron micrograph from 24 day culture on yeast-malt agar.²⁴

Reverse side of colony: No distinctive pigment (grayed yellow to yellow-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. Pigments other than melanoids not formed (or only traces of yellow) in yeast-malt agar, oatmeal agar, salts-starch agar and glycerol-asparagine agar.

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

BIBLIOGRAPHY

- Ammann, A., D. Gottlieb, T. D. Brock, H. E. Carter and G. B. Whitfield. 1955. Filipin, an antibiotic effective against fungi. *Phytopathol.* 45: 559-563.
- Anderson, H. W. and D. Gottlieb. 1952. Plant disease control with antibiotics. *Econ. Bot.* 6:294-308.
- Anderson, Lucia E., J. Ehrlich, Sung Huang Sun and P. R. Burkholder. 1956. Strains of Streptomyces, the sources of azaserine, elaiomycin, griseoviridin, and viridogrisein. *Antibiotics and Chemotherapy* 6: 100-115.
- Arai, T., T. Nakada and M. Suzuki. 1957. Production of viomycin-like substance by a Streptomyces. *Antibiotics and Chemotherapy* 7: 435-442.
- Artamonova, O. I. and N. A. Krasil'nikov. 1960. Actinomycetes of the violet group. (*Aktinomitsety fioletovoy grupp*). Biology of special groups of actinomycetes-producers of antibiotics (in Russian). *Trud. Inst. Mikrobiol., Akad. Nauk, S.S.S.R.* 8: 274-337 (Engl. transl. p. 274-330).
- Backus, E. J., H. D. Tresner and T. H. Campbell. 1957. The nucleocidin and alazopeptin producing organisms: two new species of Streptomyces. *Antibiotics and Chemotherapy* 7: 532-541.
- Baldacci, E. 1958. Development in the classification of actinomycetes. *Giorn. Microbiol.* 6: 10-27.
- _____, G. Farina and R. Locci. 1966. Emendation of the genus Streptoverticillium Baldacci (1958) and revision of some species. *Giorn. Microbiol.* 14: 153-171.
- Barr, F. S. and P. E. Carman. 1956. Streptomyces kentuckensis, a new species, the producer of raisinomycin. *Antibiotics and Chemotherapy* 6: 286-289.
- Benedict, R. G., W. Dvornich, Odette Shotwell, T. G. Pridham and L. A. Lindenfelser. 1952. Cinnamycin, an antibiotic from Streptomyces cinnamoneus nov. sp. *Antibiotics and Chemotherapy* 2: 591-594.
- _____, O. L. Shotwell, T. G. Pridham, L. A. Lindenfelser and W. C. Haynes. 1954. The production of the neomycin complex by Streptomyces albogriseolus, nov. sp. *Antibiotics and Chemotherapy* 4: 653-656.

- Berger, J., L. M. Jampolsky, M. W. Goldberg. 1949. Borrelidin, a new antibiotic with anti-borrelia activity and penicillin enhancement properties. *Arch. Biochem.* 22: 476-478.
- Bessell, Christine J., W.K. Anslow, Aileen M. Mortimer, D. L. Fletcher and A. Rhodes. 1961. Antibiotic production. U.S. Pat. 3,013,947 Dec. 19. U.S. Pat. Office.
- Brumpt, E. 1906. Les Mycétomes. *Arch. Parasitol.* 10: 554-562.
- Gonn, H.J. 1917a. Soil flora studies. V. Actinomycetes in soil. N.Y. Agr. Exp. Sta. Tech. Bull. 60: 1-16.
- _____, 1917b. Soil flora studies. V. Actinomycetes in soil. N.Y. Agr. Exp. Sta., Annual Rept. 36: 157-170.
- Davissou, J.W. and A.C. Finlay. 1959. Catenulin and its production. U.S. Pat. 2,895,876 July 21. U.S. Pat. Office.
- Duché, J. 1934. Les actinomyces du groupe albus. *Encycl. Mycol.*, VI. Paul LeChevalier and Sons, Paris. 1-375.
- Duggar, B.M. 1948. Aureomycin: a product of the continuing search for new antibiotics. *Ann. N.Y. Acad. Sci.* 51: 177-181.
- _____, 1949. Aureomycin and preparation of same. U.S. Pat. 2,482,055. Feb. 11. U.S. Pat. Office.
- Dvonch, W., Odette Shotwell, R.C. Benedict, T.G. Pridham and L.A. Lindenfelser. 1954. Antibiotics and Chemotherapy 4: 1135-1142.
- Erikson, D. 1935. The pathogenic aerobic organisms of the Actinomyces group. *Med. Res. Council (Brit.) Spec. Rep.*, Ser. 203: 5-61.
- Falcão de Moraes, J.O. and Maria Dália Maia. 1961. Uma contribuição ao estudo taxonômico do gênero Streptomyces - uma tentativa de simplificação. *Rev. Inst. Antibiot.* 3: 33-60.
- _____, Maria Dália Maia and Maria E. Souto Maior Genn. 1958. Sobre uma variedade de Streptomyces comum nos solos do Brasil: Streptomyces venezuelae var. roseospori nov. var. *Rev. Inst. Antibiot.* 1: 99-106.
- Finlay, A.C., F.A. Hochstein, B.A. Sobin and F.X. Murphy. 1951. Netropsin, a new antibiotic produced by a Streptomyces. *J. Amer. Chem. Soc.* 73: 341-343.
- _____, and B.A. Sobin. 1952. Netropsin and process for its production. U.S. Pat. 2,586,762 Feb. 19. U.S. Pat. Office.
- Fried, J., D. Perlman, A.F. Langlykke and E.O. Titus. 1958. 16 alpha-hydroxylation steroids. U.S. Pat. 2,855,343 Oct. 7, U.S. Pat. Office.
- Frommer, W. 1959. Zur Systematik der Actinomycin bilden Streptomyceten. *Arch. Mikrobiol.* 32: 197-206.
- Gardner, A.D. and E. Chain. 1942. Proactinomycin: a "bacteriostatic" produced by a species of Proactinomyces. *Brit. J. Exp. Pathol.* 23: 123-127.
- Gauze, G.F., T. P. Preobrazhenskaya, E.S. Kudrina, N. O. Blinov, I.D. Ryabova and M.A. Sveshnikova. 1957. Problems of classification of actinomycetes-antagonists (in Russian). Government Publishing House of Medical Literature, Medgiz, Moscow. 1-398.
- Gottlieb, D. 1968. Communication from G.F. Gauze. *Int. J. Syst. Bacteriol.* 18: 20.
- _____, P.K. Bhattacharyya, H.E. Carter and H.W. Anderson. 1951. Endomycin, a new antibiotic. *Phytopathol.* 41: 393-400.
- _____, and H.E. Carter. 1956. Endomycin and process for its production. U.S. Pat. 2,746,902 May 22. U.S. Pat. Office.

- _____, and E. Shirling. 1967. Cooperative description of type cultures of Streptomyces. I. The International Streptomyces Project. Intern. J. Syst. Bacteriol. 17: 315-322.
- Gougerot, H., P. Blum and J. Duché. 1934. Kerionactinomycosique du à Nocardia bovis. Arch. Dermato-Syphiligraphiques de la Clinique de l'Hop. : 376.
- Güssow, H. T. 1914. The systematic position of the organism of the common potato scab. Science 39: 431-433.
- Hamada, S. 1958. A study of a new antitumor substance, cellostatin. I. On the isolation and some properties of cellostatin. Tohoku J. Exp. Med. 67: 173-179.
- Hata, T., N. Ohki and T. Higuchi. 1952a. Studies on the antibiotic substance "luteomycin". On the strains and the cultural conditions (in Japanese, English summary). J. Antibiot. 5: 529-534.
- _____, N. Ohki and T. Higuchi. 1952b. Studies on the antibiotic substance "luteomycin". On the strain and the fermentation. Kitasato Arch. Exp. Med. 24: 67-77 (447-457).
- _____, N. Ohki and T. Higuchi. 1952c. Taxonomic studies on Streptomyces. IV. Correlation between the classification by utilization of carbon compounds and spectra on the agar plate and anti-streptomycete spectra. Kitasato Arch. Exp. Med. 25: 188-189.
- Hütter, R. 1967. Systematik der Streptomyceten. S. Karger, Basel. 382p.
- Imamura, A., M. Hori, K. Nakazawa, M. Shibata, S. Tatsuoka and A. Miyake. 1956. A new species of Streptomyces producing dihydrostreptomycin. Proc. Jap. Acad., Tokyo. 32: 648-653.
- Isono, K., K. Anzai and S. Suzuki. 1958. Tubermycins A and B, new antibiotics, I. J. Antibiot., Tokyo Ser. A, 11: 264-266.
- Johnstone, D.B. and S.A. Waksman. 1947. Streptomycin II, an antibiotic substance produced by a new species of Streptomyces. Proc. Soc. Exp. Biol. and Med. 65: 294-295.
- _____, and S. A. Waksman. 1948. The production of Streptomycin by Streptomyces bikiniensis. J. Bacteriol. 55: 317-326.
- Kawato, M. and R. Shinobu. 1959. On Streptomyces herbaricolor nov. sp. Supplement: a simple technique for the microscopical observation. Mem. Osaka Univ. Lib. Arts and Educ., B. Natur. Sci. 8: 114-119.
- Kondo, S., T. Miyakawa, H. Yumoto, M. Sezaki, M. Shimura, K. Sato and T. Hara. 1962. Isolation and characterization of a new antibiotic, Bandamycin B. J. Antibiot., Tokyo Ser. A, 15: 161-167.
- _____, J. M. J. Sakamoto and H. Yumoto. 1961. J. Antibiot., Tokyo Ser. A, 14: 365-366.
- Korenyako, A.I., N.A. Krasil'nikov and N. I. Nikitina. 1960. Actinomyces levoris. Biology of special groups of actinomycetes - producers of antibiotics (in Russian). Trud. Inst. Mikrobiol., Akad. Nauk. S.S.S.R. 8: 116-132. (Engl. transl. p. 111-127).
- _____, N.A. Krasil'nikov, N.I. Nikitina and A.I. Sokolova. 1960. Actinomycetes of the fluorescent group. Biology of special groups of actinomycetes - producers of antibiotics (in Russian). Trud. Inst. Mikrobiol., Akad. Nauk. S.S.S.R. 8: 133-159 (Engl. transl. p. 128-156).
- Krainsky, A. 1914. Die Aktinomyceten und iheren Bedeutung in der Natur. Zbl. Bakt. Abt. 2, 41: 649-688.

- Krasil'nikov, N.A. 1941. Guide to the actinomycetes (in Russian). Akad. Nauk. S.S.S.R., Moscow. 1-158.
- _____, 1949. Guide to the bacteria and actinomycetes (in Russian). Akad. Nauk. S.S.S.R., Moscow. 1-830.
- _____, 1955. Trans. Int. Symp. on Antibiotics, Warsaw: 12-18.
- _____, 1957. La classification des actinomycetes producteurs d'antibiotiques. Ann. Inst. Pasteur 92: 597-604.
- _____, and N.S. Agre. 1960. Actinomycetes of the white-blue group. Biology of special groups of actinomycete-producers of antibiotics. (In Russian). Trud. Inst. Mikrobiol. Akad. Nauk. S.S.S.R. 8: 254-274.
- Kuchaeva, A.G., N.A. Krasil'nikov, G.K. Skryabin and S.D. Taptikova. 1960. Actinomycetes of the olivochromogenous groups. (Burozelenoy grupp). Biology of special groups of actinomycetes-producers of antibiotics (in Russian). Trud. Inst. Mikrobiol., Akad. Nauk S.S.S.R. 8: 226-253 (Engl. transl. p. 222-251).
- _____, N.A. Krasil'nikov, S.D. Taptikova and R.Z. Gesheva. 1962. On the taxonomy of actinomycetes of the Lavendulae group (in Russian, English summary). Bull. Inst. Microbiol. Sofia 13: 103-124.
- Kudrina, E.S. 1957. Characteristics of antagonistic actinomycetes of the Helvolus series (in Russian), p. 77-100. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, E.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medzig. Moscow.
- Kutzner, H.J. and S.A. Waksman. 1959. Streptomyces coelicolor Müller and Streptomyces violaceoruber Waksman and Curtis, two distinctly different organisms. J. Bacteriol. 78: 528-538.
- Leben, C., G. J. Stessel and G.W. Keitt. 1952. Helixin, an antibiotic active against certain fungi and bacteria. Mycologia 44: 159-168.
- Lieske, R. 1921. Morphologic und biologic der Strahlenpilze. Borntrager, Leipzig.
- McGuire, J.M. 1954. Improvements in or relating to Terramycin. British Pat. Specification 713,795 Aug. 18. Pat. Office, London.
- Maeda, K., H. Kosaka, Y. Okami and H. Umezawa. 1953. A new antibiotic, pyridomycin. J. Antibiot., Tokyo Ser. A, 6: 140.
- Margalith, P. and G. Beretta. 1960. A new antibiotic producing Streptomyces: Str. bellus nov. sp. Mycopathol. et Mycol. Appl. 12: 189-195.
- _____, G. Beretta and M.T. Timbal. 1959. Matamycin, a new antibiotic. I. Biological studies. Antibiotics and Chemotherapy 9: 71-75.
- Millard, W.A. and S. Burr. 1926. A study of twenty-four strains of Actinomyces and their relation to types of common scab of potato. Ann. Appl. Biol. 13: 580-644.
- Müller, R. 1908. Eine Diphtheridee und eine Streptothrix mit gleichem blauen Farbstoff sowie Untersuchungen über Streptothrixarten im allgemeinen Zbl. Bakt., Abt. I. Orig. 46: 195-212.

- Nagatsu, J., K. Ansai, K. Ohkuma and S. Suzuki. 1963. Studies on a new antibiotic, tuberin. IV. Taxonomic studies on the tuberin producing organisms, Streptomyces amakusaensis. J. Antibiot., Tokyo Ser. A, 16: 207-210.
- Nakamura, G. 1961. Studies on antibiotic actinomycetes. I. On Streptomyces producing a new antibiotic tubermycin. J. Antibiot., Tokyo Ser. A, 14: 86-89.
- Nakazawa, K. 1964. Studies on streptomycetes. Microbiological characteristics of Streptomyces no. 5866. Annu. Rep. Takeda Res. Lab. 23: 69-70.
- _____, et al. 1954. Candimycin. Jap. Pat. 2125 Feb. 4.
- _____, and S. Fujii. 1957. Studies on streptomycetes. On Streptomyces sindenensis nov. sp. Annu. Rep. Takeda Res. Lab. 16: 109-110.
- _____, S. Fujii, M. Inoue, H. Hitomi, A. Miyake and I. Kaneko. 1954. On a new anti-tuberculous substance produced by a Streptomyces (in Japanese). J. Antibiot., Tokyo Ser. B, 7: 168.
- _____, and M. Shibata. 1956. Streptomyces humidus nov. sp., p. 648. In Imamura, A., M. Hori, K. Nakazawa, M. Shibata, S. Tatsuoka and A. Miyake. 1956. A new species of Streptomyces producing dihydrostreptomycin. Proc. Jap. Acad., Tokyo, 32: 648-653.
- _____, M. Shibata, M. Honjo, Y. Hamada, J. Kaneko and Y. Tokui. 1956. Candimycin. Jap. Pat. 8148 Nov. 10.
- _____, M. Shibata, K. Tanabe, A. Miyake, K. Mizuno and T. Takewaka. 1957. Studies on streptomycetes. On Streptomyces lilacinus nov. sp. and its antibiotic cladomycin. Annu. Rep. Takeda Res. Lab. 16: 111-115.
- _____, M. Shibata, K. Tanabe and H. Yamamoto. 1958. Studies on streptomycetes. Streptomyces humidus nov. sp. producing dihydrostreptomycin. J. Agr. Chem. Soc. Japan 32: 321-324.
- _____, M. Shibata, K. Tanabe and H. Yamamoto. 1960. Production of dihydrostreptomycin. U.S. Pat. 2,931,756 Apr. 5. U.S. Pat. Office. (Also, U.S. Pat. 2,950,277 Aug. 23).
- _____, K. Tanabe, M. Shibata, A. Miyake and T. Takewaka. 1955. Studies on streptomycetes. Cladomycin a new antibiotic produced by Streptomyces lilacinus nov. sp. (in Japanese). J. Antibiot. Ser. B, 9: 81.
- Niida, T. Japanese Pat. 425900. Abstr. in Japan Offic. Gaz. 38-26948.
- Nikitina, N.N. 1958. Actinomycetes of the Globisporus group. Abstr. of Thesis. Mikrobiologia 27: 141.
- _____, A. I. Korenyako and N.A. Krasil'nikov. 1960. Actinomyce strains of the species Actinomyces streptomycini Krass. Biology of special groups of actinomycetes - producers of antibiotics (in Russian). Trud. Inst. Mikrobiol., Akad. Nauk. S.S.S.R. 8: 85-103 (Engl. transl. p. 80-98).
- Nishimura, H., T. Kimura, K. Tawara, K. Sasaki, K. Nakajima, N. Shimaoka, S. Okamoto, M. Shimohira and J. Isono. 1967. Aburamycin, a new antibiotic. J. Antibiotics, Tokyo Ser. A, 10: 205-211.

- Okami, Y., K. Maeda and H. Umezawa. 1954. Studies on antibiotic actinomycetes, VIII. On Streptomyces albidofuscus Okami et Umezawa, nov. sp. producing a new antibiotic pyridomycin. J. Antibiot., Tokyo Ser. A, 7: 55-56.
- _____, and H. Umezawa. 1955. In Okami, Utahara, Oyagi, Nakamura, Umezawa, Yanagisawa and Tunematsu. The screening of anti-toxoplasmic substance produced by Streptomycete and anti-toxoplasmic substance No. 534. J. Antibiot., Tokyo Ser. A, 8: 126-131.
- _____, and H. Umezawa. 1959. In Nurase et al. Identification of an antibiotic produced by S. galbus, n. sp. with streptomycin. J. Antibiotics, Tokyo Ser. A, 12: 126-132.
- _____, R. Utahara, S. Nakamura and H. Umezawa. 1954. Studies on antibiotic actinomycetes, IX. On Streptomyces producing a new antifungal substance mediocidin and antifungal substances of fungicidin-rimocidin-chromin group, eurocidin group and trichomycin-ascosin-candicidin group. J. Antibiot., Tokyo Ser. A, 7: 98-100.
- Oswald, Elizabeth, J., R.J. Reedy and W.A. Randall. 1956. An antifungal agent, 1968, produced by a new Streptomyces species, p. 236-239. In Antibiotics Annual 1955-1956. Medical Encyclopedia Inc., New York.
- Perlman, D., J. Fried, E.O. Titus and A.F. Langlykke. 1955. 16 alpha-hydroxyprogesterone, 16 alpha-hydroxydihydroprogesterone and esters thereof. U.S. Pat. 2,709,705 May 31, U.S. Pat. Office.
- Pinnert-Sindico, Sylvie. 1954. Une nouvelle espèce de Streptomyces productrice d'antibiotiques: Streptomyces ambofaciens n. sp. caractères cultureux. Ann. Inst. Pasteur 87: 702-708.
- Pittenger, R.C. and D. Gottlieb. 1961. p. 258. In Waksman, S.A. 1961. The Actinomycetes. Vol. 2. Classification, identification and description of genera and species. The Williams and Wilkins Co., Baltimore. 1-363.
- Preobrazhenskaya, T.P. 1957a. Characteristics of antagonistic actinomycetes of the Fradiæ series (in Russian), p. 51-57. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- _____, 1957b. Characteristics of antagonistic actinomycetes of the Coerulescens series (in Russian), p. 119-130. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- _____, 1957c. Characteristics of antagonistic actinomycetes of the Ruber series (in Russian), p. 72-76. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- _____, N.O. Blinov and I.D. Ryabova. 1957. Characteristics of antagonistic actinomycetes of the Griseus series (in Russian), p. 131-145. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.

- _____, I.D. Ryabova and N.O. Blinov. 1957. Characteristics of antagonistic actinomycetes of the Chromogenes series (in Russian) p. 169-177. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- _____, and M.A. Sveshnikova. 1957. Characteristics of antagonistic actinomycetes of the Lavendulae-Roseus series (in Russian), p. 31-50. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- Pridham, T.G., C.W. Hesseltine and R.G. Benedict. 1958. A guide for the classification of streptomycetes according to selected groups: placement of strains in morphological sections. Appl. Microbiol. 6:52-79.
- _____, Odette Shotwell, F.H. Stodola, L.A. Lindenfelser, R.G. Benedict and R.W. Jackson. 1956. Antibiotics against plant disease. II. Effective agents produced by Streptomyces cinnamomeus forma azacoluta f. nov. Phytopathology 46: 575-581.
- Reynolds, D.M. and S.A. Waksman. 1948. Grisein, an antibiotic produced by certain strains of Streptomyces griseus. J. Bacteriol. 55: 739-752.
- Ryabova, I.D. and T.P. Preobrazhenskaya. 1957. Characteristics of antagonistic actinomycetes of the Violaceus series (in Russian), p. 178-197. In Gauze, G.F., T.P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- Sakamoto, Jean Marie J., S. Kondo, H. Yumoto and M. Arishima. 1962. Bundlins A and B, two antibiotics produced by Streptomyces griseofuscus nov. sp. J. Antibiot., Tokyo Ser. A, 15: 98-101.
- Sawazaki, T., S. Susuki, G. Nakamura, M. Kawasaki, S. Yamashita, K. Isono, K. Anzai, Y. Serizawa and Y. Sekiyama. 1955. Streptomycin production by a new strain, Streptomyces mashiensis. J. Antibiot., Tokyo Ser. A, 8: 44-47.
- Shibata, M., M. Honjō, Y. Tokui and K. Nakazawa. 1954. On a new antifungal and anti-yeast substance, Candimycin, produced by a streptomycetes. (In Japanese). J. Antibiot., Tokyo Ser. B, 7: 168.
- _____, K. Nakazawa, A. Miyake, M. Inoue and A. Okabori. 1957. Studies on streptomycetes. Croceomycin, a new antituberculous substance. Annu. Rep. Takeda Res. Lab. 16: 32-37.
- Shimo, M., T. Shiga, T. Tomosugi and I. Kamoi. 1959. Studies on taitomycin, a new antibiotics produced by Streptomyces, sp. no. 772 (S. afghaniensis). I. Studies on the strain and production of taitomycin. J. Antibiot., Tokyo Ser. A, 12: 1-6.
- Shinobu, R. 1956. Three new species of Streptomyces forming whirls. Mem. Osaka Univ. Lib. Arts and Educ., B. Nat. Sci., No. 5: 84-93.
- _____. 1957. Two new species of Streptomyces. Mem. Osaka Univ. Lib. Arts and Educ., B. Natur. Sci. 6: 63-73.
- _____, and M. Kawato. 1960a. On Streptomyces aerocolonigenes nov. sp., forming the secondary colonies on the aerial mycelia. Bot. Mag., Tokyo 73: 212-216.

- _____, and M. Kawato. 1960b. On Streptomyces indigoferus nov. sp. producing blue to green soluble pigment on some synthetic media. Mem. Osaka Univ. Lib. Arts and Educ., B. Natur. Sci. 2: 49-53.
- Shirling, E. B. and D. Gottlieb. 1966. Methods for characterization of Streptomyces species. Intern. J. of Systemat. Bacteriol. 16: 313-340.
- _____, and D. Gottlieb. 1968. Cooperative description of type cultures of Streptomyces. II. Species descriptions from first study. Intern. J. Syst. Bacteriol. 18: 69-189.
- Sobin, B.A., A.C. Finlay and J.H. Kane. 1950. Terramycin and its production. U.S. Pat. 2,516,080 July 18. U.S. Pat. Office.
- Stark, W.M., C.E. Higgins, R.N. Wolfe, M.M. Hoehn and J.M. McGuire. 1962. Capreomycin, a new antimycobacterial agent produced by Streptomyces capreolus sp. n. Antimicrobial Agents and Chemotherapy - 1962: 596-606.
- Sugai, T. 1956. New antibiotics 229 and 229 B of colorless, water-soluble nature (in Japanese). J. Antibiot., Tokyo Ser. B, 9: 170-179.
- Sugawara, R. and M. Onuma. 1957. Melanomycin, a new antitumor substance from Streptomyces. II. Description of the strain. J. Antibiot., Tokyo Ser. A, 10: 138-142.
- Suzuki, S., G. Nakamura, K. Okuma and Y. Tomiyama. 1958. Cellocidin, a new antibiotic. J. Antibiot., Tokyo Ser. A, 11: 81-83.
- Sveshnikova, M.A. Characteristics of antagonistic actinomycetes of the Nigrescens series (in Russian), p. 146-148. In Gauze, G.F., T. P. Preobrazhenskaya, E.S. Kudrina, N.O. Blinov, I.D. Ryabova and M.A. Sveshnikova. Problems of classification of actinomycetes-antagonists. Government Publishing House of Medical Literature, Medgiz, Moscow.
- Szabó, I., Maria Marton, Ilona Buti and G. Pártai. 1963. Actinomycetes finlayi n. sp. Acta Microbiol. Acad. Sci. Hungaricae 10: 207-214.
- Thaxter, R. 1892. Potato scab. Conn. Agri. Exp. Sta. Annu. Rep. for 1891: 153-160.
- Trejo, W. 1961. Streptomyces nodosus. p. 250. In Waksman, S.A. 1961. The Actinomycetes. Vol. 2. Classification, identification and description of genera and species. The Williams and Wilkins Co., Baltimore. 1-363.
- _____, and R.E. Bennett. 1963. Streptomyces nodosus sp. n., the amphotericin-producing organism. J. Bacteriol. 85: 436-439.
- Tresner, H.D., M.C. Davies and E.J. Backus. 1961. Electron microscopy of streptomyces spore morphology and its role in species differentiation. J. Bacteriol. 81: 70-80.
- Thirumalachar, M.J. and V.V. Bhatt. 1960. Some Streptomyces species producing oxytetracycline. Hindustan Antibiot. Bull. 3: 61-63.
- Umezawa, H. and Y. Okami. 1957. Changing the name of pyridomycin producing streptomycete. J. Antibiot., Tokyo Ser. A, 10: 172.
- Upjohn Company. 1954. The antibiotic endomycin and process for its production. Brit. Pat. Spec. 705,622 March 17. Patent Office, London.
- Waksman, S.A. 1919. Cultural studies of species of Actinomycetes. Soil Sci. 8: 71-215.

- _____, 1953. In Waksman and Lechevalier. Guide to the classification and identification of the actinomycetes and their antibiotics. The Williams and Wilkins Co., Baltimore. 1-162.
- _____. 1957. Family Actinomycetaceae Buchanan and family Streptomycetaceae Waksman and Henrici in Breed, Murray and Smith, Bergey's Manual of Determinative Bacteriology, 7th ed., 744-825.
- _____. 1959. Strain specificity and production of antibiotic substances. X. Characterization and classification of species within the Streptomyces griseus group. Proc. Nat. Acad. Sci. U.S. 45: 1043-1046.
- _____. 1961. The actinomycetes. Vol. 2. Classification, identification and descriptions of genera and species. The Williams and Wilkins Company, Baltimore. 1-363.
- _____, and R.E. Curtis. 1916. The actinomycetes of the soil. Soil Sci. 1: 99-134.
- _____, and A.T. Henrici. 1948. Family Actinomycetaceae Buchanan and Family Streptomycetaceae Waksman and Henrici p. 892-980. In Breed, Murray and Hitchens, Bergey's Manual of Determinative Bacteriology, 6th ed., The Williams and Wilkins Co., Baltimore.
- _____, Eliz. S. Horning, M. Welsch and H. B. Woodruff. 1942. Distribution of antagonistic actinomycetes in nature. Soil Sci. 54: 281-290.
- _____, and H.B. Woodruff. 1941. Actinomyces antibioticus, a new soil organism antagonistic to pathogenic and non-pathogenic bacteria. J. Bacteriol. 42: 231-249.
- Wallick, H., D.A. Harris, Mary Ann Regan, Myrle Ruger and H.B. Woodruff. 1956. Discovery and antimicrobial properties of cathomycin, a new antibiotic produced by Streptomyces spheroides n. sp., p. 909-916. In Antibiotics annual 1955-1956. Medical Encyclopedia Inc., New York.
- Wooldridge, W.E. 1957. A new fungal antibiotic NC 1968. German Pat. Not. (DAS) 1000966 Jan. 17.
- _____. 1960a. Antifungal antibiotic designated NC 1968. British Pat. 828,792, Feb. 24.
- _____. 1960b. Antifungal antibiotic and S. coelicolor var. aminophilus. U.S. Pat. 2,956,925 Oct. 18. U.S. Pat. Office.
- Yamaguchi, T. and Y. Saburi. 1955. Studies on the anti-trichomonal actinomycetes and their classification. J. Gen. Appl. Microbiol. 1: 201-235.

SOURCES OF ILLUSTRATIONS

1. G.F. Gauze. Acad. Med. Sciences of USSR, Institute of New Antibiotics, Moscow, USSR.
2. Elio Baldacci, G. Farina and R. Locci. Instituto Di Patologie, Vegetale dell' Universita', Via Celoria N. 2, Milano, Italia.
3. H. Prauser. Inst. Mikrobiol. Exptl. Therapie, Beuthenbergstr. 11 Jena, German Democratic Republic.
4. E.J. Rdzok and T.J. Oliver. Abbott Laboratories, N. Chicago, Illinois, U.S.A.
5. Y. Ohara and H. Nonomura. Faculty of Engineering, Yamanashi Univ., Kofu, Japan.
6. J. Mathews. The Upjohn Co., Kalamazoo, Mich. 49001, U.S.A.
7. A. Feltynowski and Wanda Woźnika. Państwowy Zakład Higieny, Ul. Chocimska 24, Warszawa 12, Poland.
8. T. Cross and Miss A. Maciver. Bradford Institute of Technology, Bradford 7, Yorkshire, England.
9. Mr. Oates. Dept. of Bot., Leeds Univ., Leeds, Yorkshire, England.
10. N.A. Krasil'nikov. Inst. Microbiol., Acad. Sciences, Moscow, USSR.
11. G.A. deVries. Centraalbureau voor Schimmelcultures, Baarn, Netherlands.
12. G.V. Mierlo and A. L. Houwink. Lab. f. Microbiol., Delft, Netherlands.
13. (J. Elliott) J. Spyvee. Boots Pure Drug Co., Ltd., Antibiot. and Ferm. Div., Nottingham, England.
14. K. Nakazawa. Takeda Chem. Ind., Ltd., Juso-Higashiyodogawaku, Osaka, Japan.
15. J. Fiala and Alena Řicičová. Czech. Acad. of Science, Inst. of Mikrobiol., Prague 4, Budejovicka No. 1083, Czechoslovakia.
16. W.A. Trejo. E.R. Squibb and Sons, New Brunswick, New Jersey, U.S.A.
17. M. Mayama and K. Terada. Div. of Bacteriol., Shionogi Research Lab., Shionogi and Co., Ltd., Fukushima-ku, Osaka, Japan.
18. Y. Okami. Nat'l Inst. of Health of Japan, Shinagawa, Tokyo, Japan.
19. G. Michaels. Dept. Microbiol., Univ. Georgia, Athens, Georgia, U.S.A.
20. Ina Radziminska. Hoffman-LaRoche, Nutley, New Jersey, U.S.A.
21. V.A. Tsyganov. Res. Inst. of Antibiotics, Leningrad, L-20, USSR.
22. T.R. Vernon. Dept. Scientific and Ind. Res., Private Bag, Auckland C1, New Zealand.
23. S.T. Williams. Hartley Botanical Laboratories, Univ. of Liverpool, Liverpool, England.
24. V. Pokorný and Alena Řicičová. Czech. Acad. of Science, Inst. of Mikrobiol., Prague 4, Budejovicka No. 1083, Czechoslovakia.

25. Wanda Woźnicka. Państwowy Zakład Higieny, Ul. Chocimska 24, Warszawa 12. Poland.
26. V.D. Kuznetsov. USSR Res. Inst. for Antibiotics, Moscow, USSR.
27. Carol S. Cassidy and K.E. Crook, Jr. Bristol Labs., Inc. Syracuse, New York, U.S.A.
28. Sara Wold and Lucia Anderson. Parke, Davis and Co., Detroit, Michigan, U. S. A.
29. P. Lockwood. Dept. Textile Ind., Bradford Inst. of Technology, Bradford 7, Yorkshire, England.
30. I. Szabó. Magyar Tudományos Akadémia Talajtana És Agrokémiai Kutató Intézet, Budapest, II, Hungary.
31. F. Mach. Inst. Für Mikrobiologie, Griefswald. Ludwig-Jahn-Str., 15, German Democratic Republic.
32. J. Ludvík. Laboratoř Elektronové Mikroskopie. Mikrobiologický Ústav ČSAV, Praha 4-Krč, Budějovická 1083, Czechoslovakia.
33. T.J. Oliver. Abbott Laboratories, N. Chicago, Illinois, U.S.A.
34. W. Hodgkiss. Torry Res. Sta., Aberdeen, Scotland.
35. J. Rosillo and J. Spyvee. Boots Pure Drug Co., Ltd., Antibiot. and Ferm. Div., Nottingham, England.
36. J. Routien. Charles Pfizer and Co., Inc., Groton, Conn., U.S.A.
37. C.E. Higgins, Eli Lilly and Co., Indianapolis, Indiana, U.S.A.
38. M. Mayama and K. Tawara, Shionogi Res. Lab., Shionogi and Co., Ltd., Fukushima-ku, Osaka, Japan.
39. J.O. Falcão de Moraes, Inst. de Química da Univ. Fed. de Pernambuco, Recife, Pernambuco, Brazil.
40. A. Sokolov (and V.D. Kuznetsov). Lab. of Electronmicroscopy. Acad. Sci., USSR.
41. N.M. McClung. Dept. Bot. and Bacteriol., Univ. of South Florida, Tampa, Florida, U. S. A.