ACTINOMYCETES

THEIR NATURE, OCCURRENCE, ACTIVITIES AND IMPORTANCE

S. A. WAKSMAN

THE ACTINOMYCETES

Their Nature, Occurrence, Activities, and Importance

by

SELMAN A. WAKSMAN, PH.D.

Professor of Microbiology, Rutgers University
Microbiologist, New Jersey Agricultural Experiment Station

1950

WALTHAM, MASS., U.S.A.

Published by the Chronica Botanica Company

First published MCML
By the Chronica Botanica Company
of Waltham, Mass., U.S.A.

Authorized Agents:—

New York, N. Y.: STECHERT-HAFNER, INC.,
31 East 10th Street.
San Francisco, Cal.: J. W. STACEY, INC.,
551 Market Street.
Ottawa, Ont.: THORBURN AND ABBOTT, LTD.,
104 Sparks Street.
Mexico, D. F.: AXEL MORIEL SUCRS.,
San Juan de Letran 24-116; Ap. 2762.
Lima: LIBRERIA INTERNACIONEL DEL PERU,
Casa Matriz. Boza 879; Casilla 1417.
Santiago de Chile: LIBRERIA ZAMORANO Y CAPERAN,
Compañía 1015 y 1019; Casilla 362.
Rio de Janeiro: LIVRARIA KOSMOS,
Rua do Rosario, 135-137; Caixa Postal 3481.
Sao Paulo: LIVRARIA CIVILIZAÇÃO BRASILEIRA,
Rua 15 de Novembro, 144.
Buenos Aires: ACME AGENCY, SOC. DE RESP. LTDA.,
Suipacha 58; Casilla de Correo 1136.
London, W. C. 2: WM. DAWSON AND SONS, LTD.,
Chief Agents for the British Empire,
Cannon House, Macklin Street.
London, W. C. 1: H. K. LEWIS AND CO., LTD.,
136, Gower Street.
Uppsala: A.-B. LUNDEQUISTSKA BOKHANDELN.
Groningen: N. V. ERVEN P. NOORDHOFF,
Chief Agents for Continental Europe.
Paris, VI: LIBRAIRIE P. RAYMANN & Cie.,
17, Rue de Tournon.
Torino: ROSENBERG & SELLIER,
Via Andrea Doria 14.
Madrid: LIBRERIA J. VILLEGAS,
Preciados, 46.
Lisbon: LIVRARIA SÁ DA COSTA,
100-102, R. Garrett.
Moscow: MEZHDUNARODNAJA KNIGA,
Kuznetski Most 18.
Peiping: FRENCH BOOKSTORE,
½ T'ai-chi-ch'ang - Tung-chiao min-hsiang.
Tokyo: MARUZEN COMPANY, LTD.,
6, Tori-Nichome Nihonbashi; P. O. Box 605.
Calcutta, Bombay, and Madras: MACMILLAN AND CO., LTD.
Cape Town: OXFORD UNIVERSITY PRESS
Markham's Buildings.
Sydney: ANGUS AND ROBERTSON, LTD.,
89 Castlereagh Street, Box 1516D.D. G.P.O.
Melbourne, C. 1: N. H. SEWARD, PTY., LTD.,
457, Bourke Street.

Made and printed in the U.S.A.
Designed by Frans Verdoorn

SELMAN A. WAKSMAN *was born July 2, 1888, in Priluka, a small town in the Ukraine, Russia. His parents were* JACOB *and* FRADIA (LONDON) WAKSMAN. *After graduating in 1910 from the Fifth Latin School in Odessa, he left for the United States.*

He entered the College of Agriculture of Rutgers University in 1911 and received his bachelor of science degree in 1915. He became a naturalized citizen the same year. He then was appointed research assistant in soil microbiology at the New Jersey Agricultural Experiment Station, and later Research Fellow at the University of California. He obtained a master of science degree from Rutgers University in 1916 and a doctor of philosophy degree from the University of California in 1918.

The same year, Dr. WAKSMAN *received an appointment as Microbiologist at the New Jersey Agricultural Experiment Station at New Brunswick, New Jersey, and as lecturer in soil microbiology at Rutgers University. He became associate professor in 1925, and in 1930 was made professor. He now is the head of the Microbiology Department of the College of Agriculture and Experiment Station at Rutgers University.*

In 1931, he was invited to organize a division of marine bacteriology at the newly established Woods Hole Oceanographic Institution and was appointed marine bacteriologist of that institution.

He is a member, honorary member, or fellow of a number of scientific societies in this country and abroad (Brazil, France, Germany, India, Mexico, Russia, Sweden). Among the American societies to which he belongs are the Society of American Bacteriologists, of which he is a former president, the National Academy of Sciences, and the National Research Council. He won the Nitrate of Soda Nitrogen Research Award in 1929, was president of Commission III on Soil Microbiology of the International Society of Soil Science (1927-1935), and was elected a corresponding member of the French Academy of Sciences in 1937.

In the summer of 1946, Dr. WAKSMAN *lectured before scientific groups in Europe and was given an honorary degree of doctor of medicine by the University of Liège in Belgium. He holds also honorary degrees of doctor of science, awarded to him by Rutgers in 1942 and by Princeton University in 1947, and an honorary degree of doctor of laws from Yeshiva University, New York, in 1948.*

Dr. WAKSMAN*'s work in his field has been recognized by several scientific societies in recent years. He received the Passano Foundation Award in 1947; the Emil Christian Hansen medal and award from the Carlsberg Laboratories in Denmark the same year; the New Jersey Agricultural Society medal; the Albert and Mary Lasker Award by the American Public Health Association, and the Amory Award by the American Academy of Sciences, all in 1948.*

He has published more than 300 scientific papers, and has written, alone or with others, eight books. Among these are Enzymes *(1926),* Principles of Soil Microbiology *(1927, 1932),* The Soil and the Microbe *(1932),* Humus *(1936, 1938),* Microbial Antagonisms and Antibiotic Substances *(1945, 1947), and* The Literature on Streptomycin, 1944-1948 *(1948). Another recent work, edited by Dr.* WAKSMAN, *is* Streptomycin—Nature and Practical Applications.

ANNALES CRYPTOGAMICI et PHYTOPATHOLOGICI

Volume 9

THE ACTINOMYCETES

ANNALES CRYPTOGAMICI et PHYTOPATHOLOGICI

(incorporating Annales Bryologici)

edited by

FRANS VERDOORN, PH.D.

Managing Editor, Chronica Botanica
Research Fellow, Arnold Arboretum, Harvard University
Botanical Secretary, International Union of Biological Sciences

Wij en konnen den Heer en maker van het geheel Al niet meer verheerlijken, als dat wij in alle zaken, hoe klein die ook in onse bloote oogen mogen zijn, als ze maar leven en wasdom hebben ontfangen, zijn al wijsheit en volmaaktheit, met de uiterste verwondering sien uit steken.

Antoni van Leeuwenhoek

1950

WALTHAM, MASS., U.S.A.

Published by the Chronica Botanica Company

PREFACE

Three and a half decades ago—in the spring of 1914—the writer, then a senior at Rutgers College, dug a spade into the earth of the New Jersey Agricultural Station experimental plots, to study the distribution of different groups of microorganisms occurring at different depths in the soil. This operation was repeated monthly, and sterile soil samples were removed to the laboratory and examined by use of ordinary plating procedures. A relatively simple agar medium was used.

Among the soil organisms that attracted the particular attention of the youthful investigator were the actinomycetes. Although he also enumerated the bacteria and the filamentous fungi, he was struck primarily by this much-neglected group of soil inhabitants, frequently spoken of as ray fungi and said to belong to the genus Actinomyces *or* Streptothrix. *On December 28, 1915, he presented before the 17th Annual Meeting of the Society of American Bacteriologists, a paper on the subject of "Bacteria, actinomyces and fungi in the soil." In this, his first contribution to the knowledge of the microbiological population of the soil, he said:*

"The actinomyces grow very slowly; they begin to develop from the bottom of the plate, and to the casual observer the colonies formed look like those of bacteria, even after 5-6 days' incubation; only the somewhat mealy or rough surface will disclose the fact that they are not bacteria. It requires careful observation to tell whether those white, pink or grey colonies are bacteria or not. Many counts of bacteria might have been confused, when this point was not known, and the fungi and actinomycetes were not taken into consideration."

Since this early survey of the occurrence and abundance of actinomycetes at different soil depths and in different soil types, the writer and his numerous associates and students have devoted much time to the study of the actinomycetes, their cultural characteristics, recognition of type species, their classification, their physiological properties and biochemical activities, their importance in the decomposition of pure organic compounds as well as of complex plant and animal residues in soils, peats, and composts, and finally their ability to produce antibiotic substances.

The writer has thus been concerned, during virtually his entire scientific lifetime, with the study of the actinomycetes. In summarizing our present knowledge of this interesting and important group of microorganisms, he has attempted to assemble the work of other investigators, with somewhat greater emphasis upon the work done in the laboratories

of the Department of Microbiology of Rutgers University and the New Jersey Agricultural Experiment Station.

To his many associates, who have helped in making this work possible, the author wishes to express his sincere appreciation for their unfailing enthusiasm and continuous interest and collaboration.

The writer also wishes to express his gratitude to Lt. Col. M. L. LITTMAN *of the Armed Forces Institute of Pathology, for supplying various photographs, to Dr.* E. W. EMMONS *of the National Institute of Health, for reading Chapter XI, and to Dr.* R. W. GOSS *of the University of Nebraska for reading Chapter X.*

December 20, 1949 NEW BRUNSWICK, N. J.

THE COMPOST

O how can it be that the ground does not sicken?
How can you be alive, you growths of spring?
How can you furnish health, you blood of herbs, roots, orchards, grain?
Are they not continually putting distemper'd corpses within you?
Is not every continent work'd over and over with sour dead?
Where have you disposed of their carcasses?
I do not see any of it upon you today—or perhaps I am deceiv'd.

Behold this compost! behold it well!
Perhaps every mite has once form'd part of a sick person—Yet behold!
The grass of spring covers the prairies,
The summer growth is innocent and disdainful above all those strata of sour dead.
What chemistry!
That the winds are really not infectious,
That when I recline on the grass I do not catch any disease,
Though probably every spear of grass rises out of what was once a catching disease.

Now I am terrified at the Earth! it is that calm and patient,
It turns harmless and stainless on its axis, with such endless successions of diseas'd corpses,
It distils such exquisite winds out of such infused fetor,
It gives such divine materials to men, and accepts such leavings from them at last.

WALT WHITMAN.

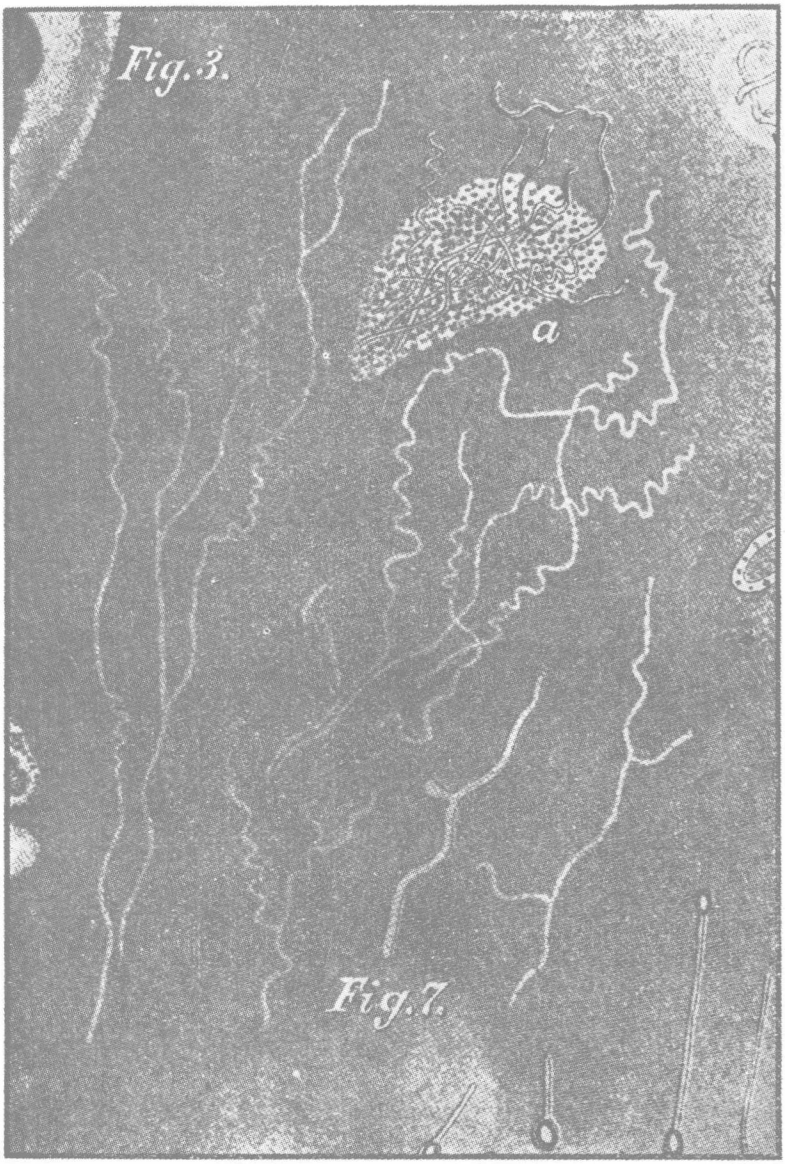

FIG. 1.—*Streptothrix* of FERDINAND COHN. The first figures ever to have been published (1875) of an actinomyces (72).

CONTENTS

Chapter XII

Appendix

Bacteria belong to the most wide-spread of organisms; we may say they are omnipresent; they never fail either in air or water; they attach themselves to the surface of all firm bodies, but develop in masses only where decomposition, corruption, fermentation or putrefaction are present. (Ferdinand Cohn, transl. by C. S. Dolley).

LIST of ILLUSTRATIONS

Mycology is the Cinderella of Botany and has suffered the disadvantages of step-sisterhood. The rest of the family at one time or another has received recognition, and occasionally with little warrant except that of importunity. But Cinderella is now fully attired for the Ball. Indeed the carriage is waiting. She has all the characteristics which usually attract in that she has developed in a comely manner and has charms of which her devotees are aware, and—she can bring her quiver full of rations for the general good. May those who have served her faithfully benefit for their devotion. . . . (J. RAMSBOTTOM).