

Sources and Management of Micro-Organisms For the Development of a Fermentation Industry

Agriculture Handbook No. 440

**Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE**

**Sources and Management
of Micro-Organisms
For the Development of
a Fermentation Industry**

By C. W. HESELTINE and W. C. HAYNES

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PREFACE

THIS REVIEW of micro-organisms provides a background for the manufacture of chemicals by fermentation. It was prepared at the Northern Regional Research Laboratory of the North Central Region, Agricultural Research Service, U.S. Department of Agriculture, Peoria, Ill. At this Laboratory, investigations are being conducted on the industrial utilization of cereal grains, oilseeds, and agricultural wastes by fermentation. The ARS Culture Collection, maintained there, is one of the world's most complete collections of industrially important bacteria, molds, actinomycetes, and yeasts. It serves as a source of authentic micro-organisms for the fermentative production of organic acids, vitamins, antibiotics, enzymes, feeds, beverages, and foods.

Inasmuch as the key to success or failure in most fermentative processes is availability of the proper micro-organisms, the characteristics of suitable microbial strains are enumerated; the industrial microbial collections of the world—their locations, their general holdings, and the names of their directors—are listed. The attributes of a good culture collection are emphasized. Various fermentation processes in use throughout the world are listed, together with the specific micro-organisms needed to carry them out.

Of these processes, the ones most likely to be beneficial in developing countries are indicated. Because information is so frequently requested about micro-organisms: for example, how to maintain stable cultures, how small fermentation plants may acquire suitable microbial strains, and how micro-organisms can be shipped through international channels, this publication is being issued to answer the many requests received yearly by the U.S. Department of Agriculture.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a commercial product or company does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

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By C. W. HESSELTINE and W. C. HAYNES, *Northern Regional Research Laboratory
North Central Region, Agricultural Research Service,
U.S. Department of Agriculture, Peoria, Ill.*

INTRODUCTION

The micro-organism used in a fermentation is the key to the success or failure of the process. It is the catalyst that makes the fermentation work. A microbial culture must have certain general attributes if the process it generates is to be operable, regardless of the nature of the product and the simplicity or complexity of the engineering process:

1. The strain must be genetically stable. A culture that constantly and spontaneously produces one or more different forms is undesirable.

2. The strain must readily produce many vegetative cells, spores, or other reproductive units. Since Basidiomycetes produce only mycelium, they are rarely, if ever, used in industrial fermentation.

3. The strain should grow vigorously and rapidly after inoculation into seed tanks or other containers used to prepare large amounts of inoculum before an industrial fermentation.

4. The strain should be a pure culture, not only free of other microscopically visible micro-organisms, but also free of phages.

5. The strain should produce the required product within a short period of time, preferably in 3 days or less.

6. The strain should produce the desired product to the exclusion of all toxic substances. The desired product should be easily separated from all others.

7. The strain should be able to protect itself against contamination, if possible. Self-protection might take the form of lowering the pH, growing at high temperature, or rapidly elaborating a desirable microbial inhibitor.

8. The strain should be readily maintained for reasonably long periods of time.

9. The strain should be amenable to change by certain mutagenetic or group of mutagenetic agents. A mutation program may even be conducted with the object of developing strains that give enhanced yields of the product.

10. The strain must give a predictable amount of desired product in a given fermentation time.

Micro-organisms that meet these conditions may be either isolated from nature or obtained from a culture collection. Trained microbiologists are required to isolate, purify, screen, and test a culture from nature. Since, in developing nations, such trained people are often in shorter supply even than money, it seems to us that culture collections would be the best source of micro-organisms for setting up a fermentation industry.

Plenty of time and money would still not guarantee success. To obtain the proper culture, sometimes one must isolate the micro-organism from a special, ecological niche that may not even exist in a particular country. For

example, *Blakeslea trispora*, which produces large amounts of β -carotene, cannot be isolated in temperate regions of the United States, but rather one must seek wild strains growing in the tropics on flowers of certain higher plants. For such cultures, collections are almost always the only logical source.

Another source of cultures in the food industry, which should not be overlooked, is the micro-organisms selected through the centuries for preparing native fermented food products. The principal micro-organisms can be obtained with little difficulty. Since the micro-organisms have been used in a particular food fermentation for centuries, there has been a constant, purposeful selection of the best strains. The yeast strains used in the municipal Bantu beer breweries of South Africa were acquired in this fashion. One of the authors (C. W. Hesseltine) was told that the original strains were isolated

from the better native brews. After a number of strains were tested, the best were chosen and are now the ones used in an industry producing 150 million imperial gallons of the beverage yearly.

In this Handbook, we have tried to be realistic in our approach to the problem of obtaining the proper micro-organisms for use in industrial fermentations. Our views are based upon first-hand knowledge of the operation of a large industrial culture collection supported entirely by government funds; experience during several years of operating a culture collection in a large industrial fermentation company; an understanding of the problems faced by fermentologists in developing countries; contact with microbiologists working in our fermentation laboratory from developing countries; and an acquaintance with some of the primitive food fermentations of the world.

SOURCES OF MICRO-ORGANISMS FOR INDUSTRY

The ultimate sources of culture and micro-organisms for industry are soil; water; fresh, fermenting, and rotting vegetables; living plants and animals; sewage; fresh and spoiled food; frass and insect droppings; and the like.

The immediate sources of cultures, however, are permanent culture collections. Almost all large industrial firms dealing in fermentations have their own collections of micro-organisms secured from a continuous program of isolation. New isolates and variant substrains derived from concurrent mutation studies swell the numbers of strains so that many of the proprietary collections are quite large. However, most of their micro-organisms never get into general circulation, being intended solely for exploitation by the parent company.

A few cultures from proprietary industrial collections are in general and private collections in the United States. In 1949, the U.S. Patent Office took the position that a culture is an essential part of a patent process and that the

culture must be disclosed. Hence, it must be deposited in a recognized culture collection and be available to the public at the time the patent issues.

As a result of this practice, two U.S. collections—the American Type Culture Collection at Rockville, Md., and the ARS Culture Collection in Peoria, Ill.—are recognized as official depositories for cultures from industrial concerns, both domestic and foreign. As might be expected, the depositing companies do not advertise that particular strains have been placed in outside culture collections, and the named depositories agree not to reveal possession of patent cultures or to distribute them without authorization by the depositor, if this is his wish, until the U.S. patent issues.

The holdings of the companies are supplemented also by accessions from public and private culture collections whose culture distributions are not so rigidly controlled.

Private collections do not have as a principal purpose of existence the distribution of cultures. They usually are specialist collections; that is, their scope is confined to one or a few taxa of special interest to the scientists who operate or control them. Generally, private collections are associated with a university or research institute. Although their curators decline to distribute cultures far and wide to anyone who asks, they nevertheless often send cultures to other investigators with like interests, or to research institutes and to industrial men who might continue research which they no longer can pursue or who might continue development of an industrial process. Private collections generally do not charge fees for their cultures. Like proprietary collections, they usually do not publish or distribute lists of their cultures.

Public collections have as one of their principal reasons for existence the accumulation of a diverse collection of salable micro-organisms. They send cultures anywhere in the world to any bona fide investigator who is willing to pay their price. As might be expected, they publish catalogs listing the micro-organisms that are for sale. They often provide other services, such as identification of micro-organisms and preservation of cultures by lyophilization or liquid-nitrogen refrigeration. Their diversity may be as wide as that of the American Type Culture Collection, which maintains actinomycetes, algae, bacteria, cell lines, molds, protozoa, viruses, and yeasts.

Among the specialized culture collections, some concentrate on industrially useful micro-organisms. Such micro-organisms are bacteria, yeasts, molds, actinomycetes, algae, and protozoa that are used in the food, pharmaceutical, and fermentation industries and in research and development laboratories to convert selected substrates to products of enhanced nutritional, medicinal, or industrial value or to reduce the biochemical oxygen demand (BOD) in sewage and industrial effluents. Such collections are of principal interest to the United

Nations Industrial Development Organization (UNIDO) and its adherent groups and members.

We concluded that a list of such collections, giving addresses, names of curators, and types of micro-organisms contained, would be useful (Table 1). We are indebted to S. M. Martin of the Division of Biosciences, National Research Council, Ottawa 7, Ontario, Canada, for most of the names of collections and information about them. Under the aegis of the World Federation of Culture Collections (WFCC, formerly the Section on Culture Collections) of the International Association of Microbiological Societies, Dr. Martin published a World Directory of Collections of Cultures of Micro-organisms (11),¹ in which most of the collections in the world are named and described.

Names and addresses of additional collections may be found in some of the larger culture collection catalogs listed at the end of this paper (2, 3, 4).

Fees for cultures vary from one collection to another. In the United States, the American Type Culture Collection charges \$30 per strain for all cultures to profit-making institutions. The cost is reduced to \$20 for nonprofit institutions (except for some special teaching strains, which are \$10). The Centraalbureau voor Schimmelcultures in The Netherlands charges 40 guilders for cultures that are to be used for industrial purposes. There is a reduction in cost if 10 strains or more are purchased in 1 year. This collection, like some others, does not guarantee the production of chemical substances by its cultures.

As a general rule, collections which advertise their cultures in printed catalogs charge a fee for their strains. Some collections, such as the one with which we are associated, do not issue a catalog, do not charge a fee, but do exert considerable restraint on the number of strains sent at any one time to any individual or institution.

¹ Italic numbers in parentheses refer to Literature Cited, p. 38.

TABLE 1.—*Collections containing industrially useful micro-organisms*
(Includes main collections and those containing at least 500 strains)

Collection, parent organization, address, and person in charge	Contents
ARGENTINA	
Centro de Micología Facultad de Ciencias Médicas Universidad de Buenos Aires Paraguay 2155, 11°, Buenos Aires Prof. Dr. P. Negróni	Fungi Yeasts
Colección Cátedra Microbiología Agrícola (FAV, Bs. As.) Facultad Agronomía y Veterinaria Universidad de Buenos Aires Avenida San Martín 4453 (Suc. 17), Buenos Aires Prof. Ing. Agr. R. E. Halbinger	Bacteria Fungi Yeasts
Colección de Cultivos Microbianos Facultad de Farmacia y Bioquímica Universidad de Buenos Aires Junin 956 Piso. 8°, Buenos Aires Prof. Dr. R. A. Margni	Bacteria Fungi Yeasts
Instituto de Microbiología e Industrias Agropecuarias Instituto Nacional de Tecnología Agropecuaria Villa Udaondo, Castelar FCDFS, Buenos Aires Ing. Agr. E. Schiel	Bacteria Fungi Yeasts
Instituto de Patología Vegetal Instituto Nacional de Tecnología Agropecuaria Villa Udaondo, Castelar FCDFS, Buenos Aires Ing. Agr. C. J. M. Carrera	Bacteria Fungi
Cátedra de Microbiología Facultad de Ciencias Agrarias Universidad Nacional de Cuyo Almirante Brown 500, Chacras de Coria, Mendoza Ing. Agr. N. J. Palleroni	Bacteria Yeasts
AUSTRALIA	
Rhizobium Strain Collection Division of Tropical Pastures Commonwealth Scientific and Industrial Research Organization Mill Road, St. Lucia, Brisbane, Queensland, 4067 Dr. D. O. Norris	Bacteria
Culture Collection The Australian Wine Research Institute Private Bag No. 1, Glen Osmond, P.O., South Australia, 5064 W. W. Forest	Yeasts

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
AUSTRALIA—Continued	
Soil Microbiology Culture Collection Division of Soils Commonwealth Scientific and Industrial Research Organization Private Bag No. 1, Glen Osmond, South Australia, 5064 Dr. E. G. Hallsworth	Bacteria
Institute of Agriculture University of Western Australia Nedlands, Western Australia, 6009 Dr. C. A. Parker	Bacteria
Division of Wood Technology Forestry Commission of New South Wales 96 Harrington Street, Sydney, New South Wales, 2000 E. B. Huddleston	Fungi
AUSTRIA	
Milchwirtschaftliche Bakterienkulturen Rotholz/Post Jenbach, Tirol Dipl.-Ing. S. Winkler	Bacteria
BELGIUM	
Collection of the Laboratory for Microbiology Laboratorium voor Microbiologie, Fac. Wetenschappen Rijksuniversiteitn Ledeganckstraat, Gent Prof. J. DeLey	Bacteria
Laboratoire de Mycologie Systématique et Appliquée Université Catholique de Louvain 92, Avenue Cardinal Mercier, B-3030-Heverlee Prof. Dr. Ing. G. L. Hennebert	Fungi
BRAZIL	
Coleção de Culturas Instituto Adolfo Lutz Av. Dr. Arnaldo 355, C.P. 7027, São Paulo F. de B. M. Jordão	Bacteria Fungi Protozoa Animal Viruses
Culture Collection, Instituto Zimotécnico (IZ) Escola Superior de Agricultura "Luis de Queiroz" C.P., 56, Piracicaba, São Paulo Prof. J. Leme, Jr.	Bacteria Fungi Yeasts

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
BULGARIA	
Bulgarian Type Culture Collection Institute for State Control of Medical Preparations Ministry of Health Vladimir Zaimov No. 26, Sofia Prof. R. Ovtcharov/Dr. M. Zheleva	Bacteria Fungi Yeasts
BURMA	
Type Culture Collection Burma Pharmaceutical Industry (B.P.I.) Industrial Development Corp., Ministry of Industry BPI Road, Gyogon, Rangoon Dr. Ko Gyi Ko	Bacteria Fungi
CANADA	
Mold Herbarium and Culture Collection (UAMH) University of Alberta Edmonton, Alberta Dr. J. W. Carmichael	Fungi Yeasts
Atlantic Regional Laboratory National Research Council of Canada 1411 Oxford Street, Halifax, Nova Scotia Dr. A. C. Neish	Bacteria Fungi Yeasts
University of Western Ontario Culture Collection (UWO) Botany Department University of Western Ontario London, Ontario Dr. J. C. Hickman	Bacteria Fungi Yeasts Algae
Biosciences Division National Research Council of Canada Sussex Drive Ottawa 2, Ontario Dr. G. C. Butler	Bacteria Fungi Yeasts
University of Windsor Culture Collection Department of Biology University of Windsor Windsor, Ontario R. J. Doyle	Bacteria Fungi Yeasts Animal Viruses
Macdonald College Collection Department of Microbiology, Macdonald College McGill University Ste. Anne de Bellevue, Quebec Dr. R. Knowles	Bacteria Fungi Yeasts

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
CANADA—Continued	
Prairie Regional Laboratory National Research Council of Canada Saskatoon, Saskatchewan Dr. R. H. Haskins	Bacteria Fungi
CEYLON	
Department of Biological Sciences (Microbiology) Vidyodaya University Gangodawila	Bacteria
CHILE	
Collection Bactéries Institut Centre National de Microbiologie Bactériologique Avenida Maratón 1000, Santiago Prof. E. Dussert	Bacteria
CZECHOSLOVAKIA	
(All but one (*) of these collections are part of the Czechoslovak Collections of Micro-organisms)	
Research Institute for Viticulture and Enology (RIVE) Matuskova ul. 97, Bratislava Dr. Ing. A. Vereš, C.Sc.	Fungi Yeasts
Collection of Cultures of Wood-Rotting Fungi Laboratory for Anatomy and Physiology of Plants (LAPP) J. E. Purkyně University Kotlářská 2, Brno Prof. Dr. V. Rypáček, Dr. Sc.	Fungi
Czechoslovak Collection of Microorganisms (CCM) J. E. Purkyně University tr. Obránců Míru 10, Brno Prof. Dr. T. Martinec, Dr. Sc.	Bacteria
Collection of Rhizobium and Other Soil Microorganisms Central Research Institute of Plant Production (CRIPP) Ruzyně, Prague Dr. E. Hamatová-Hlaváčková, C.Sc.	Bacteria
Culture Collection of Entomogenous Bacteria (CCEB) Department of Insect Pathology Institute of Entomology, Czechoslovak Academy of Sciences Na cvičišti 2, Prague 6 Dr. O. Lysenko, C.Sc.	Bacteria

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
CZECHOSLOVAKIA—Continued	
Culture Collection of Fungi (CCF) Department of Botany, Faculty of Sciences Charles University Benátská 2, Prague 2 Dr. O. Fassatiova, C.Sc.	Fungi
* Czechoslovak National Collection of Type Cultures Institute of Epidemiology and Microbiology Šrobarova 48, Prague 10 Dr. J. Šourek, C.Sc.	Bacteria Fungi Yeasts Animal Viruses Bacteriophages
Research Laboratories of the Dairies Association for the Production of Pure Milk Cultures Laktoflora (LAKTOFLORA) Ke dvoru 2, Prague 6 Ing. Dr. M. Teplý	Bacteria Fungi Yeasts
DENMARK	
Bacillus Collection Institute of Hygiene University of Aarhus DK-8000, Aarhus Prof. G. J. Bonde	Bacteria
Bacteriological Department Lövens kemiske Fabrik 2750 Ballerup L. Tybring	Unspecified
Antibiotics Department Dumex, Ltd. Prags Boulevard 37, 2300 Copenhagen S Dr. K. Andersen	Unspecified
Bacteriological Department H. Lundbeck and Co. Ottiliaveg 7-8, 2500 Copenhagen Valby L. Szabo	Unspecified
Statens Forsøgsmejeri 3400 Hillerød A. M. Madsen	Unspecified
Department of Technical Biochemistry Danmarks tekniske Højskole Bygning 223, 2800 Lyngby Dr. M. Jensen	Unspecified

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
DENMARK—Continued	
Laboratory for Microbiology Danmarks tekniske Højskole Bygning 221, 2800 Lyngby Prof. Dr. J. Hedegaard	Unspecified
FINLAND	
Culture Collection Department of Microbiology University of Helsinki Helsinki 71 Prof. U. J. Vartiomaara	Bacteria Fungi Yeasts
FRANCE	
Centre de Collection de Types Microbiens Centre d'Études et de Recherches Technologiques des Industries Alimentaires 62 Boulevard Maréchal Vaillant, Lille Dr. H. Beerens	Bacteria Yeasts Animal Viruses Bacteriophages
Institut Pasteur de Lyon: IPL Rue Pasteur, Lyon 69 M. Carraz	Bacteria
Collection de Microorganismes Associes Aux Invertébrés Station de Recherches Cytopathologiques I.N.R.A.-C.N.R.S. Montpellier 30 Saint-Christol Prof. C. Vago	Bacteria Yeasts Animal Viruses
Laboratoire de Cryptogamie Museum National d'Histoire Naturelle Paris Dr. J. Nicot	Fungi
Laboratoire des Fermentations Institut Pasteur de Paris 28 Rue du Docteur Roux, Paris 15° P. Bréchet	Yeasts
Service des Anaérobies Institut Pasteur de Paris 25 Rue du Docteur Roux, Paris 15° Dr. Rouyer	Bacteria

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
GERMANY, EAST (DEMOCRATIC REPUBLIC)	
Fachgebiet Allgemeine Botanik und Pflanzenphysiologie Ernst-Moritz-Arndt-Universität Grimmerstrasse 86/88, DDR-22 Greifswald Prof. Dr. H. Borriß	Bacteria Fungi Yeasts Algae Bacteriophages Cell lines
Kulturensammlungen Zentral Institutes für Mikrobiologie und Experimentelle Therapie (IMET) Deutsche Akademie der Wissenschaften zu Berlin Beuthenbergstrasse 11, Jena 69 H. Prauser	Bacteria Fungi Yeasts Animal Viruses Bacteriophages Protozoa Actinomycetes
Kulturensammlung Institut für Mikrobiologie Humboldt-Universität 1532 Kleinmachnow, Max-Reimannstrasse 16, Kleinmachnow bei Berlin Prof. Dr. Jentzsch	Bacteria Fungi Yeasts
Botanisches Institut Mykologie Weimar Friedrich-Schiller Universität Jena Frh.-v-Stein-Allee 2, Weimar Prof. Dr. R. Tröger	Fungi Yeasts
GERMANY, WEST (FEDERAL REPUBLIC)	
Mikroorganismensammlung Institut für Garungsgewerbe und Stärkefabrikation Seestrass 13, 1 Berlin 65 Prof. Dr. S. Windisch	Bacteria Fungi Yeasts
Instituts Staamsammlung, Biologische Bundesanstalt für Land und Fortswirtschaft Institut für biologische Schädlingsbekämpfung Kranichsteinerstrasse 61, Darmstadt Prof. Dr. J. M. Franz	Bacteria Fungi Animal Viruses
Sammlung von Algenkulturen Pflanzenphysiol. Institut Universität Göttingen Nikolausberger Weg 18, 34 Göttingen Prof. Dr. A. Pirson	Algae
Food Spoiling Molds Deutsche Forschungsanstalt für Lebensmittelchemie Leopoldstrasse 175, Munich, Bayern Prof. Dr. S. W. Souci	Fungi

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
GERMANY, WEST (FEDERAL REPUBLIC)—Continued	
Bayerische Landensanstalt für Wein-, Obst-u. Gartenbau Residenzpl. 3, 87 Würzburg, Bayern Dr. I. Benda	Yeasts
GHANA	
University Microbial Cultures, Kumasi (U.M.C.K.) Department of Biological Sciences University of Science and Technology Kumasi K. O. Nyako	Bacteria Fungi Yeasts
HUNGARY	
Culture Collection Pedological Inst. Hungarian Academy of Sciences Herman 0.15, Budapest II Dr. J. Szegi	Bacteria Actinomycetes
Diagnostical and Research Laboratory National Institute for Tuberculosis "Korányi" Pihenő ut 1, Budapest XII I. Szabó, M.D., D.Sc.	Bacteria Bacteriophages
INDIA	
BSM Culture Collection Botany Department University of Allahabad Allahabad Dr. B. S. Mehrotra	Fungi
Fermentation Technology Laboratory Indian Institute of Science Bangalore-3 Dr. J. V. Bhat	Bacteria Yeasts
Department of Microbiology Bose Institute 93/1 Acharya Prafulla, Chandra Road, Calcutta 9 Prof. P. Nandi	Bacteria Fungi Yeasts Actinomycetes Bacteriophages
D. R. L. (M) Kanpur Culture Collection Defense Research Laboratory (Materials) Research and Development Organization, Ministry of Defense P.B. 320 Kanpur, Uttar Pradesh Dr. J. N. Nanda	Bacteria Fungi Yeasts

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
INDIA—Continued	
National Collection of Industrial Microorganisms (NCIM)	Bacteria
National Chemical Laboratory	Fungi
Council of Scientific and Industrial Research (CSIR)	Yeasts
Poona-8	
Dr. V. Jagannathan	
INDONESIA	
Culture Collection, Treub Laboratory	Bacteria
National Biological Institute	Fungi
The Botanical Garden	Yeasts
Bogor	Actinomycetes
Dr. S. Saono	
IRAN	
Razi Culture Collection	Bacteria
State Razi Institute-Hessarak, Ministry of Agriculture	Animal Viruses
P.O. Box 656, Karadj, Tehran	Protozoa
Dr. F. Entessar	
IRELAND	
Department of Industrial Microbiology	Fungi
University College	Actinomycetes
Ardmore, Stillorgan Rd., Dublin, 4	
Prof. M. J. Geoghegan	
Guinness (Dublin) Culture Collection	Bacteria
A. Guinness Son and Co. (Dublin) Ltd.	Yeasts
St. James's Gate, Dublin, 8	
Dr. C. E. Dalglish	
Johnstown Castle Collection	Bacteria
Soil Laboratory	
The Agricultural Institute	
Wexford	
C. L. Masterson	
ITALY	
Centro di Studio dei Microorganismi Autotrofi	Bacteria
Istituto di Microbiologia Agraria e Tecnica	Fungi
Università di Firenze	Yeasts
Piazzale della Cascine, 27 Firenze	Algae
Prof. G. Florenzano	

TABLE 1.—*Collections containing industrially useful micro-organisms*—Continued

Collection, parent organization, address, and person in charge	Contents
ITALY—Continued	
Istituto di Patologia Vegetale Università di Milano Via Celoria 2, Milano 20133 Dr. E. Baldacci	Actinomycetes Fungi
Lepetit S.p.A. Via Durando 38, Milano 20158 Prof. P. Sensi	Bacteria Fungi Yeasts Actinomycetes Protozoa
Collezione dei Lieviti Vinari Istituto di Microbiologia Agraria e Tecnica Università di Perugia Bg. XX Guigno, Perugia 06100 Prof. T. Castelli	Bacteria Yeasts
Collezione Microbica Agraria, Marina e Industriale (COMAMI) Istituto Microbiologia Agraria e Tecnica E. de Nicola, Sassari Prof. A. Capriotti	Bacteria Yeasts
JAMAICA	
Department of Microbiology University of West Indies Mona St., Kingston 7 Prof. L. S. Grant	Bacteria Animal Viruses
JAPAN	
Department of Fermentation Technology (HUT) Faculty of Engineering Hiroshima University 3-Chôme, Senda-machi Hiroshima Dr. T. Nehira	Bacteria Fungi Yeasts
Culture Collection (IFO) Institute for Fermentation Juso Nishinocho 4-54, Higashi-yodogawa-ku, Osaka Dr. T. Hasegawa	Bacteria Fungi Yeasts Bacteriophages
Department of Fermentation Technology (OUT) Faculty of Engineering Osaka University 9-Chôme Higashinoda-machi, Miyakoshima-Ru, Osaka Dr. G. Terui	Bacteria Fungi Yeasts