

Milestone in Japanese Culture Collections

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Japanese universities, national institutes, private sectors have been interested in culture collections related to traditional fermentations and modern microbial industry. Japanese culture collections have mainly grown in response to the social needs to solve problems in the traditional fermentation and to develop modern microbial processes. The establishment of the first service culture collection in Japan dates back to 1904. After World War II, the Japan Federation of Culture Collections of Microorganisms (JFCC) (now Japan Society for Culture Collections, JSCC) was organized in 1951 for encouraging research on microorganisms and exchanging microbial information by the recommendation of the Ministry of Education, the Government of Japan. The JFCC organized the First International Conference on Culture Collections (ICCC-1), and contributed to the establishment of the World Federation for Culture Collections (WFCC). The JFCC-JSCC has since been working for strengthening Japanese culture collections and international cooperation with overseas culture collections. The JSCC aims to renew the Japanese culture collections to modern biological resource centers with the highest standard, and to expand microbial networks in cooperation with other collections throughout the world. Further, the building of a “human network” is essential for the further development of the culture collections.

Introduction

Japanese culture collections have mainly grown in response to the social needs to solve problems in traditional fermentations and to develop modern microbial processes. The Japanese traditional fermentation is recorded about 1,000 years ago. Since 17th century, conidia of *Aspergillus oryzae* grown on steamed rice have been collected and used for koji starters (*tane koji*). Koji is steamed rice grown with *A. oryzae* inoculated with the koji starter, and is widely used for making saké, soy sauce, soy bean paste (*miso*), and other fermented products. Thus the koji starter is important for the Japanese traditional fermentation. It is recorded that feudal lords strictly regulated the production of the koji starter and collected tax from its sale (Sakaguchi, 1964). Koji molds, yeasts, and lactic acid bacteria have been employed for the Japanese traditional fermentation. Saké is a national drink. Shochu is a spirit made from rice, sweet potato, and other starchy materials and is popular as well. Soy sauce and soy bean paste are fermented products of soy beans and are still important seasonings for the Japanese. Recently, soy sauce has become used worldwide. Vinegar was traditionally produced from saké and saké cake by surface culture, but now it has been produced by submerged culture.

Teaching and Research on Applied Microbiology in Japan

In 1877, the Komaba Agricultural College (now the Faculty of Agriculture), the University of Tokyo was established. Teaching of applied microbiology started

and intensive research in taxonomy, biochemistry, and physiology of microorganisms involved in the Japanese traditional fermentation has been carried out. Modern research of applied microbiology was introduced by teachers invited from overseas countries about 130 years ago. An English chemist, Prof. Atkinson, R. W. studied the saké making, and published “The Chemistry of Saké Brewing” in 1881 (Fig.1) (Atkinson, 1881). This study deals with koji, referring to rice (raw material), preparation of koji, action of koji extract upon cane sugar, maltose, and dextrin, and action of koji upon gelatinized starch. Further, he mentioned the saké making, dealing with preparation of starters (*moto*), the principal of process, fermentation of the mash, filtration of saké and yield of alcohol, preservation of saké, and shochu and mirin (sweetened saké). He included an illustration of the saké-brewery in 1789 (Fig. 2). This study is the first scientific monograph of the saké making in English.

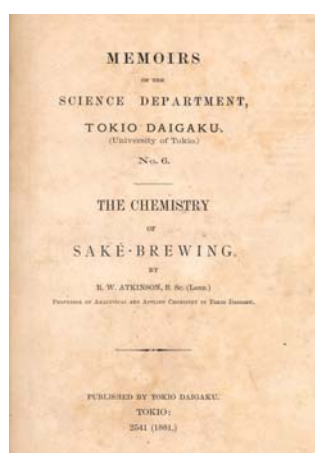


Fig. 1. Atkinson, R. W.: The Chemistry of Saké Brewing (1881).

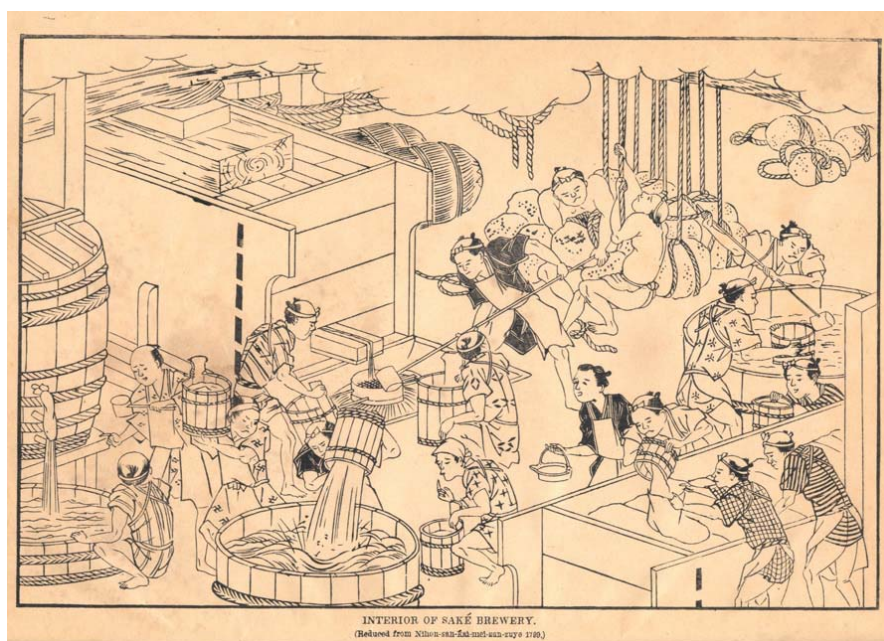


Fig. 2. Atkinson, R. W.: Saké brewery in 1789 (1881)

Agricultural colleges have been established in other universities since the opening of the Komaba Agricultural College, and teaching and research on applied microbiology have been extended in Japan.

Culture Collections in Japan before World War II

Japanese universities, national institutes, and private sectors have been interested in culture collections related to the traditional fermentation and modern microbial industry. Lineage of the Japanese culture collections is depicted (Fig. 3) (Hasegawa, 1996b).

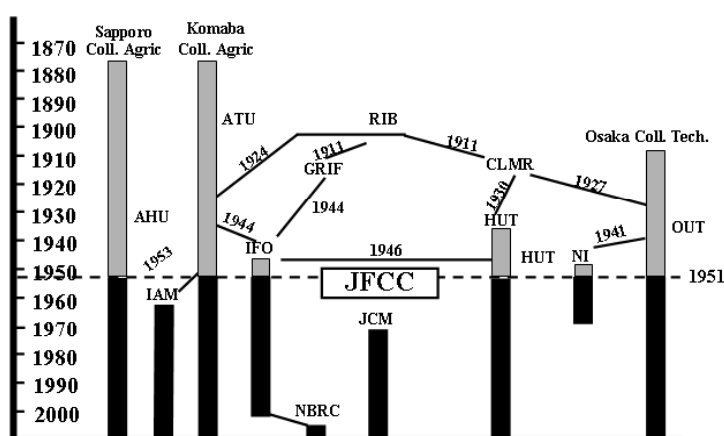


Fig. 3. Lineage of Japanese Culture Collections.

(Modified Hasegawa's original. Abbreviations: AHU, Faculty of Agriculture, Hokkaido University; ATU, Faculty of Agriculture, The University of Tokyo; CLMR, Central Laboratory, South Manchuria Railway Co., Ltd. (defunct); GRIF, Government Research Institute, Formosa (defunct); HUT, Faculty of Engineering, Hiroshima University; IAM, Institute of Applied Microbiology, (now Institute of Molecular and Cellular Biosciences), The University of Tokyo; IFO, Institute for Fermentation, Osaka (defunct); NBRC, NITE Biological Resource Center; NI, Nagao Institute (defunct); OUT, Department of Fermentation Technology (now Department of Biotechnology). Osaka University; RIB, National Institute of Brewing).

The first Japanese service culture collection to be established dates back to 1904. The Tax Administration Agency of the Government of Japan undertook basic and applied studies of making saké and other fermented products, and set up the Brewing Experimental Station (now National Institute of Brewing). A culture collection of microorganisms was located at the Station (RIB) charged with the distribution of microbial cultures on demand (Hasegawa, 1996a). Another early and noteworthy culture collection was the Central Laboratory of the South Manchuria Railway Company (CLMR) at Dairen, Manchuria, (now Dalian, Liaoning Province, China) (Hasegawa, 1996a). These culture collections were major sources of microbial cultures before World War II, but

the culture collections were damaged during the war. Part of the RIB collection has been maintained at the Laboratory of Fermentation, the University of Tokyo, and its holding was then distributed to the Culture Collection of Institute of Applied Microbiology (IAM) (now Institute of Molecular and Cellular Biosciences), the University of Tokyo. Part of the CLMR collection was moved to Hiroshima University and Osaka University (Hasegawa, 1996a). While, the Government Research Institute, Formosa (GRIF) (Taiwan) contributed to the development of Japanese culture collections. Microorganisms involved in indigenous fermented products in Taiwan and utilization of molasses were studied, and systematic studies of *Rhizopus*, *Monascus*, *Aspergillus* and other microorganisms were extensively studied. Part of the microorganisms was distributed to Takeda Pharmaceutical Company in 1939, and following years, the microbial cultures became a core collection of Institute for Fermentation, Osaka (IFO), and they were further distributed to other Japanese culture collections (Hasegawa, 1996a).

The very first service culture collection in the world is reported to be the Král Culture Collection founded by Dr. František Král in Prague probably in 1890 (Kocur, 1990; Porter, 1976). Thus the RIB was established at a similar time to the Král collection.

Nagao Institute (NI) was established in 1941, and published a catalogue of microbial cultures in 1950. This institute was a leading culture collection in Japan but was defunct in 1971 (Hasegawa, 1996b). Institute for Fermentation, Osaka (IFO) was established in 1945 (Hasegawa, 1966b). IFO was one of the most active culture collections in the world, and distributed large numbers of microbial cultures worldwide. However, its holding was transferred in 2002 to the Biological Resource Center (NBRC), the National Institute of Technology and Evaluation.

Culture Collections in Japan after World War II

The Higher Education and Science Bureau of the Ministry of Education, the Government of Japan carried out a survey in 1952 on microbial cultures preserved in research organizations, including universities, national institutes, and private sectors. It concluded that 22,300 cultures were maintained in 251 culture collections belonging to 144 organizations. The Bureau published *A Catalogue of Cultures of Microorganisms Maintained in the Japanese Culture Collections* in 1953 (Fig. 4) (The Higher Education and Science Bureau of the Ministry of Education, the Government of Japan).

The catalogue was edited by Dr. K. Kominami and scientific names of holdings, the history of the cultures, and culture collections preserving the cultures were described. The publication of the catalogue brought a deep interest in microbial cultures to Japanese microbiologists, and resulted in raising a project of reidentification of microbial cultures maintained in Japanese culture collections. The project continued 11 years and about 100 researchers were involved in it. Reidentified cultures were deposited to Japanese culture collections, and the collections were enriched their holdings in consequence.



Fig. 4. General Catalogue of the Cultures of Microorganisms Maintained in the Japanese Culture Collections (1953).

After World War II, penicillin production was introduced from USA and quickly and successfully developed and industrialized. Research has since been pursued new antibiotics energetically. Large numbers of useful strains have been isolated from natural sources and mutants with high potential have been screened. IFO and other Japanese culture collections supplied microbial cultures to researchers on demand. Consequently, large numbers of new antibiotics were found by Japanese workers, and have appeared on the market. In 1946, the Japan Penicillin Research Association, (now the Japan Antibiotics Research Association) was established for the promotion of the research and industrialization of antibiotics. Its members were from universities, national institutes, and private sectors, and they made their data open and public. The association contributed to the substantial development of research and the production of antibiotics in Japan. This type of the organization is a forerunner model for cooperation of workers involved in research of microorganisms. The organized cooperation led to success in research and industrialization of glutamic acid and other amino acids, and nucleosides and nucleotides.

Japanese Federation of Culture Collections of Microorganisms (JFCC)

The Japanese Federation of Culture Collections of Microorganisms (JFCC) was founded in 1951 following the recommendation of the Ministry of Education, the Government of Japan and Science Council of Japan (Hasegawa, 1996b). The aim of the federation is to encourage research on microorganisms and to exchange information on microbial cultures. The federation encompassed the Japanese culture collections in the fields of general microbiology, medical microbiology, applied microbiology, and environmental microbiology, and consisted of only 11 culture collections at the start. The JFCC was the first network of culture collections and data bank in Japan (Komagata, 1977). In response to social needs and growth of microbiology, the federation changed the name to the Japan Federation for

Culture Collections (JFCC), and any culture collections in Japan and persons who are interested in culture collections and microbiology became enrolled as members of the JFCC. Further, the JFCC changed the name to the Japan Society for Culture Collections (JSCC) in 1993. In commemoration of the development and progress of the Japan Federation of Culture Collections of Microorganisms, the JSCC organized and held the 50th anniversary, and commemorative lectures were presented in 2001 (Komagata, 2001a, b).

The First International Conference on Culture Collections (ICCC-1)

The delegation of the Government of Japan submitted a proposal to 12th General Conference of UNESCO in 1962 as recommended by the JFCC (Hasegawa, 1996b; Komagata, 2001b). It included the followings: (1) the development of culture collections on a worldwide scale; (2) the development of research on microorganisms; and (3) the training of researchers in both of the fields. The proposal was adopted at the 13th General Meeting of UNESCO in 1964 as a long-term project entitled "Promotion of Research of Microorganisms". Consequently, UNESCO held the International Meeting of Specialists on Microorganisms in Paris in 1966, and representatives of UNESCO, the Section of Culture Collections of International Association of Microbiological Societies (IAMS) (now the International Union of Microbiological Societies, IUMS), the JFCC, WHO, and FAO discussed plans of the long-term project. The meeting made the following recommendations to the Section on Culture Collections of IAMS: (1) a worldwide survey of culture collections; (2) the preparation of a world directory of culture collections; (3) the training of researchers; (4) the promotion of exchange of cultures; (5) standardization of terminology, methods of determination and recording of research information; (6) the convention of international conference; and (7) the organization of an international federation. These recommendations were considered by the Section of Culture Collections of IAMS, and were approved by the Executive Committee of IAMS and the ICRO-UNESCO Panel on Microbiology. Japan was requested to hold an international conference as the original proposer of the project. The JFCC discussed the matter with the Japanese National Council of Science and the Japanese Commission for UNESCO, and organized the conference in Japan. Thus the First International Conference on Culture Collections (ICCC-1) was held in Tokyo in 1968 (Iizuka and Hasegawa, 1970; Hasegawa, 1966b; Komagata, 2001a). The JFCC played important roles in the holding of ICCC-1, and 526 persons from 52 countries participated in the conference. Resolutions were unanimously decided and consisted of 7 items. They are (1) the recommendation of International Federation of Culture Collections; (2) the holding of conference of culture collections; (3) investigation on the need for special training course; (4) the establishment of reference laboratories; (5) the establishment of international centers for characterization of strains of microorganisms; (6) the provision of laboratory supplies and cultures to development countries; and (7) a feasibility study on the establishment of an international center for information (Iizuka and Hasegawa, 1970). This can be regarded as the first guideline of the World Federation for Culture Collections.

Prof. Iizuka, President of ICC-1 prepared a plaque designed with a ginkgo leaf, which was regarded as the symbol of the ICC. The plaque was made of a piece of 800-year-old wood of ebony (*Diospyros ebenum*). Ginkgo leaves mean “expanding horizons” for the Japanese people (Iizuka, 1977). He brought the plaque to ICC-2 in Sao Paul in 1973, and suggested that President of ICC-2 would sign his name on the reverse side and pass it to Presidents of the future ICCs (Iizuka, 1973; Iizuka, 1977). After a long journey, the plaque has happily returned back to Japan. This tells us of sincere endeavor and cooperation of culture collection people in the world who contributed to the development and improvement of the culture collections.

World Federation for Culture Collections (WFCC)

Importance of culture collections was recognized about 70 years ago. The First International Congress of Microbiology was held in Paris in 1930, and a Commission of Nomenclature and Taxonomy was constituted to report recommendations to the Plenary Session of the Congress (Editorial Board for Bacteriological Code, 1992). According to recommendations made by several of the delegates to the congress, a commission mentioned the significance of culture collections as follows: “Among the most important agencies working toward satisfactory nomenclature and classification of bacteria are the several type culture collections. These constitute invaluable repositories and much of the future development will depend upon their adequate growth, support and utilization; in some cases at least they should develop to research institutes of high grade. It is further urged that all bacteriologists publishing descriptions of new species or important strains of bacteria deposit pure cultures of such with a culture collection that may be made available to others interested”. However, implementation of the resolution was not progressed as would be expected.

The cooperative program of culture collections was recognized in some countries. International Federation of Culture Collections (IFCC) was set up in 1947 on the occasion of the 4th International Congress of Microbiology, and its office was located at Centre de Collections de Types Microbiens at Lausanne in Switzerland. However, the IFCC was defunct in 1954 (Hasegawa, 1996b). The British Commonwealth Scientific Official Conference (BCSOC) was held in UK in 1946. The Specialists Congress of Culture Collections of Microorganisms was held in London in 1948, and the United Kingdom National Committee of the British Commonwealth Culture Collection was organized (Cowan, 1950; Gibbons, 1963). Following the committee, the Permanent Committee of the British Commonwealth Collection of Microorganisms was set up in 1948. Further, the Canadian Committee on Culture Collections was established in 1948 because the BCSOC expected the establishment of an international cooperative organization of culture collections. Consequently, the Specialist’s Conference on Culture Collections was held in Montreal in 1962, and its main issue was “Culture Collections: Perspective and Problems” (Martin, 1963). IAMS adopted the resolution of the conference, and the Section on Culture Collections was organized in 1963.

The Executive Board of IAMS prepared plans with the constitution and rules of the section in 1964 (Hasegawa, 1996b; Komagata, 2001a).

The resolution of ICC-1 recommended the establishment of International Federation of Culture Collections. The meeting of the Section on Culture Collections in IAMS was held on the occasion of the 10th International Congress of Microbiology in Mexico City in 1970, and the future plans of an international organization were discussed. Thus the Section on Culture Collections in IAMS was dissolved, and the World Federation for Culture Collections (WFCC) was constituted (International Association of Microbiological Society, 1972a, b; Porter, 1976). Officers were then Dr. Martin, S. (Canada), President; Dr. Iizuka, H. (Japan), Vice-president; Dr. Lapage, S. (UK), Secretary; Skerman, V. (Australia), Treasurer; Hoffmann, S. (Germany); Lesesle, E. (USA); Papavassiliou, J. (Greece); and Piéchaud, M. (France).

Thus the WFCC came to be established based on national and international considerations for a cooperative network of culture collections. The JFCC took part in the establishment of the WFCC as well.

The World Data Center (WDC) (now the World Data Center for Microorganisms, WDCM) was relocated from the Queensland University in Australia to the Institute of Physical and Chemical Research (RIKEN) in Japan in 1986 (Komagata, 1987), and then moved to the National Institute of Genetics in 1996 (Sugawara, 1998).

The Activity of the Japan Society for Culture Collections (JSCC)

The JSCC holds a general meeting once a year to discuss the activity of the member collections and considers international trends in culture collections. A total of 25 culture collections are affiliated with the JSCC in 2004. The JSCC member collections hold a total of 229,840 cultures in 2003 (Report of Japan Society for Culture Collections, 2004). Of the cultures, 44,188 are filamentous fungi (19.2%), 25,319 yeasts (11.0%), 8,319 actinomycetes (3.6%), 145,285 bacteria (63.2%), 638 viruses (0.3%), 2,015 microalgae (0.9%), and 4,022 others (1.7%). The JSCC member collections distributed 22,544 cultures to domestic and overseas researchers and organizations in 2003 (Fig. 5).

The journal of *Microbiology and Culture Collections* is published twice a year by the JSCC, containing original papers covering the systematic study of microorganism, development of microbial preservation, and other related studies. Further, the JSCC awards the two JSCC Prizes to persons who contributed to the development of preservation of microbial cultures and the systematic study on microorganism. Thus the JFCC-JSCC has paid attention to maintenance of a variety of cultivable microorganisms, and encouraged the Japanese culture collections and persons who are interested in culture collections and microbial systematics. On these circumstances, the Japan Collection of Microorganisms (JCM) was established in 1980, and Biological Resource Center (NBRC), National Institute of Technology and Evaluation was set up in 2002. Thus the activity of the JSCC has been strengthened.

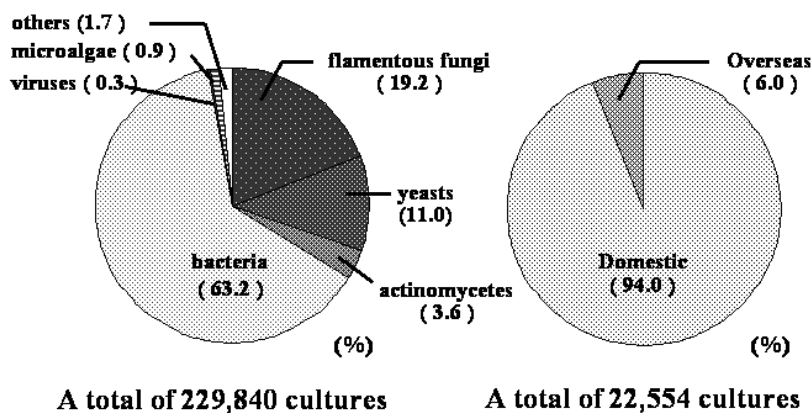


Fig. 5. The Activity of Japan Society for Culture Collections (JSCC).

Left: Holdings of the member collections of JSCC. Right: Distribution of cultures by member collections of JSCC.

The Japanese prominent bacteriologists, Dr. Kitasato, S., Dr. Shiga, Y. and other microbiologists have been working in the field of medical microbiology, but culture collections on medically important microorganisms had been private collections or laboratory scaled collections. Recently, Research Center of Emerging Infectious Diseases (RIMD), Osaka University; Research Center for Pathogenic Fungi and Microbial Toxicoses (IFM), Chiba University; Institute of Medical Mycology (TIMM), Teikyo University; Department of Microbiology (GTC), Gifu University School of Medicine and other specialized collections are core collections in the JSCC.

Genebank, National Institute of Agrobiological Sciences (MAFF) is a specialized collection for plant pathogens and other microorganisms related to agricultural sciences. The Microbial Culture Collection at the National Institute for Environmental Studies (NIES) is an algal collection to support environmental research.

Both the International Patent Organism Depository (IPOD) at the National Institute of Advanced Industrial Science and Technology and the NITE Patent Microorganisms Depository (NITE NPOD) at National Institute of Technology and Evaluation have played a role in the international depository of patent organisms.

Retrospective and Perspective

Since the early days of microbiology, astronomical numbers of microbial strains have been isolated from a wide variety of natural sources and used for scientific research and microbial industry. However, large numbers of microbial cultures had lost in the past, and they are no longer available. Microbiologists often lose the microbial cultures that they studied because of the change of their interests and difficulties in keeping the cultures. This negative outcome is due to the absence of reliable culture collections in which the microbial cultures can be maintained properly and supplied promptly on demand.

Through the study of microbial cultures maintained in culture collections, potential properties of microorganisms have been developed and the future perspective of microbiology can be foreseen. Effective research needs adequate and reliable sources of properly preserved cultures. In the near future, very large numbers of microbial cultures will be isolated through the study of biodiversity, and the attributes of large numbers of the cultures will be improved. Therefore, reliable and well-organized culture collections are needed as depositories and for the promotion of research and application of the cultures. In fact, culture collections play a key role in maintaining the type strains in bacteriology, and the study of bacterial systematics cannot be completed without reliable culture collections in consequence.

Microorganisms are widely used for biological studies and new advances in biochemistry, genetics, and molecular biology are essentially due to the study of microorganisms as a model of life. Microorganisms are not only of value for the production of useful substances, but they also play unique roles in element cycles with plants and animals. To a great degree, humans depend on individual microorganism in biotechnology and diverse ecosystems on the earth. Microorganisms are also significant gene pools, and these gene pools must not be lost. From this point of view, microorganisms can be regarded as a cultural heritage and cultural property, and must be transferred to the next generation in a normal and healthy condition.

Needs of society for culture collections are increasing year-by-year and their effective and smooth management is required. Exchange of information and cooperation among culture collections are crucial. Enhancement of culture collections is a key element for the future development of microbiology, microbial industry, and biotechnology. In addition, the good operation and management of culture collections are in great part due to the activity of highly trained and experienced personnel working in the culture collections.

The JFCC-JSCC has been working for strengthening Japanese culture collections and international cooperation with overseas culture collections. Further, the JFCC organized the ICC-1, and contributed to the establishment of the WFCC. The JSCC aims to renew the Japanese culture collections to modern biological resource centers with the highest standard, and to expand microbial networks in cooperation with other collections

throughout the world. Further, the building of a “human network” is essential for the further development of the culture collections.

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