Current status, strategy and future prospects of microbial resource collections

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Microorganisms, their cells or replicable parts (e.g. genomes, plasmids, viruses, cDNAs) are the tools for biotechnology and underpin the life sciences. The vast majority of microorganisms around the globe still remain hidden and need to be explored, identified, conserved and utilized for the benefit of humankind in particular, and the biota and environment, in general. Microbial culture collections are established in many countries around the world having a variety of purposes. These range from small, specialized collections that support small groups of researchers to the large international public service collections that provide reference materials and services to the scientific community and bio-industries. The huge gap between the discovery of new microorganisms and their potential numbers in nature has stimulated an interest in microbial diversity and the harnessing of their genes, properties and products. The operations of microbial collections have changed over the last twenty years as a result of the advancement of bioinformatics and the facility to present electronic data over the internet. This makes even the smaller collection resources more accessible.

Keywords: Biological diversity, bioinformatics, microbial resource centre, quality control.

MICROBIAL Resource Centres (MRCs) are the custodians of microbial diversity and play a key role in the storage and supply of authentic reference material for research and development. MRCs are often regarded as living libraries and represent dynamic institutions of learning, research, scientific culture and information. There is a need to ensure that such centres take advantage of modern technologies to deliver the tools for biotechnology and provide supporting services to help the government implement policies and to facilitate advancement of knowledge. MRCs harbour collections of culturable organisms (e.g. algae, bacteria, fungi, including yeasts, protozoa and viruses), their replicable parts (e.g. genomes, plasmids, viruses, cDNAs), viable but not yet culturable organisms, cells and tissues, databases containing molecular, physiological and structural information relevant to these collections and allied bioinformatics[1]. The upsurge in demand for microbial resources and the size of this relatively untapped and hidden resource offers justification for an increase in the number, scope and quality of MRCs.

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MRCs must be established with utility, particularly to serve scientific, industrial, agricultural, environmental and medical research, and development of biotechnological applications, while providing protection for intellectual property. They are a resource for public information and policy formulation amongst other roles. The benefits of the conservation and sustainable use of microbial resources emphasized by the Convention on Biological Diversity (CBD; http://www.biodiv.org), highlights the role of MRCs as *ex situ* protectors of biodiversity. They also offer an important interface between government, industry and the public, helping policy makers and the public to understand the value of conserving microbial resources. To perform such a comprehensive role, MRCs must form partnerships, share tasks and network.

Quality assurance and expertise

Implementation of international criteria in quality management is now essential for MRCs to provide reliable high-quality microbial resources and authentic information. MRCs now need to provide access to genes and genetic elements with associated information. Long-term and stable preservation of microbial resources is a crucial obligation of MRCs[2]. It is imperative to improve the infrastructure and techniques for storing recalcitrant organisms, microorganisms that are not yet culturable and DNA samples from diverse ecosystems that contain 'molecular signatures'. Reliable nomenclature and definitions become indispensable for data interoperability when listing biodiversity and making the resources available electronically. Dynamic bioinformatics tools will certainly improve data-handling, cross-referencing and transform collection catalogues as an interconnected data resource. Although the literature on 'microbial conservation protocols' is available[3–9], the UK National Culture Collection (UKNCC; http://ww.ukncc.co.uk) and the Common Access to Biological Resources and Information Consortium (CABRI; http://www.cabri.org) quality management systems have gone much further by setting minimum operational standards. The Organization for Economic Cooperation and Development (OECD) under the task force of 'Biological Resource Centre (BRC) Initiative' has taken these standards on-board and published the general requirements for the operation of MRCs (see http://

www.oecd.org/dataoecd/60/44/23547773.pdf). Thus MRCs must have access to a vast range of facilities, technologies and expertise. Additionally, governments, through the CBD, have acknowledged the existence of a taxonomic impediment to the sound management of MRCs (http://www.biodiv.org/programmes/cross-cutting/taxonomy/default.asp).

Microbial resource centres: The global scenario

As part of the OECD theme in biotechnology and environment, a panel of experts was convened to explore the development of the world's culture collections (http://oecdpublications.gfi-nb.com/cgi-bin/oecdbookshop.storefront). The panel envisaged a global virtual mechanism to improve access to high quality biological resources and proposed that a global network of centres be established to make material available for the furtherance of R&D around the world. Moreover, there is a goal to exploit biological diversity more effectively, with equitable sharing of benefits with the country of origin. Transformation of traditional culture collections to MRCs operating to internationally agreed criteria and compliant with relevant national laws, regulations and policies, is a prerequisite for this global network. The protection of intellectual property will be a priority in the execution of the MRC's role in preserving the diversity of genetic material for the benefit of humankind. To date, there are no designated MRCs under the OECD definition, but there are several microbial resource collections that could be candidates.

Microbial culture collections – An overview

Many collections originated from the work of individual researchers and have developed into the working assets of today. The World Data Centre for Microorganisms (WDCM; www.wdcm.nig.ac.jp/) describes over 470 culture collection centres in 62 countries, and over one million living cultures maintained by them. However, the WDCM listings do not include all collections around the world, as there are many private industrial collections and some in independent researchers' laboratories. Of the 470 culture collections, 175 are supported by the governments and 149 by universities; others are considered semi-governmental, private or industrial[10]. The WDCM data demonstrate a world imbalance in collection holdings. Europe and America hold 56% of the collections and 71% of the microorganisms, while greatest diversity exists outside these regions; for example, 20 to 30% of isolations in tropical environments are new to science[7,11]. Table 1 lists a number of collection centres around the world.

All collections have the same basic role to acquire, authenticate, preserve, add value to, and distribute biological material. In this work they must utilize information technology, protect intellectual property and operate to standards for the advancement, validation and application of scientific knowledge. The oldest collection that still operates today is the Centraalbureau voor Schimmelcultures; it has recently celebrated 100 years of existence (http://www.cbs.knaw.nl/). The American Type Culture Collection (ATCC) is considered the largest supplier of cultures in the world[12,13]. Collections traditionally hold strains of significant historical interest. There are many European collections (http://www.eccosite.org). Amongst their holdings are the fungi found on the 5000-year-old Tyrolean Iceman[14]. The most significant accession to the CABI living collection is considered to be IMI 24317, *Penicillium notatum*. Alexander Fleming deposited this as an example of his penicillin producer in April 1945 in the then National Collection of Type Cultures as NCTC 6978.

To meet the new demands, MRCs have recognized the need to network. This is happening at the regional, national and global levels. The UKNCC has UKNCC linked with nine collections with over 70,000 algae, bacteria, cell lines, fungi, protozoa and viruses (http://www.ukncc.co.uk). These on-line databases are easy to use and offer a convenient way to look for materials using a simple interface. The UKNCC coordinates some of the activities of the members in marketing and research. Information is provided for each member organization, including inventorying of techniques and equipments. The UKNCC offers both a culture/cell supply service and an identification service; organisms supplied include actinomycetes, algae, animal cells, bacteria, cyanobacteria, filamentous fungi, nematodes, protozoa, mycoplasma and yeasts. Similar initiatives have brought together Belgian collections, the Belgian Coordinated Collections of Microorganisms (BCCM™; http://www.bccm.belspo.be).

Asia has a long history of cultivation of fungi, particularly mushrooms for food. As early as 1500 years ago, China practised the cultivation of mushrooms for food and medicines[15,16]. As a consequence, a large number of culture collections are distributed in Asian countries. Japan too has many famous collections: most recently, the National Institute of Technology and Energy was established to exploit the microbial diversity of Asia (http://www.nitebrc.jp). The University of Hong Kong Culture Collection, situated at the Department of Ecology and Biodiversity, is one of the largest centres in China with 5000 fungal strains[17,18]. Additionally, the Agricultural Culture Collection of China (ACCC) holds more than 2000 fungal strains. The Indonesian National Commission for the Conservation of Genetic Resources (NCCGR) undertook an inventory of the existing culture collections of microorganisms in 1989, in cooperation with Research and Development Centre for Biotechnology. The findings of the inventory revealed at least 15 microbial culture collections in Indonesia. There is a general consensus among collection organizations that a functional network of existing culture collections could address the imbalance, where countries rich in biodiversity are lacking in resources. Indonesia, through the Communication Forum for Indonesian Culture Collection Curators, Malaysia and Thailand are addressing this and demonstrating that col-

Table 1. Some major MRCs with approximate number of organisms held

Name	Country	Approx. no. of organisms held
Agricultural Culture Collections of China (ACCC)	Bejing, China http://www.micronet.cn/institutes/accc/accc.html	More than 2000 strains
AHU Culture Collection	Graduate School of Agriculture, Hokkaido University, Japan http://ahu1.agr.hokudai.ac.jp/index.html	More than 1300 filamentous fungal strains and 200 yeast strains
All-Russia Collection of Microorganisms (VKM)	Moscow, Russia http://www.vkm.ru/contact.HTM	More than 3300 filamentous fungi and 23,00 yeast strains
American Type Culture Collection (ATCC)	Manassas, Virginia, USA http://www.atcc.org	27,000 filamentous fungi and yeast strains
Bioresource Collection and Research Centre (BACC)	Hsinchu, Taiwan http://www.bcrc.firdi.org.tw/bcrc/yes-flash.htm	More than 3000 filamentous fungal strains and 1500 yeast stains
BIOTECH Culture Collection	National Centre for Genetic Engineering and Biotechnology, Bangkok, Thailand http://bcc.biotec.or.th	3000 fungal strains
CABI Bioscience Genetic Resource Collection	Egham, Surrey, UK http://www.cabi-bioscience.org	28,000 living fungi and 350,000 preserved specimens
Canadian Collection of Fungal Cultures (CCFC)	Eastern Cereal and Oilseed Research Centre, Ottawa, Canada http://www. res.agr.ca/brd/ccc/ccctitle.html	11,000 fungal strains
Centralalbureau voor Schimmelcultures (CBS)	Utrecht, The Netherlands http://www.cbs.knaw.nl	28,000 filamentous fungal strains and 4500 yeast strains
Chiba University Research Centre for Pathogenic Fungi and Microbial Toxicoses	Cibra, Japan http://www.chiba-u.ac.jp/international/in/14ijr_eng/shinkinigaku.html	More than 10,000 fungal strains
China Centre for Industrial Culture Collection	China National Research Institute of Food and Fermentation Industries, Beijing, China http://www.china-cicc.org/endefault.htm	More than 1700 filamentous fungal strains and yeast cultures
Culture Collection of Basidiomycetes (CCBAS)	Institute of Microbiology, Prague, Czech Republic www.biomed.cas.cz/ccbas/fungi.htm	More than 700 fungal strains
Culture Collection of Fungi	Institute Department of Botany, Charles University, Praha, Czech Republic www.botany.natur.cuni.cz/en/structure/fungi.php	1800 fungal strains
Deutsche Sammlung von Mikrooganismen und Zellkulturen (DSMZ)	Braunschweig, Germany http://www2.dsmz.de/index.htm http://www.dsmz.de/dsmzhome.htm	2400 filamentous fungi and 500 yeast strains
Forest Research Culture Collection	New Zealand Forest Research Institute, Rotorua, New Zealand www.forestresearch.co.nz/	1500 filamentous fungal strains
Fungal Cultures University of Goteborg (FCUG)	Botanical Institute Goteborg, Sweden http://www2.botany.gu.se/database/FCUG/FCUG.html	9000 fungal strains
Fungal Genetic Stock Centre (FGSC)	Department of Microbiology, University of Kansas Medical Center, Kansas, USA http://fgsc.net	16,000 fungal cultures and cloned gene and gene library
Fungal Strain Collection	Museum National Histoire Naturelle, Paris, France	4000 filamentous fungal strains
Fusarium Research Centre (FRC)	Department of Plant Pathology, Pennsylvania State University, USA www.btny.purdue.edu/NC129	16,000 *Fusarium* cultures
IBT Culture Collection of Fungi	BioCentrum, Technical University of Denmark, Lyngby, Denmark http://www.ibt.dtu.dk/mycology/myindx.htm	22,000 fungal strains
Industrial Yeasts Collection	Dipartimento di Biologia Vegetale e Biotechnologia Perugia, Italy http://www.wdcm.nig.ac.jp/CCINFO/CCINFO	4500 yeast strains
Institute for Fermentation (IFO)	Osaka, Japan http://www.info.or.jp/index ehtml	All biological materials transferred to NBRC
International Collection of	Plant Diseases Division DSIR, Auckland, New Zealand	4700 fungal strains

(*contd...*)

Table 1. (*contd...*)

Name	Country	Approx. no. of organisms held
Microorganisms from Plants	http://www.landcareresearch.co.nz/research/biodiversity/fungiprog/icmp.asp	
Japan Collection of Microorganisms	RIKEN (The Institute of Physical and Chemical Research), Saitama, Japan www.jcm.riken.jp/	More than 1200 filamentous fungi and 2100 yeast strains
Korean Agricultural Culture Collection (KACC)	National Institute of Agricultural Science and Technology, http://www.brc.re.kr/English/ekctc.aspx	More than 1500 fungal strains
Labatt Culture Collection Labtte Brewing Company	London, Ontario, Canada www.bacterio.cict.fr/collections.html	2000 yeast cultures
Laboratory of Molecular Genetics and Breeding of Edible Mushrooms	University of Bordeaux 2, INRA d'Ornon, France http://www.wdcm.nig.ac.jp/CCINFO/CCINFO.xml	3500 filamentous fungal strains
MAFF Genebank, National Institute of Agrobiological Science	Ibaraki, Japan www.nias.affrc.go.jp/index_e.html	10,000 fungal strains
Mycology Culture Collection Mycothèque de l' Universite Catholique Louvain (MUCL)	Women's and Children's Hospital, North Adelaide, Australia www.fgsc.net/kmc/mccgermplasm.pdf http://belspo.be/bccm	2000 strains of filamentous fungi and yeast 25,000 fungal strains
National Collection of Agricultural and Industrial Microorganisms	Szent Istvan University Budapest, Hungary www.ncaim.kee.hu/	300 fungal strains and 1100 yeast strains
National Collection of Fungi: Culture Collection	ARC–Plant Protection Research Institute, Pretoria, South Africa www.arc.agric.za/institutes/ppri/	4500 fungal strains
National Collection of Pathogenic Fungi	PHLS Mycological Reference Laboratory, London, UK	1100 fungi and 200 yeast strains
National Institute of Technology and Energy Biological Resource Centre (NBRC)	Tsukuba, Japan http://www.nitebrc.jp	10,000
The Belgian Coordinated Collections of Microorganisms (BCCMTM)	BCCMTM/MUCL–Agro/Industrial Fungi and Yeast Collection Mycotheque de l' Universite Catholique de Louvain, Belgium http://www.bccm.belspo.be	More than 25,000 strains of filamentous and yeast-like fungi
The University of Hong Kong Culture Collection	Department of Ecology & Biodiversity, Hong Kong, China www.hku.hk/ecology/	5000 fungal strains
United States Department of Agriculture (USDA) ARS Culture Collection (NRRL)	Peoria, Illinois, USA http:/www. ars-grin.gov/npgs/tax/	55,000 filamentous fungi and 10,000 yeast strains
University of Alberta Microfungus Collection and Herbarium	Edmonton, Alberta, Canada http://www.devonian.ualberta.ca/uamh/	More than 9900 living strains
Yeast Genetic Stock Center	At ATCC http://www.atcc.org	1200 *Saccharomyces* stocks

Source: WFCC–MIRCEN World Data Centre for Microorganisms and links to other sites http://wdcm.nig.ac.jp.

lections can flourish and provide a better service together. A network of Japanese culture collections was initiated by the Foundation of the Japan Federation for Culture Collections in 1951 (presently known as Japan Society for Culture Collections, JSCC). The society consists of Japanese culture collections that encompass strains related to applied microbiology, medical microbiology and other areas of microbiology. It aims to encourage research on microorganisms and to exchange information concerning them. Such national and regional approaches can allow sharing of tasks and facilities, and thus a more cost-effective mechanism for better characterization of strains and a coordinated and targetted collection strategy.

Indian scenario

India is endowed with enormous variability in fungi, bacteria, including actinomycetes, viruses and cyanobacteria. These form an invaluable gene pool. India is one of the 12 countries of megadiversity, but although a rich microbial diversity is anticipated, a lack of adequate support and expertise hampers discovery. The investigation of this huge resource has been recognized by Indian Council of Agricultural Research (ICAR), initial focus to improve crop production for the food and economy. India's rich microbial diversity (14,500 species of fungi, 2000 lichens, 17,000 flowing plants are currently known), has not been adequately enumerated and catalogued. Over the years many laboratories in India have studied Indian microflora, many new genera and species have been described and their biotechnological potential has been emphasized. Data on Indian microbial resources have remained mostly with the investigators and in papers published by them. It is not known how many of them have been conserved for future use. As a result, we do not have cohesive access to information about microbial preservation and conservation in India. However, a programme was initiated to collect, collate and digitize data available on Indian microbial resources by the National Bureau of Agriculturally Important Microorganisms (NBAIM), Mau.

Major microbial resource centres in India

India has a long history of studying microorganisms, particularly fungi and research is being carried out at a variety of institutions, including the Centre for Cellular and Molecular Biology (CCMB), Hyderabad and the Institute of Microbial Technology (IMTECH), Chandigarh. Collection centres in India include the National Collection of Industrial Microorganisms, Pune and a collection of 2500 (approx.) fungal strains at Indian Type Culture Collection (ITCC), Indian Agricultural Research Institute (IARI), New Delhi (Table 2). Several non-fungal collections as well as mycological herbaria exist in India. The IARI started the conservation and characterization of agriculturally important microorganisms in 1935, a rhizobial collection was established in 1992 and a blue-green alga collection in 1988. The Indian Type Culture Collection (ITCC) was established in the Division of Mycology and Plant Pathology, IARI during 1935. The ITCC collection consists of only fungal cultures of agricultural, medicinal and industrial value.

The Microbial Type Culture Collection and Gene Bank (MTCC) at IMTECH is a well-equipped modern facility housed at Chandigarh. The main objectives of this centre are to act as a depository, to supply authentic microbial cultures and to provide identification services to scientists working in research institutions, universities and industries. Relevant information about the strains held in MTCC is computerized for easy search, analysis and retrieval. The Defence Material and Stores Research and Development Establishment Culture Collection, DRDO, New Delhi has also preserved more than 1100 fungal strains. The Biodiversity Documentation Centre, Jawaharlal Nehru Centre for Advances in Scientific Research, Bangalore, a sister organi-

Table 2. Some culture collections in India

Name	Collections (approx.)
Biodiversity Documentation Centre, Jawaharlal Nehru Centre for Advanced Scientific Research, Jakkur, Bangalore	–
Centre for Cellular and Molecular Biology, Hyderabad	–
College of Agriculture, Maharana Pratap Agricultural University, Udaipur	26 strains
Defence Material and Stores Research and Development Establishment Culture Collection, Defence Research and Development Organization, New Delhi	1100 fungal strains
Delhi University Mycological Herbarium, New Delhi	200 strains
Department of Microbiology, Bose Institute, Kolkata	102 strains
Division of Standardization, Indian Veterinary Research Institute, Izatnagar, Bareilley, UP	153 strains
Fungal Culture Collection, University of Delhi, New Delhi	70 strains of fungi
Indian Institute of Science, Bangalore http://www.iisc.ernet.in	359 strains
Indian Type Culture Collection, Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi www. iaripusa.org/	More than 4000 fungal strains
MACS Collection of Microorganisms, Pune	264 strains
Marathwada Agricultural University (Collection of insect pathogens), Parbhani	32 strains
Microbial Type Culture Collection and Gene Bank (MTCC) Institute of Microbial Technology, Chandigarh www.imtech.res.in	3020 cultures of fungi, actinomycetes, yeasts, bacteria and plasmids
National Bureau of Agriculturally Important Microorganisms (NBAIM), Kusmaur	1500 fungi and 325 bacteria
National Collection of Dairy Cultures, National Dairy Research Institute, Karnal http://www.ndri.nic.in	310 cultures
National Collection of Industrial Microorganisms National Chemical Laboratory, Pune http://www.ncl-india.org/ncim	2955 fungi and yeast strains
University of Mumbai, Food and Food Technology, Mumbai	63 strains

Source: Sites of respective culture collections.

zation of Indian Institute of Science, Bangalore focuses on selected areas of topical significance. One of these is biodiversity, and the unit is engaged in laboratory studies on microbial biodiversity and field research programmes, in the Western Ghats and the Himalaya. It is not possible to mention all collection centres/universities here, that have contributed to the identification and conservation of Indian microorganisms. A total of 14 major Indian collections have been registered with the WDCM, where further information can be found. An additional incentive to modernize India's culture collections is to support India's decision to become a signatory to the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure (http://www.cnpat.com/worldlaw/treaty/budapest_en.htm). This will enable India to establish an 'International Depository Authority' and make it possible to deposit microorganisms subject to patent in a recognized depository within India.

Establishment of NBAIM in 2001 as a National Culture Collection Centre will help in the back-up of all available Indian resources in facilities, to meet the current and future requirements for the conservation and characterization of agriculturally important microorganisms (AIMs) of India. This process is of paramount importance, not only from the point of view of protecting the gene-pool, but also for supporting integrated pest and disease management programmes. The identification of indigenous species, strains, races and types of microorganisms would also help in identifying and developing suitable biocontrol agents, which in this century, will be the main armoury for eco-friendly management of pests and diseases. The Bureau will provide novel opportunities for isolating and utilizing genes for conventional and unforeseen microbial products of high economic, environmental and agricultural value. This effort will greatly strengthen the national capability in quarantine and other regulatory measures. The NBAIM will also be the depository of AIMs that in turn will facilitate the registration and protocols for patenting. Above all, the Bureau would help in the understanding of our national microbial heritage, which hitherto has had little attention. The main aims of the Bureau are: (i) exploration and collection of microorganisms from soil, plants, freshwater and other ecosystems covering different agro-climatic regions; (ii) central storage of AIMs from existing culture collection centres, institutions and universities. The Bureau will function as a depository/repository for all the AIMs available in the country; (iii) repatriation of key cultures of Indian origin from different culture collections located in other countries, including international centres; (iv) characterization of microorganisms based on morphological, physiological, biochemical and molecular markers; (v) development of molecular markers and diagnostic tools for diversity analysis; (vi) presentation of the collection in electronic format for easy access to information; (vii) development of a National Microbial Gene Bank for conserving the variability of agriculturally important fungi, bacteria, viruses and cyanobacteria. The evaluation and characterization of microbes could find genes suitable for agricultural and industrial use. The project will boost the Integrated Pest Management programmes, and other microbial productivity-based research; (viii) conservation (both short-term and long-term) and utilization of microorganisms. Identification of AIMs for utilization, for example, as biofertilizer, biopesticides, growth promoters, bioindicators, in biodegradation, bioremediation, biocomposting, and food processing; (ix) surveillance of indigenous/exotic AIMs; (x) human resource development; (xi) promotion of bioinformatics tools for quick access to information on AIMs by end-users, while serving as a national node for international networking. Moreover, other activities including supply of authenticated cultures to users under material transfer agreements (MTA), helping prepare and providing data for international agreements/mechanisms, development of safety standards, facilitate IPR protection for novel microorganisms/ biomolecules, etc. will be undertaken in near future.

Bioinformatics and MRCs

The meticulous and thorough characterization of microorganisms, the storage and analysis of the generated information and its intelligent interrogation will provide us with microbial solutions to critical challenges of our age. It is imperative that scientists, researchers in biosystematics and taxonomy employ modern tools of informatics and data processing to make best use of our microbial resources. The elements of taxonomy such as species description, development of identification keys, scientific nomenclature, treatment of morphological, nutritional and physiological traits, are increasingly being computerized to meet the challenge.

The process of storage of genetic information with digital techniques for archiving, interpreting and quantifying of data in artificial systems is an important feature of bioinformatics[19–21]. Microbial taxonomists and curators must take full advantage of the available technology that has been so ably adopted in other biological fields. Sequence data have now been available on the web for many years for public access and utilization (http://www.ncbi.nih.gov/Genbank/GenbankSearch.html; EMBL(http://www.ebi.ac.uk/embl/) are two key resources. However, Bridge *et al.*[22] suggested that up to 20% of publicly available, taxonomically important DNA sequences for three randomly chosen groups of fungi were probably incorrectly named chimaeric of poor quality or incomplete for reliable comparison. MRCs have a role to play in providing information based on authentic and stable strains with validated sequence data. MRCs need to harness the new bioinformatics technologies and begin the networking processes to establish a global network. The groundwork can be laid by stimulating collaborative molecular taxonomic research and novel database development.

Biodiversity census

While undertaking a biodiversity census of the Western Ghats, Madhav Gadgil reported that in a set of 2500 species, approximately 17% were microorganisms (http://ces.iisc.ernet.in/hpg/cesmg/indiabio.html). Indian mycologists in particular, have described about 22,000 fungal species within the globally known number of 90,000 species. Among the 200 genera reported from India, about 80% belong to mitotic fungi. In 2000, the Ministry of Environment and Forests, Govt. of India launched the All India Coordinated Project on Taxonomy to bridge the biodiversity information gap. The coordinating centre for bacteria and Archaea is located at Pantnagar with sub-centres at Ajmer, Delhi, Jabalpur, Pune and Varanasi. In addition, the Department of Biotechnology, Govt. of India supported a network programme on microbial diversity with a two-pronged approach: one, to develop a database of the existing diversity, and the other focused on the search for new and novel taxa and their exploitation. In addition, as part of the National Biodiversity Strategy and Action Plan of the Govt. of India, a stand-alone document on 'Microorganism Diversity: Strategy and Action Plan' has been prepared[23]. The NBAIM will have a key role in supporting this national plan.

Development of MRC through national and international cooperation

Much of microbial groups hitherto undescribed and non culturable still remain to be tapped for biotechnological exploitation. Recognition and importance of culture collection is emphasized by the 'OECD-BRC Initiative', now extending into its third phase after assessment by OECD member-country ministers in March 2004. The Japanese, Thai and Chinese governments have all recognized the potential and have invested in the collection, characterization and utilization of their microbial diversity. It is essential that the developing countries should recognize and assess their microbial diversity. Investment in capacity-building, networking and partnerships will enable them to engage fully and develop their own bio-economies.

In order to address the emerging areas of the management of microbial diversity through national and international cooperation, the following areas should be strengthened: (i) underpin the efforts of scientists in microbial research in terms of human resource development, initiate courses in microbial taxonomy and identification of hitherto undescribed microbial diversity, and strengthen the extensive training programmes on morphological, physiological, biochemical, immunological and molecular characterization of microbes; (ii) establishment of major initiatives in taxonomic methodology, database, and information storage and dissemination, diversity discovery tools, genomics and microarray technologies; (iii) discovery of new tools and techniques for the characterization of new species/genera of microorganisms; (iv) survey microbial diversity in different ecological zones, and identify economically important microbial metabolites, database development and information provision; (vi) establishment of a quality management system, including database management and data access initiatives; (vii) developing new business plan and opportunities; (viii) establishment of Microbial Gene Bank; (ix) development of joint international research projects.

Conclusion

In today's world, with focus on biodiversity and bio-prospecting of novel microorganisms, culture collections play an important role in an ongoing comprehensive inventorization of the bioarithmetic and biogeography of the microbial world. The electronic capture and use of data as well as the organisms themselves will provide employment opportunities in the bioindustry. The potential of microorganisms to provide solutions to food, health, environmental and poverty issues is enormous. It is essential that India has a specialized database on microbial genetic diversity integrating morphological, nutritional, serological and biochemical characteristics. The continuing emergence of molecular biology will develop novel gene-based bioindustries as a result of the rich diversity and variety of the microbial world. To assist this development, culture collections worldwide are encouraged to create novel and better techniques for bio-prospecting of novel microorganisms, carry out molecular sequence analysis, define phylogenetics relationships, execute taxon-based research on population structure of natural consortia, and pools of microorganisms, monitor and track genetically-engineered microorganisms that have been released for use in the environment and industry, and develop novel standardized methodologies for *in situ* investigations and *ex situ* conservation of microbial genetic resources. To position India in the centre of such activities, the NBAIM will in all probability serve as a catalyst.

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