Research Resources Help To Drive Innovation in Microbiology

Making microbial resource centers more effective will benefit users while fostering research and innovative industrial developments

David Smith

Microorganisms, harnessed for thousands of years, contribute to brewing and fermentations, health care, environmental remediation, and industrial products, and thus are a key component of the global economy. Microbial collections of many sorts serve to store and supply samples for reference, production, and screening for new compounds. Strengthening infrastructures to encompass those resources could further ensure authenticity, while accelerating efforts to generate knowledge, solutions, and products. Coordinating this effort could also facilitate discovery of drugs, industrial enzymes, and probiotics—leading to healthier lives, improved natural control of pests and diseases, and many other benefits to society.

Microorganisms are essential for life on earth. They recycle carbon and provide more than 30% of the oxygen we breathe. They are a crucial component of the bio-economy, a set of economic activities including the invention, development, production, and use of biological products and processes that could prove valuable for all countries. These benefits are expected to improve health outcomes, boost agriculture and industrial productivity, and enhance environmental sustainability—in short, improving livelihoods. Indeed, participants in the European Strategy Forum for Research Infrastructures (ESFRI) recently identified several ways in which microbial resource centers could be made more effective and efficient.

Culture Collections

More than 100 years ago, biologists began establishing culture collections to provide living materials for their research. However, the task of providing resources for microbial research is too large for a single collection, necessitating a systematic and networked approach to harness microbial and cell diversity.

Summary

- European Strategy Forum for Research Infrastructures (ESFRI) participants identified several ways to make microbial resource centers more effective and efficient.
- Organizations such as the European Culture Collection's Organisation and the World Federation for Culture Collections, which began promoting culture collections more than four decades ago, support organism supply, maintenance, and delivery activities.
- Biological resource centers, or BRCs, supply samples of living organisms and provide services for preserving them to microbiologists working across a broad array of fields.
- The Organisation for Economic Cooperation and Development BRC Task Force recommends that governments, policy makers, and other stakeholders help to provide access to high quality biological material to support research and development programs.
- To succeed and become sustainable, microbial domain BRCs (mBRCs) will need to work more closely with policy makers, funders, and researchers to deliver resources and services needed for innovation.
The World Federation for Culture Collections (http://www.wfcc.info) began promoting the activities of culture collections more than four decades ago. Its efforts are supported regionally by organizations such as the European Culture Collection’s Organisation (ECCO – http://www.eccosite.org) and several national federations (Table 1). However, additional work is needed to harness fully the power of microbial diversity.

The World Data Centre for Microorganisms (WDCM) currently lists 1.7 million strains available via 585 collections. It includes 506,333 strains of fungi representing approximately 100,000 fungal species; about 25% are ex-type or subspecies. It also includes 758,831 bacteria representing 9,000 or so valid species, including 20,458 strains of Type species or subspecies of bacteria. The gap in coverage of possible phenotypes is considerable.

### Culture Collections Play Several Key Roles

The track record for researchers depositing strains into collections is dismal. Of 20,200 prokaryotic research strains mentioned in 835 articles in eight European journals during 2008, only 190 strains, or 0.94%, were deposited in public collections. Such biological resource centers (BRCs) provide living organisms and services for preserving them to microbiologists working across a broad array of fields.

Although the total of microorganisms supplied by such collections is not documented, one BRC, the DSMZ-Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, supplies on average more than 20,000 per year. Other collections are not so active, and a more likely figure for those most well used would be about 4,000 samples per year. Based on this estimate, the 585 collections registered with WDCM supply perhaps 500,000 strains each year, and those samples include all types of microorganism and cell materials, including algae, animal cell cultures, bacteria, fungi, plant cell cultures, protozoa, and viruses.

### Table 1. National and Regional Culture Collections

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Network</th>
<th>Link</th>
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<tr>
<td>ABRCN</td>
<td>Asian Biological Resource Center Network</td>
<td><a href="http://www.abrcn.net/">http://www.abrcn.net/</a></td>
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<td>BCCM™</td>
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<td>SBMCC</td>
<td>Brazil–Sociedade Brasileira de Microbiologia Coleção de Culturas</td>
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<td><a href="http://micronet.im.ac.cn">http://micronet.im.ac.cn</a></td>
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<td>FCCM</td>
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<td><a href="http://www.eccosite.org">http://www.eccosite.org</a></td>
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<tr>
<td>SCCCMOMB</td>
<td>Cuban Culture Collection and other Biological Materials Section</td>
<td>Contacts: Iglesias: <a href="mailto:elise@finlay.edu.cu">elise@finlay.edu.cu</a> (President); <a href="mailto:weng@infomed.sld.cu">weng@infomed.sld.cu</a> / <a href="mailto:ccm@inhem.sld.cu">ccm@inhem.sld.cu</a> (Vice President); <a href="mailto:nancy@iliorad.quimefa.cu">nancy@iliorad.quimefa.cu</a> (Secretary); <a href="mailto:raisi@ccmed.sld.cu">raisi@ccmed.sld.cu</a> (Finances)</td>
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<td>KFCC</td>
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<td>MICCO</td>
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<tr>
<td>PNCC</td>
<td>Philippines National Culture Collections</td>
<td>Contact: Rosario G. Monsalud, Ph.D., Head, PNCM, <a href="mailto:rosegm@laguna.net">rosegm@laguna.net</a></td>
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<tr>
<td>TNCC</td>
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Because as many as 99% of strains being studied are not from such public collections, perhaps many millions of strains are being exchanged each year without being authenticated or properly preserved. If so, this ad hoc approach could well undermine the research being done. It is essential that BRCs provide reliable and authentic biological materials (Fig. 1).

BRCs are not just repositories or suppliers of strains. They provide many additional essential
services. For example, of the WDCM-registered collections, 85 provide patent deposit services; 295 provide identifications; 250 provide training; and 261 provide consultation services. With the numbers of microbial taxonomists diminishing, maintaining a critical mass of such experts is essential. Today, when images from microscopes can easily be viewed virtually anywhere, the expertise of specialists can be drawn on through the Internet to address questions from distant environments and ecosystems. For instance, CABI Bioservices identifies about 2,000 specimens per year, while other collections deal with similar or even higher numbers of such tasks; the demand is huge.

Initiatives Aim To Develop Deeper Knowledge of Microbial Potential

At the current rate, it could take 1,400 years before we accumulate the estimated 1.4 million species of fungi believed to exist. Technologies such as metagenomics are accelerating our understanding of microbial diversity. However, we need targeted programs to provide novel material for biotechnology. Additionally, only a small fraction of the described fungal species has been screened for natural products. Although high-throughput screening helps, it affords only a snapshot of an organism’s chemistry. Deeper knowledge about the life cycle of each fungal strain and its interactions in its ecosystem is essential to ensure extracts of the organism reflect its full potential.

In Europe, ECCO has supported microbial collections for more than three decades, while fostering several initiatives to better meet user needs. Recent examples include several projects of the European Community Framework Programme: Common Access to Biological Resources and Information (http://www.cabri.org), EBRCN (European Biological Resource Centres Network—www.ebrcn.net), and the European Consortium of Microbial Resource Centres (http://www.embarc.eu).

However, funding such projects is not the full answer to these challenges. Networking is needed to improve coverage and to provide high-quality products and services. This networking, in turn, will provide access to funds for the next-generation culture collection, the microbial Biological Resource Centre (mBRC). It will deliver resources and services to support innovative research and development efforts.

These European projects prompted development of technical guidelines and information documents covering requirements for modern microbial collections to meet. The documents also provide information describing the 1999 Organisation for Economic Co-operation and Development (OECD) Biological Resource Centre (BRC) initiative, part of the paradigm shift from traditional culture collections to high-quality biological resource centers. The OECD BRC Task Force recommended that governments, policy makers, and other stakeholders acknowledge that access to high-quality biological material is vital for the support of research and development programs. As part of this initiative, the task force insisted that BRCs “meet the standards of quality and expertise demanded by the international community of scientists and industry for the delivery of biological information and materials that will enable research.” The task force also noted that “Adequate funding is required to achieve these standards and assure sustainability.”

![Figure 1](Image)

Preservation of microorganisms at ultra-low temperature close to that of liquid nitrogen at −196°C retains long-term stability for future use. (Image © CABI.)
Guidance documents for operating such BRCs specify steps for ensuring quality management and biosecurity as well as strategies for setting up a Global Biological Resources Centres Network (GBRCN). These efforts led to the 2008 demonstration project for a GBRCN (http://www.gbrcn.org). It subsequently expanded to add partners in North and South America, Africa, and Asia to its strong base in Europe. On a global level, the project aims to build a long-lasting network of collections to meet user needs and to address technical, legal, and administrative challenges.

Another development is the EMbaRC project, which lays the foundations for the European platform of the GBRCN. Key issues are biosafety and biosecurity, development of added-value techniques, and the improvement, coordination, and validation of microbial resource-center protocols. Other aims are to optimize conservation and identification of bacteria and fungi, and to generate high-quality DNA. This project is also committed to convincing more researchers to deposit their strains with collections. Deplorably, the scientific literature is full of data which cannot be verified because the material is either no longer available and/or the material once used to generate the data has changed or deteriorated. Enhanced networking will provide better access to microorganisms in these collections along with validated data describing them.

The EMbaRC project also is developing business models to increase the sustainability of these BRCs. Additional capacity already is needed to cope with the avalanche of novel materials being identified and collected. The delivery of these materials to microbiological resource centers (mBRCs) will require them to develop new expertise and greater capacity when the existence of some collections is under threat. Additional funding is needed—in part, as an investment for continuing scientific research in biotechnology.

Globally Coordinating mBRCs and Culture Collections Is a Critical Challenge

The time has come to coordinate public service microbial culture collections worldwide. To meet the needs of expanding biotechnological and biomedical research and development programs, this effort must address the technical, scientific, administrative, and infrastructural levels of quality. Culture collections will need considerable help to become modern mBRCs. More mBRCs are needed around the world, equipped with expertise and access to technologies that will help them to cope with the depth and breadth of emerging biodiversity. In turn, they can provide local scientists with ready access to high-quality biological material and scientific services while observing the rights of donor countries, intellectual property rights, and biosafety and biosecurity requirements.

One major challenge is to keep abreast of developments in taxonomy and systematics, while maintaining expertise as new methods to authenticate, identify, cultivate, and maintain cultures are developed. Because meeting this challenge is so difficult, individual mBRCs will need to cooperate, harnessing the power of networking on a national, regional, and global level.

For these very reasons, the GBRCN, ECCO, and EMbaRC consortia submitted a proposal to the European Strategy Forum for Research Infrastructures (ESFRI). This proposal, the Microbial Resources Research Infrastructure (MIRRI), was recommended for inclusion on the ESFRI Road Map. MIRRI brings together European microbial resource collections with stakeholders, including their users, policy makers, potential funders, and scientists leading microbial research efforts. Its underlying aim is to improve access to enhanced quality microbial resources in an appropriate legal framework, thus serving life sciences research.

By providing resources, technologies, and services, ESFRI will be establishing pan-European structures to drive innovation. Having launched 10 research infrastructures to support the biological and medical sciences, Europe is laying down the foundation to harness biodiversity. The ESFRI aims at overcoming fragmentation and thereby providing Europe with up-to-date research infrastructures (RI).

There are 44 RIs, each addressing a unique niche of research, with 10 established RIs in the Biology and Medical Sciences (http://www.ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri). Each RI is designed to deliver scientific and technological excellence and to provide pan-European added value. They offer unique research services to users from different
countries, attract young people to science, and help to shape scientific communities. RIs are at the center of the knowledge triangle of research, education, and innovation, producing knowledge through research, diffusing it through education, and applying it through innovation.

MIRRI is one of three new RIs added to the 2010 ESFRI road map (www.mirri.org). It will be initially co-ordinated by the GBRCN Secretariat based in Braunschweig, Germany, uniting the efforts of EMbaRC, ECCO, and the GBRCN. It will integrate services and resources, bridging the gap between collecting and maintaining particular microorganisms and the provision of innovative solutions when it comes to using those microorganisms. MIRRI will provide coherence in the application of quality standards, homogeneity in data storage, and coordination in sharing workloads. It will work with microbiology societies, users, and policy makers to ensure it delivers the services that are required. During 2012, MIRRI will focus on technical, legal governance, and financial issues. Specific programs and goals include:

- networking to enable broader coverage of such resources;
- taking a coordinated approach to acquiring microorganisms, building the expertise to handle them, and establishing mechanisms to implement best practices;
- designing a platform for microbial taxonomy;
- establishing a human resource development program;
- tackling key obstacles to research needs in a coordinated way;
- helping to establish facilities and resources in countries or regions rich in microbial diversity but without their own resources and facilities;
- linking to other data systems to improve data mining efficiency;
- establishing common operational safe-access procedures within a legal framework;
- coordinating scientific needs with government policies;
- forging ties with countries lacking BRCs; and
- enhancing efficiency while reducing redundancies, and improving transparency.

MIRRI plans to establish clusters of expertise to address problems faced by BRCs and to meet the specific requirements of individual users. It also will cooperate with other RIs, including the Biobanking and Biomolecular Resources Research Infrastructure (BBMRI), that cater mainly to different user groups. Because user demands vary, one collection will rarely be capable of serving all their needs. Hence, international cooperation is the sensible way forward. To succeed and to become sustainable, modernized culture collections and the mBRCs will need to work more closely with policy makers, funders, and researchers to deliver resources and services needed for innovation.

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SUGGESTED READING
EBRCN Information Resource (Online), http://www.ebrcn.eu
Institute of Fermentation, Osaka. Proceedings of the Kral Symposium to celebrate the centenary of the first recorded service culture collection, Osaka, Japan.
World Data Center for Microorganisms (Online). http://www.wfcc.info