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Global microbial commons: institutional challenges for the global exchange and distribution of microorganisms in the life sciences

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Abstract

Exchanges of microorganisms between culture collections, laboratories and researchers worldwide have historically occurred in an informal way. These informal exchanges have facilitated research activities, and, as a consequence, our knowledge and exploitation of microbial resources have advanced rapidly. During the last decades of the twentieth century, the increasing economic importance of biotechnology and the introduction of new legislation concerning the use of and access to biological resources has subjected exchanges of genetic resources to greater controls. Their access and distribution are more strictly regulated and, therefore, exchanges are becoming more and more formalized. This paper analyzes one of the main drivers of the movement toward more formal worldwide exchange regimes, which is increasing global interdependency of access to genetic resources. Its main finding is that formalization of exchange practices as such is not necessarily leading to more restrictive licensing conditions. The goal of further formalization and harmonization of institutional frameworks should therefore be to provide the broadest possible access to essential research materials (within the constraints set by biosecurity and quality management requirements), while maximizing the reciprocity benefits of access and exchange (which motivate the exchange practices to start with).

Keywords: Culture collections; Material transfer agreements; Governance; Convention on biological diversity

1. Introduction

In the twentieth century, there was a tremendous increase both in the quantities of microbial and genetic resources exchanged and in the global interdependencies of these exchanges (Parry, 2004). This movement is related to several scientific developments, among which the introduction of improved techniques for the handling and long-term maintenance of living microbiological samples (e.g. freezing, freeze-drying), and thus easier and safer shipping of samples, has had a major impact (Cypess, 2003). Similarly, the development of innovative methods for the isolation and cultivation of new microbial strains (Janssen, 2008; Kamagata, 2004), the genomics revolution (Colwell, 2002; Zengler, 2008; Stackebrandt, 2007), and the broader impact of globalization of research in the life sciences in general (Beattie et al., 2005; Ten Kate and Laird, 2002) have enhanced interest and cooperation in microbial research.

The global distribution and exchange of microorganisms is organized on a formal basis by the network of over 500 culture collections that are member of the World Federation of Culture Collections (WFCC) (Dugan and Tang, 2000; Kurtzman and Labeda, 2009; WFCC, 2010). Access to microbial genetic resources from the culture collections is granted under terms and conditions that vary widely between countries and within countries, between the larger collections – which have formal arrangements for access – and the smaller collections – which often do not use written contracts for access arrangements.

Previous studies have shown that informal exchanges among scientists and/or culture collections represent a large percentage of the exchanges (Stromberg et al., 2006; Dedeurwaerdere, 2009). Informal exchange amongst scientists mostly occurs in the context of collaborative projects or between researchers who know each other. For example, as stated by one culture

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collection manager, in the field of clinical research (and in particular epidemiology), informal exchange occurs on a regular basis among study groups (to be considered as clubs which sometimes have their own material transfer agreement (MTA)), or between researchers who know each other or have read publications in which particular strains were used. Providing single strains is usually not a problem, but requests to other researchers for collections are more complicated because they cannot give away the material needed their own future research. Sometimes this is solved by collaborating or inviting the requesting colleague to come and work in the laboratory of the donor (L. Dijkshoorn, personal communication). However, these patterns of informal exchange are not limited to clinical research, but have been consistently reported to be an important feature of exchange in all collections in the various fields of microbiology (Stromberg et al., 2006; Dedeurwaerdere, 2009).

Informal distribution of strains occurs without any written contract governing the terms of provision or receipt of the material concerned, under the presumption that it will only be used for research and non-commercial purposes. Some collections even distribute material only on an informal basis. This is especially true for the smaller and more specialized collections. Other collections are using or have recently started to use standard forms for depositing as well as for distributing strains for non-commercial purposes. As a general trend, however, more and more collections, in both developing and developed countries, are moving toward formal arrangements.

This paper surveys recent discussions on the design of institutional arrangements for the worldwide exchange of microorganisms and examines propositions for placing the global microbial commons on a more solid legal and institutional basis. Most of the survey data reported in the empirical results section (Section 3) comes from questionnaires that have been addressed to all the culture collections, independently of their field of specialization. The majority of the answers that are reported did, however, come from the field of environmental, food and agricultural microbiology, and from some important taxonomic collections. A smaller number of clinical research collections responded to the surveys. The first section discusses the disadvantages of the current informal system and presents three real-world examples of a formal approach. The second section analyses one of the main drivers of the movement toward more formal worldwide exchange regimes, which is the increasing global interdependency of access to genetic resources. Some institutional suggestions and possible implementation paths are discussed in section three.

2. Examples of a self-regulatory approach to formalized exchanges

The main advantage of the existing informal networks (clubs or loose networks of scientists) is to lower transaction costs (that is, costs related to negotiations to be undertaken, contracts to be drawn up, inspections to be made, arrangements to be made to settle disputes, and so on, cf. Coase, 1995), while allowing the re-use and further distribution of the research materials with few, if any, strings attached to them arising from concerns about potential future commercial applications (Reichman, J. H., Dedeurwaerdere, T. and Uhlir, P.F., unpublished). At the same time, tacitly recognized quality management standards observed by trusted members of the club guarantee the authenticity and integrity of the materials exchanged.

Despite their presumed efficacy, however, these informal networks exhibit a number of serious disadvantages (Ibid and Stern, 2004). They are necessarily limited in size because, without a personal relationship built on trust, the participants would not willingly sustain the case-by-case efforts of verifying compliance with acceptable quality standards. They would also expose themselves to the risk that unknown third parties could free-ride on the underlying tacit norms that support the system, without affording reciprocal access to collections of equal quality on equivalent terms. If third parties were allowed to extract materials from the club's resources, moreover, the original providers would lose control over them and thereby forfeit the ability to claim either reputational or commercial benefits from ensuing research use and commercial applications.

Given the commodity pressures on microbial science, moreover, the stability of the informal system over time will probably be diminished as more and more contributors succumb to the high-protectionist MTAs offered by a few non-profit and private members of the World Federation Culture Collections (WFCC). This is illustrated below through the example of the MTA used by the American Type Culture Collection.

The adoption of rather restrictive access measures by several developing countries, as a reaction to excessive bioprospecting and patenting by developed countries (Safrin, 2004), further threatens the efficacy of an informal regime. In particular, access procedures may lack transparency and be quite complicated, involving lengthy delays in obtaining genetic materials (Roa-Rodriguez and Van Dooren, 2008). Scientists from both developed and developing countries have repeatedly expressed concern about the harm that restrictive access regulations may have on scientific research (Jinnah and Jungcurt, 2009).

To offset these negative trends, some WFCC members have developed MTAs that formalize the basic norms and benefits of the informal club system, along with the obligations and responsibilities that support them. These formal MTAs are, however, only a first step in the attempt to build a truly global microbial commons and are hampered by the wide variety of license conditions which are currently being adopted and the lack of public funding that affects some of the most important collections. This can be illustrated by three examples of MTAs adopted by large collections or federations of collections. These examples have been selected to represent a broad geographic scope and a wide diversity of funding structures.

2.1. The American Type Culture Collection: an example of a private culture collection MTA

More than 80% of the WFCC collections belong to public sector entities (universities or governments). The remaining are semi-governmental (8%) and, in a few cases, private non-profit (4%) or private industry collections (1%) (Stern, 2004). Private non-profit and private industry collections are more likely to impose restrictive license conditions. One example is the policy adopted by the American Type Culture Collection, which currently receives only 15% of its core funding from direct government grants (Stern, 2004; www.atcc.org). The ATCC model is the exception rather than the rule, both because it is one of the rare private non-profit collections and because of its controversial restrictive license policy (Trüper and Tindal, 2005; Perrone and Soriano, 2005). However, because of its dominant historical role and the importance of its holdings, the ATCC attracts considerable interest from other collections in both developing and developed nations.

The ATCC MTA (www.atcc.org, last accessed December 2009) requires that the material be used for research purposes only, within the purchaser's laboratory. In the case of industry-sponsored academic research, the authorized use extends only to research carried out at the university and by the university's employees. Any use of the biological materials by the industry sponsor requires a separate license from the collection. The MTA also deals with ownership and intellectual property rights. The collection categorically affirms its "ownership" of the materials deposited in and distributed from its collection. Hence, with the notable exception of samples deposited by the Yellowstone National Park (see Kerry, K., Touche, L. and Collis A., 1998, http://www.cbd.int/abs/cs.shtmlet al.), ATCC's MTA states that the collection and/or its contributors retain ownership of all rights, titles and interests in the distributed materials, their progeny and unmodified derivatives, including any materials contained or incorporated in modifications. Any recipient that would violate any of the terms of this MTA, for example, by distributing type strains received from ATCC to a third party or using it in a different laboratory then the one stipulated in the contract, is acting illegally and faces the eventuality of a lawsuit.

The MTA does, however, recognize that the recipient of the material has ownership of (a) modifications (except that the collection retains the rights to any original material included therein) and (b) any substances created through the use of the distributed material which do not contain that material. Moreover, the conditions discussed here, do not apply to materials acquired before the introduction of the restrictive MTA conditions by ATCC in the late 1990s.

2.2. The European Culture Collection model: a license for public knowledge assets

In February 2009, the European Culture Collection (ECCO) adopted a core Material Transfer Agreement (see www.eccosite.org). The main purpose of the agreement was to make biological material from ECCO collections available under the same core conditions, which were to be implemented by ECCO members either as such, or integrated into their own more extended documents.

The ECCO core MTA applies to the distribution of the material to end-users, intermediaries or those involved in legitimate exchanges. Recipients must not transfer the material to any others, except those acting as intermediaries and those involved in legitimate exchanges. Legitimate exchange is defined as the transfer of the material between scientists working in the same laboratory, or between partners in different institutions collaborating on a defined joint project, for non-commercial purposes. This also includes the transfer of material between culture collections for accession purposes, provided any further distribution by the receiving collection is under MTA conditions equivalent to and compatible with those in place at the supplying collection.

The ECCO MTA requires the material to be used only for non-commercial purposes. If the recipient desires to use the material or modifications of it for commercial purposes, it is the responsibility of the recipient, in advance of such use, to negotiate the terms of any benefit sharing with the appropriate authority in the country of origin of the material (as indicated by the collection's documentation). In principle, the ECCO agreement does not require that the collection be involved in the benefit-sharing negotiations.

2.3. A developing country MTA: the BIOTEC culture collection

The MTA adopted by the BIOTEC culture collection, at the National Center for Genetic Engineering and Biotechnology in Thailand (see www.biotec.or.th), is an example of a science-friendly MTA used in a developing country. BIOTEC uses two standard material transfer agreements, one for the general distribution of materials to customers (MTA1), and the other for the exchange of materials between biological research centers (BRCs) and other culture collections which allow recipient collections to further distribute the materials to third parties (MTA2).

MTA1 requires the material to be used only for research and education. The material may be distributed to co-workers, as long as it remains under the recipient's direct supervision. Its release to colleagues in other institutions (or outside of the recipient's direct supervision) is only allowed with BIOTEC's written permission and after an MTA1 has been signed between the third party and BIOTEC. If the recipient wants to use the material for commercial purposes, BIOTEC will, in advance of such use, negotiate with the recipient to establish the terms of a commercial license. The MTA2 is quite similar. The main difference refers to the part of the agreement covering other public collections. Thus, the MTA2 allows further distribution of the material by public collections that receive material from BIOTEC under the recipient's direct supervision or the recipient's explicit agreement. As with ECCO's core MTA, this second model facilitates the exchange and distribution of strains by the scientific community.

3. Global interdependency as a driver of exchange

This brief overview of three examples of formal MTAs allows two important features of the formal MTA regime to be highlighted. First, the formal MTAs are tailor-made for the various collections. So, in spite of general similarities, each MTA is different in its details. This reflects the heterogeneity of the culture collections, both in relation to the type of material that is conserved, their funding structures and the requirements of their national policy frameworks. Second, the move from an informal exchange regime to a formal one does not necessarily mean the introduction of restrictive license conditions, with the notable exception of the ATCC license discussed above. As can be seen from the examples of the ECCO model and the MTA2 in the BIOTEC collection, it is possible to design formal license conditions that allow further exchange for non-commercial research purposes.

For the design of a worldwide microbial commons, however, sufficient guarantees of reciprocity have to be provided in the exchanges. Therefore, a more systematic approach, based on a set of agreed rules between the collections and between the collections and the provider countries, is needed. The next section argues for the introduction of such a systematic approach, based on an analysis of the patterns of interdependency between collections and countries in access to microbial research materials.

In order to improve the current state of affairs, a better understanding is needed of the costs and benefits of alternative institutional frameworks, which would harmonize the conditions of exchange and put the emerging worldwide microbial commons onto a solid legal and institutional basis. The main issue that has to be addressed in this context is the creation of a better fit between these formal institutional arrangements for building the scientific commons and the norms and goals of the microbial science communities (Rai, 1999; Dedeurwaerdere, 2004; Dedeurwaerdere, 2009; Dasgupta and David, 1994; David, 2003). In particular, to foster wide acceptance and thereby accelerate scientific progress, any formal arrangements need to be committed to facilitate the exchange of materials and need to be easy to implement by regulatory bodies as well as by both parties involved in the exchange (providers and recipients). This raises a double set of problems. On the one hand, institutional frameworks that rely excessively on monetary incentives or formal control can crowd out the social norms of communalism and the intrinsic values that drive scientific communities (Frey and Jegen, 2000; Frey and Osterloh, 2002; Lepper and Greene, 1978; David and Spence, 2003). This is especially relevant for the bulk of microbial resources which are exchanged for public research purposes. On the other hand, without a formal arrangement of some kind for regulating the exchanges, the benefits might be restricted to the most advanced researchers where exchanges are organized on the basis of networks of personal relationships.

The goal of further harmonization of the institutional frameworks should therefore be to provide the broadest access possible to essential research materials – within the constraints set by biosecurity and quality management requirements, while maximizing the reciprocity benefits of access and exchange which motivated the practice of exchange to start with (Cook-Deegan and Dedeurwaerdere, 2006; Dawyndt et al., 2006). The various reciprocity benefits, such as culture collections receiving strains from many other collections because they, in turn, provide strains under similar facilitated access conditions within the network of collections, or more direct benefits between providers of resources and users who access to new technologies or training in return, will be further illustrated in the next subsection.

3.1. Patterns in the exchange of microbial resources

The majority of microbial resources coming into public culture collections arise from in situ resources, either directly through collecting by internal staff at the culture collections, or indirectly through deposits by external researchers; the bulk

Table 1
Deposits from in situ sources in nine major culture collections in 2005

	1	2	3	4	5	6	7	8	9
Total number of strains	N/A	N/A	N/A	N/A	N/A	2000	N/A	N/A	2500
% Deposited before 1993	51	N/A	90	N/A	35	40	50	50	50
Accessions in 2005	**436**	**886**	**55**	**2812**	**104**	**32**	**272**	**736**	**108**
% Without restrictions	98	N/A	100	86	79	98	100	100	100
% Restriction to non-commercial uses	2	N/A	0	0	0	2	0	0	0
% Other restrictions	0	N/A	0	14	21	0	0	0	0
Depositors									
% National	65	45	98	86	70	100	99	57	100
% Other	35	55	2	14	30	0	1	43	0
Number of foreign countries	18	14	1	3	8	0	1	23	0
Country of origin									
% National	26	10	98	98	60	53	99	N/A	41
% Other countries	74	90	2	2	40	47	1	N/A	59
Number of foreign countries	43	42	1	3	16	8	1	N/A	19
Number of strains of unknown origin	35	1	0	19	N/A	0	0	N/A	N/A

N/A: data not available.
Source: Dedeurwaerdere et al., 2009.
Note: The WDCM (World Data Centre for Microorganisms) numbers of the 9 collections (http://wdcm.nig.ac.jp/hpcc.html) are 32 (Sweden), 124 (Iran), 296 (Belgium), 308 (Belgium), 342 (Russian Federation), 412 (Spain), 604 (Brazil), 779 (Finland), and 783 (Thailand). The collection numbers not in the same order as in the Table to protect the anonymity of the research.

of microbial diversity is still unknown (Colwell, 2002; Bull, 2003). ASM (American Society for Microbiology) journals state in their instructions that representative strains mentioned in ASM publications must be made available. In practice this is not systematically checked, but it is generally considered an indispensable part of sound microbial science.

Quantitative assessment (Dedeurwaerdere et al., 2009) of the entire accession databases of a representative set of nine collections (totaling more than 15,000 single accessions), covering the years 2005, 2006, and 2007) has shown that new deposits from in situ resources in the culture collections are mostly from national depositors (between 45% and 100% of the new deposits) (see Table 1). However, a substantial proportion of these new deposits by national depositors come from foreign countries (over 40% in five of the eight collections for which data was available, four of these being OECD countries). This suggests that national depositors often collect in other countries and deposit the resulting material in their national collections. Direct deposits from foreign countries also represent an important subset. For instance, the survey showed that every year, depositors from India, the Philippines, China, Brazil, Columbia and Uruguay directly deposit strains from their countries in OECD collections. A remarkable fact that deserves comment in the context of this paper is the lack of restrictions on the distribution and use of the microorganisms which have been deposited using formal deposit forms. Eight of the nine collections use formal deposit forms for all new deposits and between 98% and 100% of these deposits came without any restrictions attached.

Some new strains deposited in culture collections come from ex situ collections (Fig. 1). In 2005 Stromberg et al. (2006) surveyed the 499 public collections that were members of the World Federation of Culture Collections (WFCC) and documented the origin of the new accessions to their collection. Based on 119 fully completed survey forms, the survey shows that 45% of the new accessions came from their own collecting efforts in situ, and 30% from collecting efforts by academic and hospital research groups. Accessions from research collections were mostly from researchers who deposited a subset of their microbial strains when publishing their research results, or who deposited strains to keep a safe backup copy of important reference material. However, some 20% of all accessions came from other public culture collections. These accessions are very important, as they represent well-validated and well-characterized microbial resources. Their exchange allows research results to be checked by competing laboratories. It also enables cumulative follow-up research to be based on identical certified biological materials (Furman and Stern, 2006, Working Paper 12523, National Bureau of Economic Research) and serves as the backbone of microbial taxonomy (Kurtzman and Labeda, 2009). Finally, the survey also showed the heavy reliance of industry on the culture collections for acquiring type and reference materials. This had also been remarked in earlier studies (Ten Kate and Laird, 2002; Kuo and Garrity, 2002; Beattie et al., 2005).

The results summarized in this section show the importance of two types of exchange practices that provide reciprocity benefits on a worldwide scale: first, the exchange of in situ resources from various geographical regions, and, second, the exchange of well-characterized materials between culture collections. Institutional arrangements that reinforce such exchanges can therefore be expected to increase the socio-economic benefits from investment in public culture collections.

3.2. Patterns of exchange of digital knowledge resources (data and literature)

The empirical results on patterns of exchange show a high level of interdependency between countries in access to and use of microorganisms. However, it is important to stress that microbial research relies not only on worldwide access to microbial resources, but also on access to digital knowledge resources, such as genomic databases and the published literature. Increasingly, access to results of genetic sequencing, strain information databases and bioinformatics is becoming a key component of microbial research. In many cases, research results are obtained through computational research on digital data and information available through on line databases (Dawyndt et al., 2006). With the introduction of next generation sequencing technology, these databases are expanding rapidly and in silico research likewise.

A few studies have documented the scope of the sharing of digital resources in microbiology. One such study addresses the problem of access to the microbial research literature through a survey of 303 journals dedicated in whole or in a major part to microbial research (Reichman et al, in preparation). Its principle findings show that only about 10% of the microbial journals are fully open access, while 20% are read-only open access, 20% subscription-based with an author-paid open-access option, and 50% subscription-based without any open-access option. Only the fully open-access journals (and those with an author-paid open-access option) allow full sharing of the digital resources for automated data mining, extraction of content, and reassembly for the building of new knowledge resources such as systematic taxonomic databases (Agosti and Egloff, 2009). This growing trend toward more openness can only fully deliver upon its promises for improving microbial science if the peer-review process is organized in a serious manner. There is, however, no evidence from this survey that the peer-review process would be less well organized in the average open-access journals, in comparison to the average non-open-access journals.

To the best of my knowledge, no similar study of microbial databases has been carried out. Increasingly, however, many essential microbial databases are in the public domain. This is true for the public culture collections' on-line catalogues of strain holdings and associated information, and for many molecular biology (genomic, proteomic) databases which also cover microorganisms. However, molecular data in specialized areas of research are often not deposited in the public databases, and are therefore not publicly available. As a general rule, the use of the public genomics data is free. However, the recently adopted EU database directive may complicate

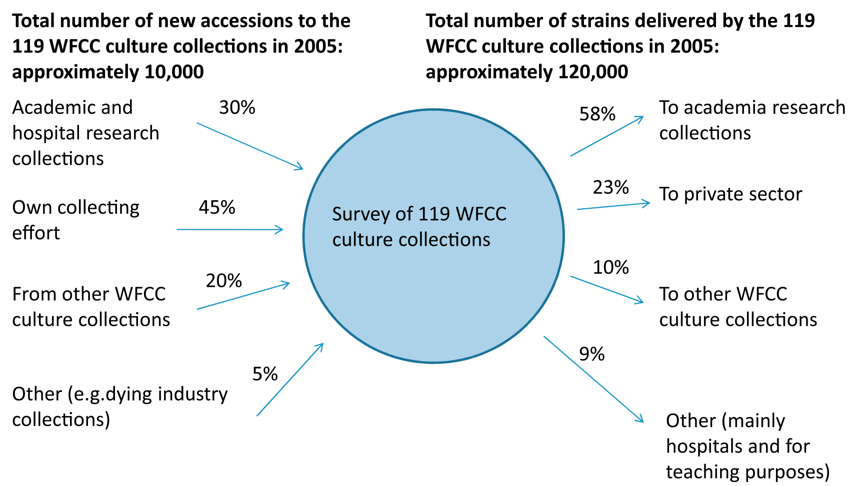

Fig. 1. Survey of accession and distribution patterns based on a survey amongst collections that are member of the World Federation of Culture Collections (119 valid responses analyzed). Adapted from: Stromberg, P., Pascual, U., Dedeurwaerdere, T., 2006. Information sharing among culture collections, unpublished survey report.

matters in the future, though its effects on life science databases is still uncertain (Reichman et al., in preparation).

Despite some major initiatives which will be discussed below, this brief survey shows that systematic solutions for enabling automated knowledge integration across the taxonomic, genomic and scholarly literature domains are still in their infancy. What is needed are measures that provide sufficient motivation to the research community to make their upstream data, and their published research results, more widely available and usable, while preserving attribution and other reputational benefits to the fullest extent possible.

4. Interim solutions for building microbial commons

The adoption, on an international level, of a set of legally binding rules to govern transactions involving microbial resources would potentially alleviate many of the problems caused by the lack of standardization and formal rules which characterize the current system of exchange. To the extent that an efficacious standard MTA would harmonize the servicing of culture collections across the globe, it would lay the basis for a de facto commons for the global conduct of microbial research in the foreseeable future. The primary questions that need answering concern the extent to which such a commons would be truly science-friendly, and the further extent to which such a science-friendly regime could implement the potential for new discoveries inherent in digital technologies and new automated knowledge tools (Dawyndt et al., 2006).

Important steps in that direction could be made by the systematic adoption in all public culture collections of measures that:

- implement the use of deposit forms for each new deposit in a culture collection, thereby putting the practice of making material available for the broad scientific community on a sound legal basis (which is already a practice systematically adopted by a subset of the public culture collections);
- introduce standard MTA conditions for the distribution of materials for commercial use, thereby preventing a race to the bottom, by either providers (who might impose more restrictions) or users (who might block access to innovations based on materials from foreign countries), as is, for example, the case in the standard MTA adopted for plant genetic resources in the International Treaty for Plant Genetic Resources for Food and Agriculture (currently none of the standard MTA's adopted in the microbial field include standard conditions for commercial use);
- explicitly allow public culture collections to redistribute microbial strains received from other public collections to collaborating scientists, or a third collection (as is, for example, the case in the ECCO MTA discussed above).

In short, there is a "bundle of rights" attached to biological resources which should be regulated by laws and managed through agreement and contracts. The question of "who owns what" should be modified to "who has what rights" over microbiological resources. Culture collections clearly have rights in the material they manage and preserve. Having these rights, they also can specify the conditions under which they distribute their material. So ownership, appropriately understood, allows the culture collection community to define when biological material should be shared on a non-exclusive basis and, conversely, when a restrictive licensing policy is justified. In this way the concepts of the "microbial commons" (shared use) on the one hand, and "intellectual property rights" (exclusive use) on the other are not opposed, but become two complementary tools at the disposition of the culture collection community (Dedeurwaerdere, 2007; Chen and Liao, 2004).

The adoption of a full-fledged international treaty takes time, however, and, in the light of the threats to the commons and the good public benefits that may potentially be lost, it is urgent to work on interim solutions for putting the global microbial commons on a sound legal basis. These solutions should aim to go beyond the insufficiencies of the informal exchange regime discussed above and address the current fragmentation of incipient formal self-regulatory frameworks. The end goal of this process might eventually be a full-fledged international regime, but interim solutions can already be elaborated, building on and extending the ongoing efforts of microbial science unions and the culture collection federations (WFCC http://wdcm.nig.ac.jp/wfcc/InfoDoc.html; Fritze, 2004; Desmeth, 2004), and within international organizations such as the OECD (2001) (Réchaussat, 2004; Smith, 2007).

In the field of the microbial commons, there are some emerging examples of processes of incremental change leading to the building of a global commons. One prominent example is the Science Commons MTA initiative. Science Commons is pursuing ambitious projects to standardize exchanges of both data and materials that could considerably increase access and re-use while lowering transaction costs (see www.sciencecommons.org). In one of its projects, Science Commons proposes a low transaction cost MTA for non-commercial uses through a web-based interface, which can be interrogated via machine-readable search engines. In 2008, a network of laboratories for research into Huntington's disease agreed to use this standard MTA and opened up their catalogues to be accessed through a single semantic network, allowing materials to be procured by using the same MTA across all repositories (Kronenthal 2008, see http://www.bio-itworld.com/issues/2008/may/biobanking-personalized-medicine.html).

A second example illustrates the process of the gradual integration of digital information networks through the StrainInfo bioportal (Dawyndt et al., 2005, 2006, 2007; Van Brabant et al., 2006). In February 2007 StrainInfo.net started a prototype project for the on-line integration of the strain catalogues of about 20 major collections. Through an agreement with the information providers on the use and re-use of the content of the databases, it was able to build various automated knowledge integration tools and webservices. These included automated strain name disambiguation and cross-linking of strain names, literature and genomics data. This network is still growing, and today it covers the catalogue data of over 60 collections. In a new project (Verslyppe et al., 2010), StrainInfo is developing a standardized passport for digital strain information, which should further speed up the data integration process.

What is common between these and other emerging initiatives is the negotiation of a collective agreement within a network of players, who together build a pool of common biological and digital research resources. These pools are open to new network members and participants as long as they play by the rules. The collective agreements are based on the negotiation of common rules that govern access to and use of the pooled resources. Other incipient examples in this direction are the BIOTEC/NITE memorandum of understanding (www.biotec.or.th), the World Health Organization (WHO) network of Collaborating Centers for influenza (WHO, A/PIP/IGM/13 report, 2009) and the Global Biological Resources Center Network (GBRCN) pilot project (Smith, 2007). Such decentralized collective agreements can provide interim solutions which form a stepping stone between a fully global legal regime for pooling microbial and digital research resources and the incipient self-regulatory agreements discussed above.

5. Conclusion

Exchanges of microorganisms between culture collections, laboratories and researchers worldwide have historically occurred in an informal way. These informal exchanges have facilitated research activities and, as a consequence, science and exploitation of microbial resources have advanced rapidly. During the last decades of the twentieth century, this situation has changed. Major drivers of this transformation are the increasing commercial pressures from biotechnology firms active in microbiology and the introduction of new legislation on the use of and access to biological resources. As a result, the access and distribution of genetic resources are now more strictly regulated, and therefore, exchanges are becoming more and more formalized. There is no evidence, however, that formalization as such is leading to more restrictive license conditions, although it might lead some collections to depart from the scientific-sharing ethos and increase the administrative burden on the collections. Therefore, the goal of the development of formal institutional arrangements should be to ensure that both researchers and the broader public receive the maximum benefits from investments in culture collections and to enable researchers to continue to build upon the value chain of investments in research materials and research data.

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