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Microorganisms, Australia and the Convention on Biological Diversity

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Abstract. The Convention on Biological Diversity arose as an international agreement for the conservation and continued exploitation of Earth's biological diversity (biodiversity). It directly affects those involved in conservation, exploitation and investigation of biodiversity in all its forms, as well as affecting the viability of all life. Australia is one of more than 170 countries that have ratified the Convention. Its involvement in this Convention will be considered in terms of the National Strategy for the Conservation of Biological Diversity with a focus on the coverage of microorganisms within this strategy. Microorganisms represent a major part of the biodiversity on Earth but, as yet, remain relatively unknown. Among those microorganisms that have been described, many, originating from a range of countries, have been deposited in culture collections worldwide. The Convention contains articles that impact on *ex situ* collections, although precise protocols are not set out therein. An international code of conduct is now being formulated to ensure ongoing access to and exchange of microorganisms in the interests of sustainable development in industrialised and developing nations.

Key words: Australia, microbial diversity, MOSAICC, the Convention on Biological Diversity

Introduction: biodiversity conservation and the importance of microorganisms

The move to conserve biodiversity has been growing since the 1960s although the need for wildlife conservation and protection was recognised as early as 1900 (The London Convention on the Protection of Wild Fauna in Africa, was concluded on 19 May 1900, although never ratified). This recognition resulted in the formation of international laws designed to accomplish a symmetry between the preservation of species and the rights of sovereign nations (de Klemm and Shine 1993), the international culmination of which has become the Convention on Biological Diversity ('the convention'). The Convention provides an international legal framework for, amongst other aspects, biodiversity prospecting and the exchange of genetic materials.

Microorganisms represent the largest proportion of biodiversity on this planet (Whitman et al. 1998), outnumbering vertebrate species, for instance, by 75 to 1

(Heywood 1995). They are largely responsible for a great number of products and environmental services (Figure 1) but remain relatively unknown.[1] They do, however, provide a great reservoir of bioresources, some of which have already been exploited. For instance, of the antiinfective drugs currently available, approximately 60% are derived from natural sources with the majority originating from microorganisms (Liles 1996). Microbes also play a vital role in ecosystem services and have been exploited in various ways to minimise harmful human environmental impacts. This may occur through post-release pollution management (bioremediation for instance) and through the microbiological treatment of effluent pre-release into the environment (Frederick

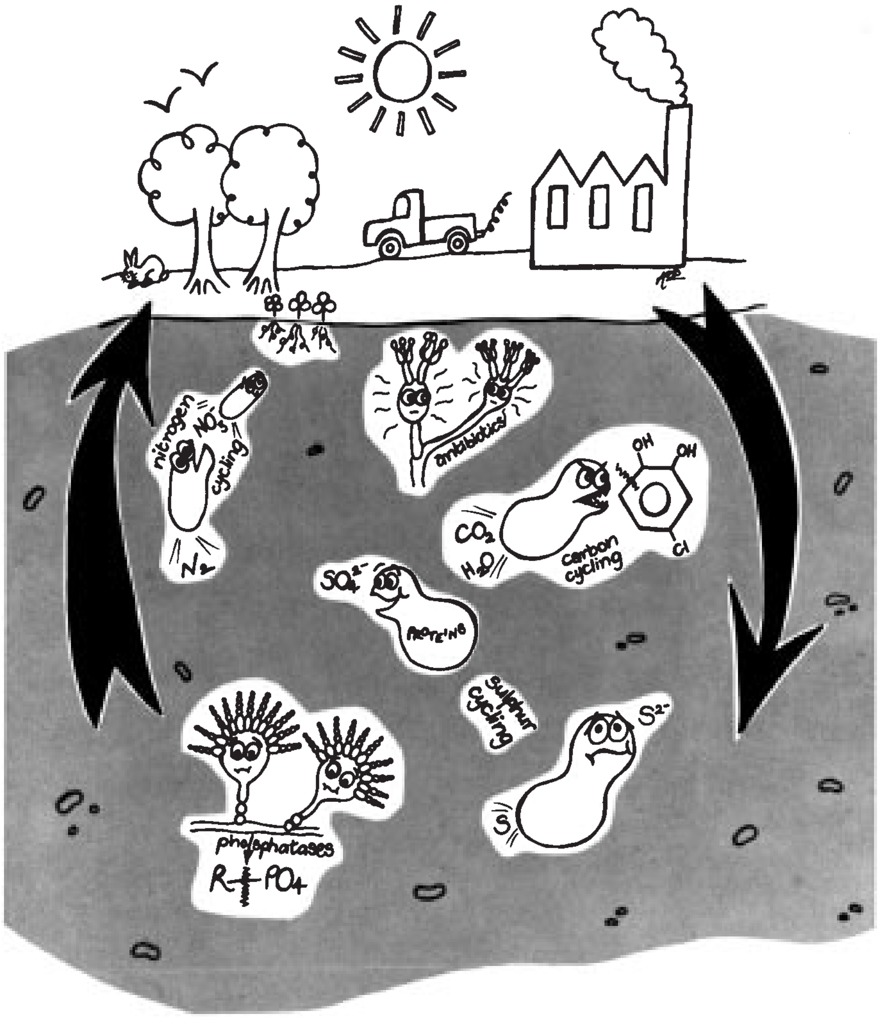

Figure 1. Microorganisms effect many ecosystem functions and have enormous potential as an important bioresource, much of which is yet to be exploited (reproduced with kind permission from Microbiology Australia).

and Egan 1994; Bull 1996; Davison 1997; Davison and Veal 1997). Microbial nutrient recycling, mainly nitrogen and phosphorus, has also been shown to be an important factor in the maintenance of various ecosystems (Skyring 1996).

In addition, many beneficial relationships exist between microorganisms and plants or animals, or indeed other microorganisms. A recent example is the association between the marine invertebrate (bryozoan) *Bugula neritina* and the bacterium *Endobugula sertula* (Pain 1998a). Those bryozoans living in water deeper than 10 metres have been found to produce a compound called Bryostatin-1. This compound has enormous potential as an anticancer drug and is anticipated to form the basis of a market worth $US1 billion per annum. However, it is suspected that Bryostatin-1 is actually produced by *E. sertula* rather than the bryozoan. Strains of *B. neritina* growing above a depth of 10 metres do not produce the compound. It is thought that some ecological advantage is conferred on the bryozoan through the bacterial association by the production of Bryostatin-1.

Microorganisms play an important role in soil fertility and agriculture in general. Soil structure is influenced by microbial diversity, both in terms of its stability and its fertility. In the dry Australian environment, soil erosion is a major environmental problem. Erosion affects 90% of arable land and the subsequent loss of soil structure in the Murray-Darling River basin alone, has been estimated at $A100 million per annum (Beattie 1995). Furthermore, fungal associations with plants (mycorrhizae) may enable Australian plants to establish in otherwise inhospitable conditions, facilitating the uptake of phosphorus and water for instance. A recent study has shown that the diversity of mycorrhizal fungi may be a major determinant of plant diversity and ecosystem productivity (van der Hiejden et al. 1998). However, as pointed out by Brundrett (1996), the importance of the role of mycorrhizal associations in Australian habitats is yet to be established.

Desertification remains a major global environmental problem (Anon 1997) and microorganisms may play a role in helping to combat this destructive process or in the rehabilitation of denuded habitats. The stability of soils is improved by the formation of aggregates bound together by fungal hyphae and polysaccharides of microbial origin. Various microorganisms, including algae, bacteria and filamentous fungi may participate in the aggregation of soil particles (see Lal 1991). In Australia, the stabilisation of arid soils by soil crusts composed of lichens, cyanobacteria and other microorganisms is particularly important (Eldridge 1997).

Microbial diversity is an essential component of the total pool of biodiversity and as such, we cannot afford to let it decrease. Without biodiversity, humans and the ecosystems they depend on, run the risk of a reduced ability to cope with environmental stresses, including global warming. Furthermore, the pool of bioresources, which includes possible cures for disease, as well as intrinsic values, will be lost. As Pimm (1997) states, the preservation of biodiversity and the environment in general, rest in the hands of those “. . .who realise that there is more to a whale than its meat, and that wetlands, like all other ecosystems, provide services we cannot afford to replicate."

Ecosystem services, provided in the main by microorganisms, contribute to the overall economic value of this planet. Minimum estimates have put this value at around US$33 trillion ($10^{12}$) per year in contrast with a global gross national product of approximately US$18 trillion per year (Costanza et al. 1997). Thus, as a source of biological wealth, microbial and other forms of biodiversity should be equitably shared between developed and developing nations and indigenous peoples.

The Convention on Biological Diversity

The need to conserve biodiversity was established at the United Nations' Conference on the Human Environment in Stockholm, 1972 but the Convention on Biological Diversity did not arise until the Earth Summit at Rio de Janeiro in 1992. Australia ratified the Convention on 18 June 1993, along with now more than 170 countries.

The convention has three main objectives:

1. Conservation of biological diversity
2. Sustainable use of the components of biodiversity
3. Fair and equitable sharing of the benefits arising out of the utilisation of genetic resources

While the Convention is essentially one for the conservation of biodiversity, it also sets out guidelines for the sustainable exploitation of its components. Some of the key features of the Convention are set out in Table 1.

Although the Convention provides an international agreement for biodiversity prospecting and the exchange of genetic materials, it does not set out clear protocols on how to achieve these ends. The Convention opens the way for cooperation and knowledge sharing, with emphasis on North-South issues, in the scientific and technical fields. This is particularly important as Bull (1996) points out, as most megadiverse countries (in the case of macroorganisms) are in the South whereas most exploiters of biodiversity are in the North (see also Craig 1995). Whether this is also true of microorganisms (and also depending on what type of microorganism) is yet to be determined. Benefit sharing and cooperation specifically include the promotion of technology transfer (Articles 12, 16 and 18) and the fair and equitable sharing of the benefits of genetic resources, as well as access to technology including biotechnology (Articles 15, 16 and 19). Although guidelines for technology transfer and related issues are covered by the Convention, these articles lack legal specificity relying, for instance, on each Contracting Party to "develop and implement[ation] national policies for technical and scientific cooperation" including strengthening national capabilities human resources' development and institution building (Article 18 (2)), or promote joint ventures and research programs "subject to mutual agreement" (Article 18 (5)).

Table 1. Some of the key features of the Convention (Adapted from Iwu (1996) and the Convention).

Article	Details
1.	Main objectives of the Convention: • conservation of biological diversity • sustainable use of biological resources • fair and equitable sharing of resulting benefits
3.	Recognition of the sovereign rights of nations over resources and their right to exploit resources pursuant to that nation's environmental policies. To ensure that activities within a nation do not cause damage to the environment of other nations.
5.	Encouragement of cooperation between Contracting Parties, within and beyond national jurisdictions, for the conservation and sustainable use of biodiversity.
6.	Outlines measures to be put in place by the Contracting Parties to promote conservation.
7.	A key article of the Convention. It sets down the requirements for monitoring, identifying and maintaining biodiversity.
8 and 9.	Establish conditions for *in situ* and *ex situ* conservation. In particular, art. 8(j) recognises the rights of indigenous peoples.
10.	Provides recommendations for the sustainable use of biodiversity. In particular, art. 10(c) recognises the use of "traditional culture practices."
12.	Promotion of research and training particularly in developing countries.
15.	Reaffirms the rights of sovereign nations over their genetic resources. However, sovereign nations should not restrict access to genetic resources for environmentally sound uses (art. 15(1)). Promotes the fair and equitable sharing of the benefits arising from the utilisation of genetic resources (art. 15(7)).
16.	Access to and transfer to technology, including biotechnology (art. 16(1)).
17.	Exchange of information should be facilitated between Contracting Parties including "indigenous and traditional knowledge." (art. 17(2)).
18.	Promotion of technical and scientific cooperation between Contracting Parties.
19.	Promotion of fair and equitable benefit sharing from Biotechnology arising from exploitation of genetic resources provided by the Contracting Parties.
20–42.	Specifically address the administrative, financial and legal issues arising from the Convention.

Articles 15 and 16 are two main items in the Convention that deal with the issue of equity. Article 15.1 recognises the sovereign rights of States over their national resources and the authority to determine access to genetic resources, while Article 16 focuses on access to and transfer of technologies. Both items are dealt with in only a general way. Article 3 also recognises the sovereign rights of nations to exploit their own resources pursuant to their own environmental policies and to ensure that activities within a nation do not cause damage to the environment of other nations.

Although an international framework has been laid down by the Convention for the exchange of genetic materials and for biodiversity prospecting, Iwu (1996) states that "...the Convention does not provide a blueprint that should be followed by collaborating groups; there is no ideal agreement or model contract available to address satisfactorily all the expectations of the contracting parties, and to satisfy the various interpretations of the treaty.” It is clear that many issues need to be addressed and outlined to achieve workable bioprospecting contracts and sustainable exploitation. Proactive agreements and codes of conduct between interested parties need to be drafted. To address this, issues have been suggested (Iwu 1996) that should be addressed in the drafting of bioprospecting contracts:

- supply of samples (determination of ownership of samples);
- up-front payments and royalties;
- non-monetary compensation: training and sponsorship of research in the source country; availability of test results to source country scientists; authorship of publications;
- future supplies of raw materials: sustainable collection; collaborating institution and country as first source; fair price;
- provisions for conservation;
- technology transfer;
- rights of indigenous people[s]: reciprocity and equity considerations.

These provisions are now being incorporated into national legislation world wide. Not surprisingly, as pointed out by Glowka (1997), developing countries have been some of the first to incorporate the provisions, outlined by article 15 of the Convention, in their legislation in an effort to “redefine benefit flows from the use of genetic resources” (Glowka 1997).

Australia and the Convention

As the Convention is signed by governments, there are problems with representation both of Indigenous Peoples and of industry (which is likely to be the major proprietor of many genetic resources) at the Conference of Parties. Article 15(1) states that the authority to determine access to genetic resources rests with national governments and is subject to national legislation. This issue becomes complicated in a country such as Australia, on two levels. Firstly, Australia is federated which means that while the Commonwealth is ultimately responsible[2] for acting as a “nation state” in signing off on Conventions and Treaties, it must, out of necessity, rely on the cooperative response of State and Territory governments in implementing appropriate legislation for the conservation of biodiversity (Kennedy 1996). The Commonwealth does, however, have various constitutional powers that allow it to conserve biodiversity or threatened habitats, should it choose to use these powers. The reality however, is more sobering where a perceived “culture of consent” (Kelly and Farrier 1996) might facilitate development rather than biodiversity conservation.

Secondly, albeit the interests of Indigenous Peoples are voiced through non-governmental organisations, Indigenous Peoples, in their diversity, have not had an official voice in the Conference of Parties of the Convention and thus must rely (as industry must) on the Government representative of the country in which they reside. Thus, although the knowledge of Australia's Indigenous Peoples can provide bioprospectors with valuable clues (Tangley 1996), control of resources is governed by the Nation State, in Australia's case the Commonwealth, even though the role of Indigenous Peoples is recognised in the preamble to the Convention and in Articles 8(j) and 10(c) (see Craig 1995 for further discussion of this topic).

The former notwithstanding, Australia originally made good progress in the area of biodiversity conservation, preempting the 1992 Earth Summit in Rio de Janeiro, by establishing a public advisory committee in 1991 to develop the National Strategy for the Conservation of Australia's Biological Diversity (Kennedy 1996; Department of the Environment Sports and Territories, 1996). Although the Commonwealth *Endangered Species Protection Act 1992* emerged soon after, in the opinion of Kennedy (1996) "it became a very watered-down affair".

Nevertheless, a biological diversity conservation strategy (NBDCS) for Australia has emerged which mirrors many of the goals of the Convention. The NBDCS has many references to microorganisms as an important component of biodiversity and not only in terms of exploitation but also, in recognising the need for further research into identifying the components of biological diversity that are inadequately understood (Objective 4.1.1. (a)), including an extension of the Australian Biological Resources Study to cover microorganisms (Objective 4.1.5). Other objectives also recognise the need for the rapid assessment of Australia's biodiversity (Objectives 4.1.2. (b) and (c)).

On this note, collections of microorganisms, including herbaria for plant pathological and mycological work (Grgurinovic and Walker 1993), already exist in Australia and provide a repository of microbial diversity, although the skills necessary for microbial taxonomy appear to be on the decline. A survey carried out in 1991 by Grgurinovic and Hyde (1993) highlighted the critically low numbers of mycological taxonomists being trained in universities and other institutions within Australia. It is likely that taxonomy of pure cultures may be facilitated by molecular techniques. However, work in molecular microbiology laboratories around the world is emphasising the complexity and diversity of microbial communities. There are now over 40 bacterial divisions (roughly equivalent to a phylum) recognised, many of which are known only from DNA sequence data (see Hugenholtz 1998). In fact, more different 16S rRNA gene sequences have now been reported than there are formally described bacterial species.

Of course underpinning the adequate *ex situ* conservation of microbial diversity are the issues of organisation and monetary resources. As pointed out by Sly (1998), no progress has been made to fulfilling objectives 4.1.5 (accelerate research into taxonomy) and 1.9.1 (strengthening *ex situ* conservation) of the NBDCS. Although some funding has been made available through the Australian Biological Resources Study (ABRS) for research into the taxonomy of algae and fungi, bacteria and viruses are apparently not covered by the ABRS (Sly 1998).

Microorganisms are the most adaptable forms of life, and are found everywhere on the planet. Some microorganisms can live in temperatures as high as 113 °C and at depths of up to 3.5 km in solid rock. In addition, extreme habitats are not the sole domain of bacteria, for instance, both bacteria and protozoans have been found in active communities from deep underwater sediments (Pain 1998b). However, although many groups of microorganisms are apparently ubiquitous in nature, it is estimated that up to 99% of these cannot be cultured (see Yeates 1996 for a discussion of microbial diversity). The Acidobacterial groups, for instance, are found in soils all around the world, and often comprise a large proportion of 16S clones recovered from soil DNA. However, only a single culturable member, *Acidobacterium capsulatum* represents this group (see Hugenholtz 1998). The role of this apparently ubiquitous and numerous group is unknown.

Even when we can culture microorganisms, we know comparatively little about them. Microorganisms suffer from bad press because they are not cute, cuddly or charismatic like koalas and kangaroos and are known more for their disease-causing members (germs) than their beneficial members. Thus, a bacterial strain indigenous to Australia (see for instance Davison et al. 1996) is likely to remain unrecognised both nationally and internationally and is never likely to become a popular icon. The Australian Society for Microbiology is planning to change this by promoting microbiology and making the general public more aware of the beneficial roles of microorganisms in the environment.

Nevertheless, in Australia, microorganisms can be found either specifically or under umbrella terms (such as genetic resources) in several of the NBDCS objectives, including the risk of introduced species (Objective 3.3.3), the use of innovative technologies in pollution management (Objective 3.3.4) and the *ex situ* conservation of genetic material (Objectives 2.8.6, 1.9).

In broader terms, Australia's biodiversity effort is moving slowly, but the NBDCS aims by the year 2000 to have "fully implemented provisions of those international agreements relating to the conservation and sustainable use of biological diversity to which Australia is a signatory" (Objective 7.1.1. (r)). Some States have progressed to the extent that the New South Wales Biodiversity Strategy has an expected release date of 1998 and the draft state of the environment report for Western Australia has identified biodiversity maintenance as the highest priority environmental concern. The Victorian draft Flora and Fauna Guarantee Strategy, however, remains in limbo (Community Biodiversity Network, 1997). Under the Convention, Australia has a requirement through Article 18(2) "...in implementing [the] Convention, *inter alia*, through the development and implementation of national policies." Thus, policy and legislation development for the conservation of biodiversity is mandatory. It must also be noted that Australia, and other countries, must consider not only legislative measures but a mix of policies to include economic measures, as well as regulation, for achieving a more holistic approach to biodiversity management (Gunningham 1996; Gunningham and Young 1997).

Of course, at the root of many conservation initiatives is funding. It is estimated that $20 million per annum is required to effectively implement the Commonwealth *Endangered Species Protection Act 1992*, the allocation from the Federal Government's Natural Heritage Trust is only $6.7 million (Community Biodiversity Network, 1997). Furthermore, the fact that some States may devolve the Act into their own jurisdiction could potentially interfere with the Commonwealth's constitutional powers. Given that the Commonwealth has ultimate control over the export of biological products and specimens under the terms of the Convention, it could use its constitutional powers to veto exports and external trade. All parties however, will have to be guided by the provisions of the Convention to ensure that the three main objectives of the Convention are met. Australia has already visited a model of "cooperative federalism" through the Intergovernmental Agreement on the Environment in 1992 which sought to reduce conflict between the Commonwealth and State governments over the environment (Prest 1997). Therefore, it is possible that such a model could be used, in conjunction with the provisions of the Convention, to reach an agreement over biodiversity conservation and exploitation. In addition, the Federal Government has just released a consultation paper on reforms to Commonwealth environment legislation, including biodiversity conservation. The aim of these reforms is to expedite and streamline the Commonwealth's legislative efforts and to allow it to "adequately discharge its environmental responsibilities – for example, in relation to certain international responsibilities and matters of clear national significance." (Department of the Environment 1998). However, although legislative reforms are presented by the Commonwealth, the proposed legislation will of course, be judged on its enforcement.

Microorganisms and the Convention

As pointed out by Kelley (1995):

> It is fairly clear that higher plants and to some extent animals were the main considerations taken into account during the drafting of this Convention. Yet in many ways its significance to the microbiology world is greater than to higher plants and animals.

Representation was made, at some of the initial United Nations Conference on Environment and Development meetings, by the World Federation of Culture Collections (WFCC). The WFCC facilitated discussion on the importance of microbial diversity in the overall biological diversity sphere and continues to do so, although some commentators feel that the Convention still failed to recognise the fundamental role of microorganisms in ecosystem functioning (Sands 1996).

In the whole Convention, there is only one mention each of "microorganism" and "microbial" (Glowka 1996). Moreover, we would point out that there is no specific mention of microbial diversity in Annex I, the area of the Convention, which identifies the species and communities to be identified and monitored. As stated by Sands (1996), if there is no express mention of microbial diversity in the Convention, then it may not be recognised by the states and may go unprotected by the Convention. It should be noted however, that microbial diversity has now been recognised as an essential component of agricultural success, through the Conference of the Parties to the Convention.[3]

Biodiversity is recognised on three levels, ecosystem, species and genetic diversity. While this system operates well for most larger organisms, microorganisms can not easily be described in terms of conventional species concepts. The biological species concept describes a species as being a population whose members are able to interbreed freely under natural conditions. This idea was originally formulated for macroorganisms reproducing by sexual means, but is not relevant for microorganisms, which reproduce asexually and in many cases, are capable of freely transferring and accepting genetic material from other microbial ‘species’. Further, microorganisms often form symbiotic associations with each other, and with macroorganisms, where the concept of an individual species makes little sense. It is now generally accepted that there are difficulties in formulating a species definition that can usefully be applied to all organisms (see Claridge et al. (1997) for an in depth treatment of current thoughts on species concepts). Nevertheless, the Convention is couched in terms of species, so microbial diversity may also be measured in terms of species and their genetic diversity. We must simply bear in mind that microbial “species” are probably not equivalent to species of larger organisms.

Given that biological diversity, for the purposes of the Convention (see Article 2), is defined on the three levels described above, and doubt exists about the application of the term ‘species’ to microorganisms, one must question the power of the Convention over this group of organisms. However, the Convention also contains other terms under which microorganisms may also be broadly classified and which may help to get around this dilemma. For instance ‘biological resources’ (according to Article 2) includes genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity. Microorganisms, or parts thereof, fall into this broad category of ‘genetic material’.

Microorganisms are mentioned specifically under Article 9 (*Ex situ* collections) “[e]stablish and maintain facilities for *ex-situ* conservation of and research on plants, animals and micro-organisms preferably in the country of origin of genetic resources;”. However, because many culturable microorganisms are easy to subculture and store (historically undertaken to advance global knowledge in the microbiological sciences), many have been taken from their country of origin and are now deposited in internationally held *ex situ* collections (see next section). This has been exacerbated, in part, by the Budapest Treaty which is an international treaty enabling a patent applicant to deposit a microbe (in a collection achieving international depository authority (IDA) status), and then rely on this deposition as a means of describing that microbe. Only a minimal number of countries have collections achieving the IDA status and therefore, as a consequence, many patented strains might only be professionally preserved and stored in only a small number of countries (de Brabandere 1992).

Access to *ex situ* collections poses legal problems within the context of the Convention in terms of benefit sharing and technology transfer. Furthermore, it is not always possible for companies and provider countries to come to understandings of agreement or for bioprospectors to know who to contact in relation to brokering a deal with the inclusion of mutually agreed terms. Indeed, some countries propose to punish individuals who transfer commercially valuable results (on research into biological resources) to foreign nationals without official approval (Jayaraman 1997). Debate is also occurring in the United States over questions of who reaps the benefits from bioprospecting (Adair 1997; Kleiner 1998). However, without access there can be no sustainable development and benefit sharing. With this latter aspect in mind, a code of conduct is now being developed for *ex situ* collections of microbial cultures.

Microbial collections and the Convention

Although it is recognised that biodiversity is best conserved *in situ* (see Preamble to Convention and Principles of NBDCS), many *ex situ* collections of biological and genetic material exist. A code of conduct is currently being drafted which specifically deals with *ex situ* collections of microbial cultures (de Brabandere (BCCM™) 1997). MOSAICC (*M*icro-*O*rganisms *S*ustainable use and *A*ccess regulation, an *I*nternational *C*ode of *C*onduct) aims to represent a pragmatic and widely accepted code of conduct for the access to and sustainable use of microbial resources within the framework of the Convention (de Brabandere 1997). The code is currently being developed between some culture collections, industrialists, judicial experts, North and South representatives and NGOs (non-government organisations) (Davison et al. 1998).

Many *ex situ* culture collections of microorganisms exist world wide, this is, in part, due to the relative ease with which those microorganisms can be cultured and stored (Davison and Veal 1993; de Brabandere 1996). These culture collections could play a role in the dissemination of organisms between developing and developed countries as well as in technology transfer. Furthermore, Article 9 of the Convention makes specific provisions for *ex situ* culture collections. This has legal and political ramifications in that countries ratifying the Convention have a duty to fund these collections.

The two main objectives of MOSAICC are to (i) secure easy access to and international circulation of microbial resources and (ii) fulfil the interests of sustainable development of industrialised and developing nations i.e. to ensure benefit sharing wherever sustainable. However, stumbling blocks to these objectives exist within the body of the Convention. For instance, some cultures are deposited in collections under the constraints of confidentiality agreements. Furthermore, the curators of collections can not monitor the commercial use of distributed cultures or know whether prior informed consent (PIC) was granted to the researcher from the country of origin. Curators must also operate in a climate of limited resources and consequently, are unable to track or control possible future transfers of the distributed strains. These issues will be addressed by the creation of MOSAICC which will be developed (initially as a voluntary code) with the consideration of the key issues set out by Iwu (1996). Furthermore, it must be noted that the “problems” outlined above are relevant to preexisting collections rather than post-MOSAICC collections. MOSAICC could therefore be used as an instrument to advance the Convention in such issues (see below).

In addition, the code will endeavour to draw up model forms dealing with access to biological resources and biotechnology, PIC procedures, material transfer agreements and mutually agreed terms. Being scheduled as a pragmatic type of contractual toolbox, it is acknowledged that many issues will have to be considered on a case by case basis. It is anticipated, however, that the evolution of the project can be monitored via the BCCM™ website (http://www.belspo.be/bccm).

MOSAICC is being developed as a European initiative with seed money from the European Commission (Table 2). Despite its initial voluntary status, it is hoped that MOSAICC will become a global document, possibly as a protocol to the Convention through the power vested in Article 28 which provides for adoption of protocols to the Convention. Australia will thus have a role as all Contracting Parties to the Convention can cooperate in the formulation of protocols. Protocols can then be formally adopted at a meeting of the Conference of the Parties and be used to advance the Convention in the area of microbial diversity. It should be noted however, that while protocols need to be adopted by the Conference of the Parties, this does not mean that they are legally binding on all Convention parties. Protocols are separate legal documents to which contracting parties have the option of signing, ratifying and becoming a party to.

Australia, as a signatory to the Convention, is committed to abide by its provisions (see Sands (1996) for a discussion on these issues). Similarly, as a signatory to any protocol encompassing the framework of MOSAICC, it would be a very powerful argument for microbial scientists (researchers, taxonomists, culture collection personnel) to use to gain funding and other resources, towards microbial diversity. MOSAICC also has common ground with Objective 7.1.1(p) of the NBDCS that aims to have “established legislative and administrative mechanisms for control of access to Australia’s genetic resources” by the year 2000.

As alluded to previously, Australia’s ‘genetic resources’ also include the microbial component of biodiversity. Australia is in the unique position of being a developed megadiverse country, at least in terms of macrobiodiversity, there is no reason to believe that this should be any different in terms of microbial diversity. In fact, current research is challenging the view that many common microorganisms are ubiquitously distributed (for a discussion see Service 1997). Techniques already exist in Australia for the assessment of biodiversity including pioneering techniques developed in the

Table 2. Founding partners involved in the drafting of MOSAICC (reproduced with kind permission from Microbiology Australia).

Partner and institution	Country
Jan de Brabandere, Philippe Desmeth (Coordinators) (desmeth@mbla.ucl.ac.be) Office for Technical and Cultural Affairs, Belgian Co-ordinated Collections of Micro-organisms (BCCM^{TM})	Belgium
OECD Directorate for Science Technology and Industry	International (France-based)
IUCN (World Conservation Union) Environmental Law Centre	International (Germany-based)
Royal Botanic Gardens, Kew	United Kingdom
Forum Industrial Microbiology (FIM)	Denmark
International Mycological Institute Centre for Agriculture and Biosciences International (CABI)	International (United Kingdom-based)
World Federation of Culture Collections (WFCC)	International (United Kingdom-based)
Industrial Platform for Microbiology (IPM)	International
Colecao de Culturas Tropical	Brazil
Agricultural Research Council	Republic of South Africa
Universitas Indonesia Culture Collection	Indonesia
Inbio (Universidad Nacional de Biodiversidad)	Costa Rica

Key Centre for Biodiversity and Bioresources (‘the Centre’). The Centre is currently undertaking a major study examining biodiversity at many levels, including microbial, in a region of the Sturt National Park in the north western corner of New South Wales (350 km north of Broken Hill). These techniques coupled with Australia’s biological richness will make Australia ideally placed to participate in capacity building and technology transfer with our developing neighbours.

Australia, as a developed nation, may not at first glance appear to gain much from the MOSAICC concept. However, Article 9 specifically states that conserving, and establishing and maintaining *ex situ* conservation facilities should preferably be *in the country of origin*. In Australia, there are currently no adequately resourced national collections of microorganisms. Further, it is difficult to gain access to Australian microbial resources which include, among others, type cultures, standard reference strains and conserved microbial diversity (Sly 1998). As Sly (1998) states:

> Unfortunately, valuable type material from past studies is often not available or not accessible, owing to the lack of a national inventory. Frequently, the easiest – or sometimes the only – way to obtain cultures is to re-import them from permanent overseas collections if the cultures have been accessioned in the past.

It has been proposed that a tripartite system be required, to include an Australian Microbial Resources Study, Australian Collections of Microorganisms[4] and Australian Microbial Resources Information Network, to allow an adequate framework to be developed for conserving and providing access to Australian microbial diversity

(Sly 1998). However, as Glowka (1996) points out, for this to be relevant to the Convention and gain the required resources needed for its support, the proposed system could be accomplished by implementing activities such as:

1. Linking activities to the Convention's implementation and, in particular, referring to the Convention in research and funding proposals....;
2. Building alliances and undertaking joint or interdisciplinary research with non-microbial scientists working on biological diversity issues;
3. Tailoring research programmes and results to the needs of biological resource managers and policy-makers.

Much of this is consistent with the tenets of MOSAICC and thus, Australia could itself use MOSAICC as a framework for adapting and advancing domestic policy in the area of microbial diversity research, conservation, information sharing and exploitation.

Conclusions

The conservation, management and knowledge of all forms of biodiversity remain of vital importance to the well being and functioning of this planet and the human race. Currently, little is known on a global scale of the extent of all types of biodiversity and specifically microbial diversity.

While Australia has some useful forms of legislation to protect and conserve biodiversity, lack of funding, further population growth and the unsustainable development of human activity may ultimately lead to further decreases in its biodiversity reservoirs.

Australia has the opportunity to participate in the international arena through schemes such as MOSAICC that could lead to more equitable sharing of benefits from microbial products and services. However, again, without the funding to support such schemes, it is doubtful what their impact will be on maintaining and conserving *ex situ* collections. Furthermore, Australia may miss yet another opportunity to lead the way in the conservation and sustainable use of all forms of biodiversity.

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Notes

[1] For the purposes of this paper, the term 'microorganism' will be used to cover those groups of organisms which are detectable with or without the aid of an electron or light microscope including viruses, prokaryotes, including Eubacteria (bacteria) and Archaea (archaebacteria) and eukaryotes such as protozoa, filamentous fungi, yeasts and algae (as used by Glowka (1996) from Stackebrandt (1994)).
[2] To this end, a Commonwealth-State working group on Access to Biological Resources to investigate options for a national approach to access to biological resources in Australia was established in May 1994. Conference of the Parties to the Convention on Biological Diversity November 1996 Third Meeting, Buenos Aires, Argentina. UNEP/CBD/COP/3/20.
[3] Report of the Second Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice UNEP/CBD/COP/3/3.
[4] In much the same manner as the Belgian Coordinated Collections of Microorganisms.

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