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PROCEEDINGS OF THE SEMINAR "BARCODING OF LIFE: SOCIETY AND TECHNOLOGY DYNAMICS - GLOBAL AND NATIONAL PERSPECTIVES"

Submitted by the International Development Research Centre of Canada

Note by the Executive Secretary

1. The Executive Secretary is pleased to circulate herewith, for the information of participants in the ninth meeting of the Ad Hoc Open-ended Working Group on Access and Benefit-sharing, the proceedings of the seminar "Barcoding of Life: Society and Technology Dynamics–Global and National Perspectives" organized by the International Development Research Centre of Canada and held at the Third International Barcode of Life Conference in Mexico City, on 9 November 2009.

2. The report is being circulated herewith in the form and languages in which it was received.

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Proceedings of the Seminar "Barcoding of Life: Society and Technology Dynamics - Global and National Perspectives," held at the Third International Barcode of Life Conference in Mexico City, Mexico, November 9th, 2009.

Sponsored by the International Development Research Centre of Canada.

REPORT ON THE SESSION "BARCODING OF LIFE: SOCIETY AND TECHNOLOGY DYNAMICS - GLOBAL AND NATIONAL PERSPECTIVES", HELD AT THE THIRD INTERNATIONAL BARCODE OF LIFE CONFERENCE IN MEXICO CITY, MX, NOVEMBER 9TH, 2009

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EXECUTIVE SUMMARY

The intentions of the International Barcode of Life project (iBOL) are admirable as it champions the core values of open access to information and sharing of benefits (ABS) arising from the knowledge produced by the project. However, developing nations are understandably hesitant to allow the free flow of biological materials across their borders, and it would be naive to believe that commercial activities making use of data gathered by iBOL will honour ABS principles without well-established guidelines in place. For this reason, iBOL should create an ABS Advisory Committee—under the guidance of the International Development Research Centre, which includes experts in the legal, economic, and social science fields—to ensure that iBOL receives "state of the art" advice on ABS issues and operations follow appropriate international laws and guidelines.

INTRODUCTION TO DNA BARCODING

In the 250 years since the Swedish scientist Carl Linnaeus first started the task, taxonomists have formally described roughly 1.7 million species. While this is a monumental accomplishment, it represents a small fraction of the estimated 10 to 100 million species on the planet. Moreover, human activities are causing the extinction of these species hundreds of times faster than the natural rate, and fully one third of all species on the planet may be gone by the end of this century—many of whom will pass without ever having the chance to be studied and, more important, protected. It is within this context that the technology of DNA Barcoding was introduced by Dr. Paul Hebert at the University of Guelph, Ontario, in 2003. The concept is simple but powerful: to build a library of short, standardized pieces of DNA from all of Earth's species that would enable the scientific community to quickly and accurately assess the Earth's biodiversity and monitor it over time. In the few intervening years between then and the present, nearly 800 thousand individual specimens have had their DNA barcode analyzed and deposited into a database, representing approximately 100 thousand species. These individual organisms have all been placed into museum collections so that future generations can study them, and their extracted DNA has been placed in a secure repository—a particularly valuable aspect of an endeavor that will allow the essence of an organism to survive even if the entire species is lost to history.

THE INTERNATIONAL BARCODE OF LIFE PROJECT (IBOL)

To date, most DNA barcoding has been performed by researchers in developed countries, but it is a well known that the majority of Earth's biodiversity lives within tropical and subtropical regions. It is for this reason that the International Barcode of Life Project (iBOL) will be launched in 2010—the International Year of Biodiversity—and will include researchers from 25 nations around the globe. This project has the ambitious goal of retrieving DNA barcodes from 5 million specimens representing 500,000 of Earth's species within the first five years of its operations. Recognizing that many developing countries lack the resources and scientific capacity to perform DNA sequencing within their borders, a tiered participation structure was developed: "National Nodes" (*e.g.*, Argentina and Kenya) are primarily responsible for the field collection and taxonomic identification of specimens that are destined for DNA barcoding. "Regional Nodes" (*e.g.*, Brazil and Australia) are responsible for organizing the efforts of National Nodes within their geographic regions, and assisting in basic laboratory work. Finally, "Central Nodes" (*e.g.*, Canada, the United States of America, and Europe) are to be responsible for the majority of DNA sequencing and informatics work. Under this scheme, a large amount of biological material must flow between the nodes of the network. However, due to historical injustices, many of these countries are loathe to allow their biodiversity resources to leave their borders—especially into the hands of the developed nations.
It should be made clear that the goals of iBOL—and the DNA barcoding community at large—are completely honorable. The database of Earth's biodiversity arising from iBOL is to be free for the whole world to access and use. While there are almost certainly commercial applications that will arise from this rich data source, iBOL is committed to ensuring that citizens of all nations have an equal chance to take advantage of these commercial opportunities. Nevertheless, perhaps because it is a project driven by natural scientists, iBOL has thus far taken a rather naive stance on issues of access and benefit sharing (ABS). Where difficulties have been encountered in obtaining specimens from certain countries with strict biodiversity export rules (e.g., Brazil and India), it has often been possible to take advantage of grey areas or loopholes in the law. However, this strategy is not sustainable as the iBOL continues to grow in size and scope. For this reason, we are grateful that the International Development Research Council of Canada (IDRC) insisted in addressing this situation at the Third International Barcode of Life conference held in Mexico City in November, 2009. Expert panelists were asked to write position papers on ABS issues as they relate to the iBOL project, and to present their views to the attendees of the conference.

THE PANELISTS

JUNKO SHIMURA, PROGRAMME OFFICER, SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY

Dr. Shimura, who is a Programme Officer for the Global Taxonomy Initiative, highlighted the goals of the Convention for Biological Diversity (CBD) and how they relate to the study of taxonomy. According to the Convention, by 2010 the world was supposed to have reduced the rate of biodiversity loss; for this reason, it has been named the International Year of Biodiversity. Since the science of taxonomy is key to our understanding and monitoring of biodiversity, the Global Taxonomy Initiative has a pivotal role to play in meeting the CBD's goals. This includes building and maintaining taxonomic knowledge and resources; improving access to those resources and information; generating new information required for key decision-making; all while maintaining the principles of access and benefit sharing (ABS).

MANUEL RUIZ MULLER, DIRECTOR OF THE PROGRAM OF INTERNATIONAL AFFAIRS AND BIODIVERSITY OF THE PERUVIAN SOCIETY FOR ENVIRONMENTAL LAW

Mr. Ruiz Muller, a lawyer with expertise in ABS issues, indicated the need for science and the law to find synergies. Since the International Barcode of Life Project (iBOL) requires access to biological and genetic resources, it is important to address how this affects the core rights of countries, as recognized by the CBD: sovereignty, property, and intellectual property. In many cases, these rights are already protected by state laws, although they typically stress the protection of tangible assets (i.e., biomaterials) rather than intangibles (i.e., information and knowledge). This raises a number of intriguing questions. For example, since the United States of America has not ratified the CBD, how does this affect the legal status of biological materials and information entering the U.S.? How can the benefits of the iBOL project be shared in an equitable manner? Are indigenous rights affected by iBOL operations? This depends on the relation of biological samples to traditional knowledge (TK), and whether or not prior consent from indigenous people was obtained. In light of these concerns, Mr. Ruiz Muller had a number of specific suggestions for iBOL:

1. Liaise with government policymakers, providing specific details on the opportunities for developing countries to participate in the iBOL Project in an equitable way
2. Create specific guidelines for the handling of IP, ABS, and TK issues
3. Research the potential commercial uses of iBOL products, and how this could impact on ABS principles
4. Raise the awareness of iBOL to researchers in developing countries
5. Connect with international policy development groups to ensure that state of the art recommendations are being followed.

HARIBABU EJNAVARZALA, PROFESSOR OF SOCIOLOGY, UNIVERSITY OF HYDERABAD, INDIA

Dr. Ejnavarzala outlined how the National Biological Diversity Act of India was created to prevent biopiracy and bioprospecting. It includes regulatory agencies at all levels of government: national, state, and local. In his interviews with scientists and civil society organizations (CSOs), feedback on these laws was mixed. Some scientists expressed concerns that these laws could stifle scientific progress. On the other hand, others thought that the laws created a good framework in which DNA barcoding research could take place. CSOs, interestingly, wished that the laws were equally stringent for Indian

citizens to prevent exploitation of traditional knowledge by India's own citizenry.
Dr. Ejnavarzala recommended that iBOL recognize the various levels of consent that exist: states, local governments, and finally communities. Risks—especially to communities—should be assessed by independent 3rd parties and the implications of DNA barcoding activities (both intended and unintended) should, to the extent possible, be clearly laid out beforehand. Finally, since there could be significant social and ethical implications to iBOL activities, Dr. Ejnavarzala strongly recommended that iBOL fund studies in these areas.

JOSEPH HENRY VOGEL, PROFESSOR OF ECONOMICS, UNIVERSITY OF PUERTO RICO-RIO PIEDRAS

Dr. Vogel took a reductionist approach to DNA barcoding, and realized that at its core DNA barcoding is simply information. However, unlike artificial information that is protected by international intellectual property laws, natural information has no protection and can therefore be exploited by commercial interests—clearly violating the principles of ABS.
Dr. Vogel argued that sovereignty, though well-meaning, only leads to price wars between countries that share similar biological resources. This can be seen empirically, where MTAs (where public) typically show royalties as small as 0.5%, and even 0.2% in extreme cases. The solution, according to Dr. Vogel, is for megadiverse countries to form "biodiversity cartels" that can engage in price fixing, ensuring fairer royalty rates in the range of 13-15%. In cases where a species is present in such a large number of countries that transaction costs exceed the benefits of the royalties, the proceeds could come back to the iBOL corporation, allowing it to be a self-funded enterprise.

DAVID SCHINDEL, EXECUTIVE SECRETARY, CONSORTIUM FOR THE BARCODE OF LIFE (CBOL)

Dr. Schindel noted that DNA barcoding is the only technology that can address the global need to document and catalogue biodiversity. Indeed, the CBD has made clear that it believes DNA barcoding has a critical role to play in conservation. Dr. Schindel made clear that in his opinion, DNA barcoding activities do not constitute biopiracy since there are myriad not-for-profit benefits that have and will continue to arise from iBOL and related projects. Nevertheless, CBOL has been active in investigating the implications of DNA barcoding on ABS issues, and have identified some core issues that should be addressed:

1. What happens if there is a change of intent from non-commercial to commercial research?

2. How do we prevent the transfer and unauthorized use of tissues held in foreign repositories?

3. How do we monitor the post-publication use of research findings for commercial purposes, to ensure that benefit sharing is taking place?

In CBOLs investigations into these issues, they have determined that while there is no clear distinction between commercial and non-commercial activities, there are a few telltale signs. For example, while non-commercial research typically puts its results into the public domain, commercial research seeks IP protection and restricts the dissemination of information. In order to lower transaction costs associated with ABS negotiations, these agreements should be standardized, and should include access to pre-publication results. Finally, many risks can be mitigated through good policies: CBD policies should be institutionalized, codes of conduct should be formalized, and long-term relationships should be encouraged rather than permit-based relationships.

PAUL HEBERT, SCIENTIFIC DIRECTOR, INTERNATIONAL BARCODE OF LIFE PROJECT (iBOL)

Dr. Hebert gave an overview of the iBOL project and its efforts to promote fairness among the participating countries. For example, each country has equal representation on the iBOL Scientific Steering Committee. In addition, Dr. Hebert stressed that iBOL can help correct injustices of the past. Historically, scientists from the West visited developing nations and collected the flora and fauna, only to bring these valuable specimens back to their home countries where they sit in museum collections to this day, locked away and inaccessible to most of the public. By taking pictures of these specimens, reading their DNA barcodes, and putting these data into an open-access, online database, it allows countries of origin to reclaim the knowledge that was stolen from them so many years ago. Finally, taxonomic monographs are extremely expensive, making them all but impossible to obtain by scientists in the developing world. However, DNA barcoding breaks down these barriers, democratizing taxonomic knowledge and making it accessible not only to scientists, but also to the general public.

DISCUSSION

While ABS issues are of extreme importance, it is also important to avoid stifling scientific research—especially if it hurts the developing nations that ABS-related laws are meant to protect. Participation in the iBOL project has many direct benefits for the developing world. As Dr. Hebert noted, by imaging and DNA barcoding museum collections and allowing open access to these records in an online database, the iBOL project is, in a way, returning these precious biological specimens back to their countries of origin. In addition, these DNA barcode libraries will allow developing nations to quickly, accurately, and inexpensively inventory their biodiversity assets and track them over time and space. Moreover, there are many secondary benefits to iBOL participation such as the training of students in state of the art field collection and laboratory techniques, and the development of basic science infrastructure and capacity. Nevertheless, there are countless examples of other scientific projects where—even with the best of intentions—benefits were derived from biological materials that were never transferred back to the nations of origin. For this reason, the governments of developing nations are understandably skeptical of scientific endeavors originating from the West, sometimes resulting in strict laws (as in India) where foreign access to biological materials is all but impossible.

Can the system be gamed by redefining a "biological material"? For example, if the country of origin can perform a DNA extract on a particular specimen, perform PCR amplification of just the barcode region of the genome, and send only this product across the border, can we avoid the red tape? Clearly, the answer is no. The CBD defines biological and genetic resources very broadly, including not only the biological material itself but also information arising from that material. In light of this, it is quite frustrating to note that pharmaceutical and food products—biological materials by any definition—flow freely across borders while well-meaning scientific endeavors are blocked. This is still an area of active debate within the CBD, and final decisions are scheduled to be made in 2010. It behooves the iBOL project to exact influence on this process, in order to ensure a set of recommendations that protects biodiversity-rich nations while simultaneously avoiding the inhibition of scientific progress.

RECOMMENDATIONS

The road ahead will likely not be a smooth one for iBOL as ABS issues become more prominent. However, there are steps that can be taken to ensure that roadblocks are minimized. First and foremost, it is necessary to formalize what it means for a nation to participate in iBOL. ABS concerns must be clearly laid out, including but not limited to how information arising from the project can be accessed, how researchers from developing nations can participate in research (including co-authorship on publications), and how research results will be shared (including pre-publication results). Guidelines for the commercial or industrial use of iBOL-related products and services should be established. Policymakers from each participating nation as well as international policy development groups should be approached to help create standardize agreements in order to establish long-term contracts with participating countries rather than operating on a permit-by-permit basis. To the extent possible, iBOL must determine all consequences of the project (both intended and unintended) up front so that governments can develop informed policies. Finally, although it is critical to engage national and state governments, the true stewards of biological diversity at the local level must also be included in the process. This not only means obtaining consent before collection and DNA barcoding efforts, but also sharing the resulting data with these local communities and training them in its use.

The participants in iBOL are chiefly natural scientists who do not have the capacity or training to adequately address ABS issues relating to the Project. For this reason, it is necessary for iBOL to establish an ABS advisory board, consisting of experts from the legal, social science, and economic fields to ensure that state of the art recommendations are being followed. The International Development Research Centre is in an excellent position to help find a chair for this board, and to recommend board members who can provide the best advice to the Project.

WORKING PAPER

The Global Taxonomy Initiative: engaging science in national biodiversity strategies in concordance with the fair and equitable sharing of the benefits arising out of the utilization of genetic resources

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I. INTRODUCTION

The Convention on Biological Diversity (CBD) has three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. The Convention is a legally binding international agreement under the United Nations, by which each contracting Party commits to develop a National Biodiversity Strategy and Action Plan to integrate the Convention into relevant sectoral or cross-sectoral plans, programmes and policies (Article 6 of the CBD). Parties also commit to identify and monitor their biodiversity as far as possible for the purpose of conservation (Article 7) and present, through their national reports, information on measures that have been taken for the implementation of the provisions of the Convention (Article 26).

To identify and monitor the county's rich biodiversity with existing capacity requires international collaboration in taxonomy and robust activities of technology transfer in bio-technology. The contracting Parties, taking into account the special needs of developing countries, shall establish and maintain programmes for scientific and technical education and training in measures for the identification, conservation and sustainable use of biological diversity (Article 12).

In this process, access to biological materials by non-national researchers often occurs. In accordance with Article 15 of the Convention, governments have the authority to determine access to genetic resources. Access to genetic resources is subject to the prior informed consent of the provider country. The terms of access and use of the genetic resources, including the sharing of benefits arising out of the use of these resources are to be set out in mutually agreed terms between the country providing the genetic resources and the user of the resources. The country providing genetic resources may also require prior informed consent when genetic resources are being accessed for scientific research. In this situation, benefits to be shared could include the results of research and other non-monetary benefits, such as the transfer of technology which makes use of those resources. The full text of the Convention is accessible at http://www.cbd.int/convention/convention.shtml

To support the implementation of the Convention, the Conference of the Parties (COP) to the CBD decided to establish the Global Taxonomy Initiative (GTI) as one of its cross-cutting issues to build taxonomic capacity in relevant sectors working for conservation and sustainable use of biodiversity. This includes non-commercial research by taxonomic and biodiversity informatics experts in collaboration with local experts of the country providing biological materials. To date, some national requirements for access to genetic resources and benefit-sharing have been considered cumbersome by the scientific community and have led to difficulties in promoting the GTI. The activities of GTI require international collaboration in taxonomy, which includes the need for access to and transfer of biological specimens. There is concern that access and benefit-sharing regulations of provider countries may create an impediment to the collection of samples, transport, DNA analysis and information-sharing and consequently hinder taxonomic research and the transfer of technology.

This paper summarizes the background of the GTI and DNA barcoding, and their great potential to contribute to the CBD in enhancing biodiversity-monitoring capacity. Such capacity provides information on national biodiversity status, which is essential for sound decision-making, and strongly assists development of national biodiversity strategies and action plans (Article 6), as well as the reporting process on the effectiveness of conservation measures (Article 26).

II. THE GLOBAL TAXONOMY INITIATIVE: UNDERPINNING THE IMPLEMENTATION OF THE CBD

Importance of Species Identification

The Convention recognizes biodiversity at three levels: species diversity, genetic diversity and ecosystem diversity. Species diversity is most commonly recognized to indicate diversity of biological components in the environment. To date, the number of all known species in the world is almost 1.9 million out of the estimated diversity of 11 million; other estimates place the number in a range of between 3 and 100 million[1]. Genetic diversity, which refers to genetic variation within species and between species, provides valuable information about genes or the part of genes responsible for a unique characteristic of the species or biological functions derived from the expression of responsible genes. Ecosystems consist of inter-linked relationships between species, and the uniqueness of each ecosystem is the result of interaction among species and other non-biological environmental elements, including climate. Species is therefore a fundamental concept to determine the components of biodiversity in all three levels of biodiversity.

The term "species" is a scientifically agreed concept that refers to a group of organisms as one distinguishable component of biodiversity. This concept is used as a unit to observe biodiversity. For planning and monitoring of national conservation and sustainable use of biodiversity there is one basic need: identification of species. Conservation status, such as "endangered" or "threatened", is based on the count of individuals found in each species. Species identification determines which organisms are targeted for control of pests or diseases and attests the labels on the vials in seed / cell banking. The same identification need applies to benefit-sharing for the utilization of genetic resources. For example, indication of species name on biological products sometimes influences its market value, and species names provide information on the origin of genetic resources. Therefore, sound decision-making on biodiversity requires species identification, influences economies and is deeply inter-linked with national

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[11] http://www.environment.gov.au/biodiversity/abrs/publications/other/species-numbers/2009/pubs/nlsaw-2nd-complete.pdf

development strategies.

To distinguish between groups of organisms, taxonomy uses various technologies. It includes morphology, chemistry and enzymology; today, DNA sequences of selected genes also provide useful information. Further, taxonomy is the science that can reveal the hierarchical relationship between these groups of organisms. It helps people to understand the overall picture of evolution of life-forms on Earth. Taxonomic research is also a way of preserving reference materials, such as specimens and living cultured cells, and DNA sequence information to secure the concept of species. This *ex-situ* preservation is a fundamental practice to provide necessary information for sound planning and decision-making, such as, for example, identifying the animals and plants that exist in the country and how the species can be distinguished from other animals and plants and this provides the base for sound biodiversity strategies and action plans. In addition, the taxonomic information associated with the preserved specimens and cultured cells includes their collection dates and the locality or site where the samples were obtained / isolated on Earth. Once the locality information is integrated worldwide, it provides valuable information on the distribution of species both in the past and the present. This information can be subjected to studies predicting species distribution in response to climate or other environmental changes. Armed with this information, each country can assess the risks and impacts of environmental changes.

The COP has recognized that the current level of taxonomic expertise to conduct the research activities described above is not sufficient to support the implementation of the CBD, and called this situation the "taxonomic impediment". Overcoming this taxonomic impediment is the *raison d'être* of the GTI. The COP adopted its programme of work in 2002, subsequently reviewing it in-depth and updating[1] it in 2006. In decision VIII/3, the COP requested the Executive Secretary of the CBD to develop a guide on how to implement the GTI programme of work and to convene a project development seminar for pilot projects under the GTI for those countries where taxonomic need was identified for implementation of the CBD. In 2008, outcome-oriented deliverables for each of the planned activities of the programme of work of the GTI (OOD-GTI)[2] were adopted. In response to the COP request, CBD Technical Series No. 30, *Guide to the Global Taxonomy Initiative* was published in 2009[3], to assist Parties to implement the GTI on the ground.

As GTI is a cross-cutting issue under the CBD, the GTI is relevant to virtually all of the work under the CBD. It is important to remember, however, that in every country, the inadequacy of taxonomic resources is an obstacle to conducting the planned activities outlined in the programme of work for the GTI. Even in the developed countries, where research facilities and materials, such as specimens and taxonomic literature, are available and maintained in good condition, taxonomic capacity remains inadequate to support national assessment of biodiversity[4].

Obstacles for Promoting the GTI under the Present Circumstances

For the realistic implementation of the GTI, the need for international collaboration between taxonomic institutions and the trans-boundary movement of specimens for research will continue. In this regard, it is worth noting that the "Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization" adopted by the COP in 2002 recognise that "taxonomic research, as

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1 UNEP/CBD/COP/8/3 http://www.cbd.int/decision/cop/?id=11015
2 UNEP/CBD/COP/9/22 http://www.cbd.int/decision/cop/?id=11665
3 CBD Tech Ser No. 30 http://www.cbd.int/doc/publications/cbd-ts-30.pdf
4 The CBD Third and Fourth National Reports http://www.cbd.int/reports/

specified in the Global Taxonomy Initiative, should not be prevented, and providers should facilitate acquisition of material for systematic use and users should make available all information associated with the specimens thus obtained." (par. 11(l) of the Bonn Guidelines)[1].

These guidelines also indicate that special terms and conditions should be established under mutually agreed terms to facilitate taxonomic research for non-commercial purposes. In the OOD-GTI, approved by the COP in 2008, an international workshop to discuss the obstacles to international transfer of biomaterials for non-commercial research is listed as one of the deliverables under the planned activities to support access and benefit-sharing (ABS). Taking the OOD-GTI into account, the workshop "Access and Benefit-sharing in Non-commercial Biodiversity Research" was held in Bonn from 17 to 19 November 2008. The report of the workshop, *Preserving International Access to Genetic Resources for Non-commercial Biodiversity Research,* was circulated as an information document to the participants in the eighth meeting of the Ad Hoc Open-ended Working Group on Access and Benefit-sharing[2].

The other obstacles to the implementation of the GTI are the view (i) that time-consuming taxonomic research might not help conservation before serious biodiversity loss occurs; and (ii) that local and national implementers in relevant sectors could not receive necessary training of identification of species due to limited taxonomic expertise within the country. To address these obstacles, the GTI needs to explore technology to accelerate the speed of taxonomic research and invite the wider community to improve taxonomic capacity for on-site monitoring of conservation and environment at the national level. To address these obstacles, the case of international DNA barcoding projects collaborating with developing countries serves as a useful reference to the on-going discussion on an international regime for ABS.

III. DNA BARCODING UNDER THE PROGRAMME OF WORK FOR THE GTI

DNA barcoding is a relatively new technology to identify species using short genetic markers in the given organism's DNA. It is a powerful tool for both taxonomists and non-taxonomists to rapidly identify unknown specimens, tissues, cells or extracted DNA in a well studied, known classification. For animals and other eukaryotes (organisms which carry nuclear and other membrane-bound organelle, such as mitochondria) mitochondrial cytochrome oxidase subunit I gene is commonly used for identification. For flowering plants, chloroplast (organelles found in plants and protista conducting photosynthesis) genes are candidates for DNA barcoding, and some fungi, bacteria and archaea are subjected to DNA barcoding by using DNA encoding a small subunit of ribosomal RNA. Currently, several national, regional and global DNA barcoding organizations are collaborating internationally to increase species coverage and to improve its throughput time, accuracy, cost, and applicability to biodiversity monitoring and other uses which require species identification.

The Consortium for the Barcode of Life (CBOL)[3] has represented the DNA barcoding community at the meetings of the Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) and the COP to the CBD, and has supported project

[1] Bonn guidelines on access to genetic resources and fair and equitable sharing of the benefits arising out of their utilisation. http://www.cbd.int/decision/cop/?id=7198

[2] UNEP/CBD/WG-ABS/8/INF/6 http://www.cbd.int/wgabs8/doc/

[3] Consortium for the Barcode of Life http://www.barcoding.si.edu/

development for the GTI on the occasion of the 3rd International Conference of the Barcode of Life. CBOL is mentioned as one of the suggested actors in several planned activities of the OOD-GTI. For instance, the following outputs in the OOD-GTI seek the active participation of CBOL:

- *Output 2.6.3.* Identify regional hubs for DNA barcoding taking into account other relevant initiatives and incorporate them into the Leading Labs Network of the Consortium for the Barcode of Life (CBOL) as appropriate in accordance with the national legislation by 2010.
- *Output 4.12.1.* Create a centre for exchange of information on taxonomic guides and other identification tools for pollinators by 2010, populated with all available information.
- *Output 4.12.3*. Develop and begin testing DNA barcodes by 2010 as an identification system for pilot taxa (e.g. tephritid fruit flies or scale insects) in the view of agricultural border inspection.
- *Output 2.5.1*. Create an online registry of repositories of biological collections that provides globally unique identifiers for these collections, and initiate an analysis of countries and regions that lack essential collection infrastructure by 2012.
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A strength of DNA barcoding in the GTI is its potential in transferring the technology to non-professional taxonomists (often called para-taxonomists), including environmental practitioners in developing countries. This would be counted as benefit-sharing for the countries which collaborate internationally through CBOL. As mentioned earlier in this paper, species identification by DNA barcoding is only applicable in the well studied classification. To increase the coverage of species which can be identified by DNA barcoding, further collaboration with taxonomic experts in the mega-diverse countries is required to review and update classification of organisms, which have not been completely studied due to limited capacity. If national authorities consider this type of collaboration utilization of genetic resource and their national legislation is too restrictive, both science community and the environment practitioners will lose a precious opportunity to utilize a flourishing new technology. And it would be very unfortunate if implementation of the CBD limits conservation only in a well-known group of organisms.

IV. PLANNED ACTIVITIES FOR ACCESS AND BENEFIT-SHARING IN THE GTI

The programme of work for the GTI describes the rationale for planned activities for access and benefit-sharing (ABS) as follows:
the inventory of biological resources could provide useful information in view of the elaboration of measures regarding access to genetic resources and the equitable sharing of benefits arising from their exploitation. In order to carry out this inventory, increased capacity is often needed at the country level. The primary goal of the GTI is to assist countries in carrying out this inventory in a timely and efficient manner.
Briefly, the following three outputs are expected under this planned activity:

- Taxonomic support, including at the molecular level, to provide clear identification of specimens in *ex situ* collections, especially in developing countries.

- A series of country-driven projects, combining the development of basic taxonomic capacity and an improved information base on biological resources.
- Information on genetic resources, a basis for the commercialization of components of that biological diversity would be provided.

The *Guide to the Global Taxonomy Initiative*[6] [1]offers commentary on the planned activities for ABS. Regarding species inventories, Parties are committed to identify and monitor the components of biodiversity by Article 7 of the Convention. Briefly, this process is supported by useful information resources in open-access taxonomic literature, on-line databases as well as *ex-situ* collections held by museums and herbaria both within and outside the country where the species is found. There is controversy regarding collection by non-nationals and subsequent taxonomic work on specimens taking place outside the country of origin. As a result of their commitments under the CBD provisions on ABS, many countries are evaluating and changing the permit systems for researchers. It is important to safeguard rights, but if the system developed is too restrictive, expensive or time-consuming, researchers will not be able to do the key taxonomic work that the country needs, thereby hindering the development of inventories and other information needed to implement the Convention.

The CBD Ad Hoc Open-ended Working Group on ABS is mandated by the COP to elaborate and negotiate the international regime on ABS and to complete its work before the tenth meeting of the COP in 2010. In this context, it will be important for the negotiators of the international regime to keep in mind the need to develop a regime that will take into account the particular requirements of taxonomic research. It should be recognized that development of national biodiversity inventories for ABS, national biodiversity strategies and action plans, and national reports on effectiveness of the measures are all dependent on national capacities in taxonomy. As for DNA barcoding relevant to the outputs of planned activities for ABS, it is clear that the effectiveness of rapid species identification will greatly aid the development of national inventories of biological resources. One of the COP-approved outputs in OOD-GTI is to identify regional hubs for DNA barcoding and incorporate them into the Leading Labs Network of the CBOL in accordance with national legislation. Effectiveness of this new technology and the information it provides for implementation of the CBD is largely dependent on the result of the emerging international regime on ABS, and how it affects international scientific collaboration.

> The governments of the world that recognise the Convention on Biological Diversity have affirmed the existence of a taxonomic impediment to sound management and conservation of biodiversity. Removal of this impediment is a crucial, rate-determining step in the proper implementation of the Convention's objectives.
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> *Darwin Declaration, 1988*

Acknowledgement: The author thanks Ms Jacqueline Grekin for her editorial

[1] Guide to the Global Taxonomy Initiative, CBD Tech Ser No.30 http://www.cbd.int/doc/publications/cbd-ts-30.pdf

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WORKING PAPER

Preserving International Access to Genetic Resources for Non-commercial Biodiversity Research

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The non-commercial research sector is speaking up as Parties to the Convention on Biological Diversity negotiate an International Regime for Access to Genetic Resources and Benefit Sharing

For the past few years, a Working Group formed under the Convention on Biological FDiversith (CBD) has been developing an International Regime for Access to Genetic Resources and Benefit Sharing (IR-ABS) (1). If the CBD Conference of the Parties approves an overly restrictive IR-ABS in October 2010, then researchers could lose access to biological specimens and materials that are critical to their research. The

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[4]51 participants from 24 countries attended an international workshop on "Access and Benefit Sharing in Non-commercial research" at Museum Koenig in Bonn, Germany on 17-19 November 2008 (see http://barcoding.si.edu/ABSworkshop.html for list of sponsors and participants and workshop report).

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Consortium for the Barcode of Life, together with the German Research Foundation (Deutsche Forschungsgemeinschaft - DFG) and other science organizations held an international workshop in Bonn, Germany in November 2008 on the subject of "Access and Benefit Sharing in Non-commercial Research". Participants represented a balance between industrialized and developing countries and a mixture of researchers, policy-makers, lawyers and economists. As described here, the participants identified key issues and outlined a rational solution that serves research, protects national property rights of genetic resources, and generates important non-monetary benefits such as enhanced ability to monitor and preserve national biodiversity. (2)

The CBD is a legally binding international agreement administered under the UN Environment Programme which entered into force in late 1993, to which more than 190 countries are a Party. The CBD's aims are "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the utilization of genetic resources." (3) The IR-ABS is expected to substantially help in implementing the third objective but there is a controversy over what, specifically, is meant by "the utilization of genetic resources". Interpreted narrowly, it could mean the use of organisms or biological specimens for the purpose of cultivation, selective breeding, genetic modification, or gene splicing. That is, a narrow reading of the phrase would restrict the focus of an IR-ABS to activities using genetic resources only to produce more organisms based on their heritable traits. Many countries and Parties to the CBD, however, support a much broader interpretation of the CBD's definition of "genetic resource" which includes "genetic material … containing functional units of heredity", and "their derivatives … and products". (3) Since "functional units" of DNA and RNA can be found in wood, wool, soil, water, airborne particles, as well as in all agricultural and many pharmaceutical products, this broader interpretation would cover essentially the entire biosphere and many commodities, including anything a biologist might want to touch or sample.

This ambiguity is deeply rooted in the language of the CBD but there is a practical solution. Genetic resources are utilized in different ways and these uses generate different types of benefits. In December 2008, the CBD convened a Group of Legal and Technical Experts to study the issue of definitions in the treaty (and other issues), and they defined seven categories of uses (4). Five of these categories involve making organisms, new varieties, compounds or products for commercial purposes from genes or the metabolic pathways they control. One category is the use of "genetic resources" to conserve endangered species through captive breeding programs or repositories of living organisms (e.g., seedbanks, zoos, botanical gardens, culture collections). The seventh category, "characterization and evaluation", includes the study of organisms for the purpose of generating knowledge of biodiversity and its functional characteristics. Non-commercial biodiversity research fits within this category of utilization. Within these confines, a discussion of access and benefit sharing related to non-commercial may be much less controversial.

Non-commercial research may be linked or lead to research and development of commercial products, but in many cases it does not. Non-commercial and commercial research can use the same methods and facilities and be pursued by the same researchers, making it difficult to distinguish intent. Nevertheless, at the practical level at which international agreements for access to specimens and genetic resources are negotiated, it is possible to separate non-commercial projects and activities from their commercial counterparts. Participants in the Bonn workshop compiled a list of tangible indicators that separate non-commercial from commercial research (e.g., restrictions on dissemination of research results, restrictions on access to reference specimens, patent applications). Distinguished in this way, non-commercial research generates new knowledge and collections of reference specimens that generate benefits through the public domain, without generating proprietary benefits. Countries that provide access to their biodiversity for non-commercial research derive a range of non-monetary benefits, including training, a better understanding of their genetic resources, and an improved basis for managing, conserving, and developing their biodiversity.

The concerns of provider countries were important components of discussions at the Bonn workshop, and three emerged as central: (A) changes of intent from non-commercial to commercial research; (B) use of sample materials by third parties in ways that were not approved by a provider country in legal agreements; and (C) the commercial use of research results in the public domain without sharing benefits with the provider country. The workshop produced suggestions for specific measures, described below, that could be built into legal agreements between researchers and provider countries and would manage the risk of lost benefits associated with these concerns. In the terminology of CBD, these legal ABS agreements include "Prior Informed Consent" to enter into an access arrangement, "Mutually Agreed Terms" of the agreement, and "Material Transfer Agreements" that stipulate the terms of international movement of specimens. The IR-ABS would be highly relevant in developing national legislation that would govern legal agreements to access to genetic resources in both provider and user countries.

(A) *Changes of intent.* Research projects that begin with purely non-commercial intent can make serendipitous discoveries with commercial potential. This is both reasonable and desirable, as long as the mutually agreed terms of the project between provider countries and researchers are followed and the provider country receives its agreed upon share of the benefits. If the terms of a project assumed no commercial intent, then new terms should be negotiated if commercial intent emerges during the project. The indicators of commercial intent, mentioned above, could serve as operational criteria for determining when new terms must be negotiated.

(B) *Third party use of samples.* International transfer of samples is often necessary because many developing provider countries lack taxonomic expertise for identification and the resources to create and maintain repositories for long-term curation of reference collections of biological samples (e.g., museums, herbaria, culture collections) as well as the instrumentation for important analytical techniques (e.g., DNA sequencing, electron microscopes). Provider countries are concerned that once samples of their genetic resources are stored abroad, they could be lent to third parties who will use them for commercial purposes without sharing benefits. New IT systems and codes of conduct that enable the tracking of loaned specimens are becoming more common among repositories and communities of repositories (e.g., IPEN (5), ITPGRFA (6) and MOSAICC (7)). Creative Commons licensing (8) is also gaining acceptance as a mechanism for improving access, documenting ownership, and giving attribution to providers while prohibiting commercial use. Through these systems, provider countries will have access to information on the downstream use of their genetic resources (9).

(C) *Data in the public domain.* Developing countries may have limited capacity for commercial development based on research results in the public, including the results of research on their own genetic resources. In the long-term, capacity building and training will reverse this inequality of capabilities – two key benefits of many non-commercial research projects. In the short term, provider countries should be given the opportunity to protect their property rights before they are published and lead to commercial development by others. This could be accomplished by including a standard element in non-commercial ABS agreements -- a requirement that users must provide copies of manuscripts to provider country authorities when they are submitted for publication. Provider countries would not have the right to block, delay, or edit the publications, but they would have an opportunity to protect property rights before publication.

Ensuring the fair and equitable sharing of the monetary benefits of commercial research is a complicated legal challenge. The CBD's ABS Working Group has labored over this issue for years. In contrast, ensuring the open sharing of the benefits of non-commercial research may be relatively straightforward. As the deadline for submitting the text for an International Regime approaches, Parties to the Convention may wish to harvest this 'low-hanging fruit'. At the April 2009 meeting of the ABS Working Group, the notion of a simplified system of access to genetic resources for non-commercial research seemed to be gaining support. Specific proposals were put forward by several Parties in the negotiation and, relative to other ABS topics, these generated no heated discussion. The next rounds of ABS negotiations will be in November 2009 in Montreal and in March 2010 in Colombia. Participants in the Bonn Workshop will be submitting documents that support the proposal for a simplified access regime for non commercial research, such as the following.

An operational definition for non-commercial research. Research with the goal of adding knowledge to the public domain, without restrictions or proprietary ownership, is non-commercial in nature. The research specimens collected during this research should either remain in the country of origin or should be maintained in *ex situ* collections under terms of usage that are mutually agreeable to the provider country and stewards of the specimens.

Simplified, standardized access procedures. Countries such as Australia have implemented procedures that minimize the transaction costs, bureaucracy, and delays associated with granting access to genetic resources for non-commercial research. By using standardized documents, provider countries can promote international research collaborations without compromising control of the use of their genetic resources. Examples of such documents are the Standard Material Transfer Agreement of the ITPGRA (6) and Creative Commons licenses (8).

Proactive measures that promote trust. The research community can be active in building trust with provider countries, thereby reinforcing the mutual benefits of simplified access procedures. A consortium of botanical gardens has developed guidelines for ethical access to and use of plant genetic materials (10) and these guidelines form the basis of institutional policies. The Swiss Academy of Sciences has compiled good practices for non-commercial research that provide detailed guidance to institutions and their researchers (11). The German Research Foundation has produced obligatory Guidelines for grant applications in the scope of the CBD regulations (12). Provider countries can have more confidence in long-term relationships with institutions that adopt these policies than they can with individual researchers who may have no established relationships of trust with a provider country. Repositories of *ex situ* collections can modernize their systems for documenting their specimens, linking them to the ABS agreements under which they were obtained from provider countries and documenting their subsequent use in more transparent ways. Research funding agencies can begin to require adherence to ethical practices, as they do for research involving human and animal subjects.

The most important next step is for researchers, their institutions and professional societies to become aware and involved. Without a concerted effort, an International ABS Regime may make no distinction between commercial and non-commercial research. Taxonomists, ecologists, and many other biologists will then be viewed in the same light as bio-prospectors from pharmaceutical and agribusiness companies (12). The time remaining before the CBD's July 2010 deadline is getting shorter, and the doors to international non-commercial biodiversity research could soon be closed.

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4. Report of the meeting of the Group of Legal and Technical Experts on Concepts, Terms, Working Definitions, and Sectoral Approaches; https://www.cbd.int/doc/meetings/abs/abswg-07/official/abswg-07-02-en.pdf
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WORKING PAPER

The Convention on Biological Diversity Access and Benefit Sharing Principles in the Context of Barcoded Genetic Information: The Case of iBOL

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Abstract: In the mind of a policymaker and lawyer, genetic resources, biotechnology and traditional knowledge remit to sovereignty and rights, access and benefit sharing policy and law, intellectual property legislation and the Convention on Biological Diversity. On the other hand, a scientist would associate genetic resources, biotechnology and traditional knowledge almost invariably with taxonomy, databases, genomics, bioinformatics and, rather recently, to the International Barcode for Life Project (iBOL). This paper reviews how, whether, and if connections between these differing perspectives exist or are possible.

BACKGROUND

Since 1993, the year the Convention on Biological Diversity (CBD) entered into force, many biodiversity-endowed countries have become ever more active in claiming their sovereign rights over biodiversity located within their jurisdictions, including genetic resources (Glowka, 1998; 2003; Carrizosa, 2004). As a result, the "common heritage of mankind" principle has given way to the recognition of sovereignty and laws and regulations in the Andean Region, Brazil, the Philippines, Panama, many African and Asian, etc. They affirm state rights over genetic resources and seek to establish access to genetic resources and fair and equitable access and benefit sharing (ABS) legal regimes (Tvedt and Young, 2007).

These legal frameworks cover mostly animal, plant and microbial genetic resources (as defined by the CBD), except for human genetic resources, which are expressly excluded from the scope of the Convention – given their very special nature and ethical, moral, human rights and cultural considerations surrounding their potential use. Global policy and guidelines in regards to these resources has been left to United Nations bodies and the World Health Organization in particular.

In parallel, over the past two decades or so, advances in modern biotechnology and other technologies as well as their application to biodiversity and genetic resources, have

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given way to a silent revolution in the way scientists understand and uncover the potential in almost all human activity: from gardening to drug development, from breeding to conservation, from natural product development to taxonomic identification, to name a few (Ten Kate and Laird, 1999).
The power of genetic engineering, genomics, proteomics and the like, coupled with increasingly important bioinformatics, all based on analysis of biodiversity and its components (genes, proteins, DNA sequences, RNA, etc.), have transformed research and development processes. These technologies and new scientific disciplines, ride ahead of and are practically unaccounted for in policy and legal debates, including ABS discussions in the context of the CBD and the development of an international regime on ABS in particular (Melendez-Ortiz and Sanchez, 2005; Pastor and Ruiz, 2009).

The International Barcode of Life Project (iBOL), run by the Consortium for the Barcode of Life, is one global project which, based on the use of many of these tools, is dramatically altering taxonomy and its scientific process, by generating highly automated and reliable identification methods, through the combination of information technology instruments and DNA related technologies (Ratnasingham and Hebert, 2007; Stoeckle and Hebert, 2008).

From a policy and legal perspective, members of iBOL "…are committed to the regulatory framework established under the CBD" and expressly indicate that "transactions between iBOL members will respect all restrictions with respect to biomaterials transfers". However, it is far from clear what exactly this commitment means and how it will be put into practice.

This brief essay, seeks to identify and highlight some of the implications which the CBD principles and national regulations on access to genetic resources, fair and equitable benefit sharing and intellectual property rights (IPR), may have on iBOL and its own guiding scientific principles and development plans.

THE CONCEPTUAL CHALLENGE: GENETIC RESOURCES VIS-A-VIS GENETIC INFORMATION

The CBD defines genetic resources as "genetic material of actual or potential value" and genetic material as "any material of plant, animal, microbial or other origin containing functional units of heredity". These are very broad definitions, that cover the tangible element (materials) as subject matter, though with reference to DNA and genes (as functional units of heredity). The "potential value" of materials and genetic information is rapidly being realized and expressed in many fields, including the pharmaceutical sector, medical diagnosis, the plant-breeding industry and bioinformatics development.
The CBD and its ABS principles were conceived by negotiators based on a well-known paradigm (long since surpassed). This was the idea of a scientist, entering the tropical forest, talking to indigenous people, collecting and identifying specimens of medicinal plants, identifying an active compound, patenting a new miracle drug and becoming rich … all part of an almost imaginary past and an inspiration to blockbuster films such as *Medicine Man*. Today, technology has advanced to a point where useful compounds from almost any imaginable source can be extracted, screened and used: deep sea hydro thermal vents, hot springs in the Arctic, micro-organisms of all sorts and origins, botanical gardens, closely related or even totally disassociated species found in the marketplace, etc. (Ten Kate and Laird, 1999; Sasson, 2005; Aldridge, 2006).

Furthermore, anyone with the requisite scientific skills can also access, screen and transform genetic information into potentially useful innovations, with the aid of a good laptop computer and a reliable Internet connection. Gene libraries and extremely sophisticated and rich databases are also transforming the way scientists undertake their routine daily research. In the biological and biochemical field, technology has become almost as important as the material base (biological materials) on which it is founded or over which it is applied.

As part of this progress, taxonomy—once a slow process, often tedious and downplayed by many—has also been reinvigorated. New theories, tools and technologies are changing the way biological classification takes place. Today, individual morphological and phenotypical descriptions of specimens and their subsequent classification is being transformed through DNA-related classification. But as soon as DNA or genes are involved, the CBD ABS policy and legal principles may become relevant.

Though it is generally accepted that taxonomy (whether classical or more modern versions) is typically a *purely scientific* endeavour (in the sense that no profit or commercial interests are usually at stake), taxonomy results are increasingly required in one way or another to embark on practical, profit-oriented, commercial or industrial activities (Stoeckle and Hebert, 2008). More often than not, taxonomy *is* a precondition for research and development. So should taxonomy remain undisturbed and unaffected by often cumbersome ABS rules, sovereignty claims by states, and even IPR? The response is probably yes and no at the same time. There is also the question of iBOL's position within this context: should it relate more closely to these policy and legal considerations?

Key CBD principles in play

In terms of ABS, the CBD calls for the equitable and fair sharing of benefits derived from access to and use of genetic resources. This is a general principle which seeks to ensure that countries of origin, as providers, participate in the value-adding chain generated from utilization of their genetic resources. In each case the precise benefits, and when these will be realized and shared, will depend on policies, regulations and ultimately, agreements between states, researchers, companies and indigenous people.

Box 1. ABS in the Andean Community

Andean Community Decision 391 on a Common Regime on ABS (1996)

is a legal instrument designed to regulate access to genetic resources (in a *tangible* form). It obviates references to genetic information, which remains, in practice unregulated and freely available when isolated and deciphered. Over the past 10 years, implementation of Decision 391 in Bolivia, Colombia, Ecuador and Peru (Andean Community Member States) has been very limited, not least because it is based on a limited understanding of science and the scientific process in general. Taxonomists have been especially vocal about its deterring and chilling effect, especially due to its complex administrative procedures and provisions. Decision 391 makes no distinction between commercial and non-commercially oriented research (as much as these boundaries may be blurred) nor does it facilitate research in the latter. As a result, it is national scientists who are feeling the pain. On the other hand, it could also be argued that iBOL-related activities *are* under the scope of Decision 391 inasmuch as it applies to all conservation, research and other activities that imply using genetic resources. How Decision 391 rules and principles will be applied to activities under the iBOL framework, is anyone's guess.

Bioprospecting projects, usually involving universities, companies, indigenous people organizations and museums (from source and user countries), are usually governed by these principles and rules. ABS is mainly applied to cases where potential commercial or industrial benefits may be derived from the use of genetic resources. Negotiation clauses dealing with IPR in different agreements of such projects are just one indication of the commercial value of activities (Reid, Laird, et al, 1993).

In regard to intellectual property, the CBD also seeks to ensure that biodiversity- derived innovation in general, including biotechnological processes or products, is appropriately protected. There is, however, a compromise to promote technology transfer to countries of origin and providers of genetic resources. This tense balance between private rights and sovereignty is one of the driving forces behind CBD policy and legal developments, from access legislation to defensive protection measures, including protection of traditional knowledge.

Finally, an often overlooked set of provisions of the CBD refers to conservation *per se* and the need to undertake efforts to understand biodiversity and species at the ecosystem level (through education, capacity building, repatriation of information, etc.). Taxonomy, in this regard, is a critical discipline which serves conservation and may also play an important role in profit, commercial or industrial endeavours. Taxonomy is in essence the starting building block for all types of activities. Historically, taxonomy has usually been a costly effort, mostly driven by the interest and needs of researchers (in developed countries) seeking to understand and classify biodiversity. Thereafter, the results of this research serve may serve different purposes.

POTENTIAL IMPLICATIONS OF THE CBD ON IBOL

The main concern really is whether and how CBD principles (equity, fairness, benefit sharing, IPR) are pertinent or even relevant to work and activities undertaken by iBOL. Here is a preliminary list of questions and possible responses:

- *Do ABS principles apply to iBOL activities?* Yes, as long as there are biological materials (genetic resources) involved in the process of researching and classifying species. However, there are additional considerations regarding this response, which may give it a slight turn. These include: how and where were samples collected? In countries with ABS legislation in place? Was this prior to the CBD entering into force? Are materials from *ex situ* sources being used? Or are materials from areas outside national jurisdictions being collected? What is the situation with materials that are currently within the US (which has not ratified the CBD) but were collected elsewhere? Responses could indeed vary considerably from country to country.
- *How do developing countries participate in iBOL?* One very obvious way is best expressed by David Schindel, the Executive Secretary of the Consortium, who says

developing countries "… have a critical role to play because it is they who bring the wealth of biodiversity to the table." (Masood, 2005). In simple terms, at some point data and information have been discovered, isolated, and produced based on biological samples of some sort. This is one way to envision participation. Another, relates to the actual involvement in and benefits from iBOL which developing countries can realize in terms of enhancing their own national scientific capacities and supporting conservation and development efforts.

- *Do iBOL activities affect national sovereignty of countries of origin?* Yes, provided biological samples being used in barcoding and taxonomic identification of species were legally obtained and the sovereign rights of countries respected. Nevertheless, new technologies and widespread distribution of genetic resources and information (especially among megadiverse countries) challenge the concepts of sovereignty and possibilities of effectively controlling flows and movements of resources based on unilateral action by countries.
- *Are the rights of countries of origin being affected when genetic information is accessed from Barcode of Life Consortium databases?* No, provided the data and information is backed by documents which guarantee that biological samples from which these data were obtained, were accessed legally and the appropriate use of data and information conditions has been determined. At the same time, the problem of shared resources and shared genetic information, brings into question how relevant (in practical terms) sovereignty and ABS regimes may be in regards to samples being evaluated, barcoded or used in any way as part of iBOL (Vogel, 1994). Genes are not discreet, unique entities located in a single specie or location. They are shared across borders and are not bothered by sovereignty considerations (Pastor and Ruiz, 2009).
- *How might the cultural rights of indigenous people be affected by iBOL?* This may happen when specimens for barcoding and taxonomic identification are accessed and obtained from indigenous peoples' land without prior informed consent. All biological samples, and even use of traditional knowledge, in iBOL should be backed by legal documents regarding ABS as much as possible.
- *How can benefits be shared with countries of origin?* The key practical issue here is accessibility and availability of all data and information contained in the database developed by iBOL. Provided the data and information remain a common pool, freely available to developing and developed countries institutions and researchers alike, it could be argued that benefits for conservation are being equitably and fairly realized by simply being in a position of participating in accessing and using iBOL for research purposes.
- *Are commercially or industrially oriented uses of iBOL services and products envisioned? If so, are there limitations, guidelines or other orienting principles?* There may be potentially lucrative markets for iBOL products and services (i.e. in public health and virus identification; certifications of product origin; border inspections and sanitary purposes; CITES species trade; etc.). How benefits derived from these types of activities are shared between iBOL partners, and especially countries, is another area requiring further exploration.

These questions can be further qualified and broken down, and some become relevant only in specific situations. However, for a global project such as iBOL it is important to consider and at the very least reflect upon the potential social, cultural and economic, implications—direct and indirect—of its activities. This is of particular concern for developing countries that over the past few years have become extremely sensitive to the use of their biodiversity and its components—even, and more so, at the genetic level.

Recommendations

1. iBOL needs to ensure effective, practical ways in which developing countries can participate in and benefit (very specifically) from iBOL activities at all levels and stages. Further research may be required to determine how iBOL may play an effective role in supporting the realization of the fair and equitable benefit sharing principles enshrined in the CBD. Developing countries (and their research institutions) should become fully involved in planning iBOL activities and in technological and scientific advances.
2. Development of a set of guidelines by iBOL regarding ABS, IPR and traditional knowledge (even if not 100 percent relevant in the context of its present activities) may be one option to stimulate further thinking and reflection regarding the relation of iBOL with these fields, and their implications for iBOL.
3. Specific research should be undertaken regarding potential commercial or industrial use of iBOL products, services, data and information to ensure equity in accessibility and use.
4. An intensive process of awareness-raising and education among the scientific community in developing countries regarding the existence of iBOL and its role is one way in which gaps may be bridged between the industrialized nations promoting and financing iBOL and the developing countries. In most developing countries (at least in the Andean region), iBOL is a distant, “exotic” concept, for all but a very small set of individuals.
5. In the specific context of Peru, monitoring and controls in certain activities such as fisheries, forestry (when and if iBOL moves to plant barcoding), and the export of Andean camelids, with a close connection to conservation concerns, could benefit from barcoding technology, and from iBOL in particular.

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WORKING PAPER

DNA Barcoding: Society and technology dynamics in the Indian context

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Abstract: Access to biodiversity for research and development in India is regulated by the National Biological Diversity Act of 2002 which gave effect to the Convention on Biological Diversity (CBD). In addition to the provisions that govern access and benefit-sharing for commercial research, specific provisions regarding access and benefit-sharing in the context of non-commercial research have to be evolved in the wake of DNA barcoding becoming a reality for advancing knowledge of biodiversity in the country. Ethical questions that are significant in the context of barcoding technology, have to be framed in terms of consequences for the livelihoods and culture of the stewards of biodiversity and the environment. Stewards of biodiversity must be involved in evolving norms regarding the access and benefit-sharing in the context of extending access to biodiversity for commercial and non-commercial research and also in the development and democratization of barcoding technology and its use so that they are empowered to monitor, maintain and develop biodiversity.

Introduction

DNA barcoding as a scientific idea, initiated by Prof. Paul Hebert in 2003, has been attracting international attention for its significance in advancing the taxonomy of life forms. The objective of DNA barcoding is to transform conventional taxonomy by digitizing the identity of a given species. DNA barcoding employs sequence diversity in short segments of standardized regions of the genome as a digital system for species recognition (iBOL Project: Overview of Research 2008). Linnaean taxonomy, which began 250 years ago, is based on phenotypic separation of species by morphological dichotomies. Stoeckle *et al* (2004) point out that Linnaean classification is an abbreviated label for morphology of a species; the short sequence is as an abbreviated label for the genome of the species.

DNA barcoding promises several useful applications apart from species recognition. Ensuring food quality and controlling agricultural pests, disease vectors and invasive species are some of the areas in which barcoding technology may be deployed. The digital codification system that barcoding seeks to create could lead to innovations in electronics, bio-informatics and devices such as hand-held barcoders. DNA barcoding would be useful in documenting prior art in the patent seeking process.

Although a few million species have been discovered and identified, many millions more, including micro-organisms, remain to be discovered and documented. Whether a species is endemic to a geographical region or is widely distributed, barcoding of life is truly international in scope. However, geographical regions are divided into modern nation-

states, and each nation-state decides whether or not to sign international treaties based on national interest. The 1992 Convention on Biological Diversity (CBD) has been signed by 168 countries (www.cbd.int/convention/parties/list). The Government of India, for example, signed the CBD on February 18, 1994, but the government of United States of America, though a signatory to the CBD has not yet ratified it. The objectives of the international Consortium for the Barcode of Life and those of the CBD are related. Members of the iBOL consortium are 'committed' to the regulatory framework established under the Convention on Biological Diversity (iBOL project: Research Overview, 2008, p.14).

II

SOCIETY AND TECHNOLOGY DYNAMICS

Throughout history human beings have interacted with nature through the medium of technology. This interaction has transformed nature while simultaneously transforming society and social relations. Since the latter half of the 20th century, science and technology on the one hand and economy, polity and culture on the other have been intimately interconnected so that it is now difficult to maintain the classical distinction between science as the *act of knowing* and technology as the *act of doing.* Science has undergone a cultural revolution, from academic science and its associated values like disinterestedness, to post-academic science and its associated values like profit and efficacy (Ziman 1996).

Technoscience, a concept first coined by the Belgian philosopher Gilbert Hottois, captures the character of science in the 21st century (Latour 1987, Haraway 1998). Modern biology has become a technoscience. For example, mapping the genome of a crop plant or an animal species is not merely aimed at description of the whole complement of the genes but also at understanding the functions of the genes for possible technological interventions. The pursuit of knowledge about and manipulation of, life forms or parts thereof raises raise interrelated questions of policy and ethics. Similarly, DNA barcoding enhances our descriptive understanding of the diversity of species and may pave the way for new interventions. Policy questions relate to access to biodiversity for research and development and ethical questions relate to consequences — intended and unintended— of barcoding for individuals, groups and communities.

The consequences of barcoding for maintenance and development of biodiversity and communities and stewards of conservation have to be visualized at the time of accessing biodiversity for barcoding. Pertinent questions relating to the communities and stewards of conservation are: what are the consequences— intended and unintended— of barcoding a species that has commercial value and on which a particular community depends for its livelihood? Similarly the consequences of barcoding a plant species that has medicinal value have to be anticipated. If the consequences pose risk to the community, risk analysis must be undertaken by an independent third party in collaboration with the community. If the potential loss to the livelihood of the community arising out of barcoding turns out to be greater than the benefits, then the species should not be barcoded until alternative livelihoods are made available to the community. Also, what norms should govern sharing of benefits – monetary and non-

monetary - resulting from barcoding with the community for conserving the species? In What ways the communities and stewards and their representatives could be involved in the wide-ranging activities relating to barcoding work?
Democratization of decision-making regarding technological choices, regulating technology and equitable access to technology— has assumed significance in the context of economic and social development. It is against this backdrop that the study on barcoding technology and its interface with social, ethical, economic and political domains will be explored.

III

Objectives

The present exploratory study attempts to:

- Understand technical issues relating to access to biodiversity for barcoding of species in the Indian context, as well as relevant ethical, social, economic and political issues, such as dealing with prior informed consent, risks, access and benefit sharing in order to incorporate these elements in the policy framework.
- Provide a perspective from the viewpoint of actual or future users, beneficiaries, and participants of the technology, including scientists, policymakers, and in particular, the owners or stewards of the natural resources being barcoded by examining the provisions of the National Biological Diversity Act of 2002.

I drew upon the Indian legislation on biodiversity to examine the policy environment which has implications for DNA barcoding in India. Using a theoretical sampling strategy (Glaser and Strauss 1967) to select the research sites, I selected 10 scientists based in reputed molecular biology research institutions located in Hyderabad for depth interview. The scientists, belonging to the disciplines of molecular biology, taxonomy and plant breeding, were selected on the basis of their involvement in barcoding and/or taxonomy/ conservation and related work. One of them is involved in a project on barcoding bird species in India. I also interviewed representatives of two civil society organizations (CSOs). The interviews were conducted during September-October 2009. I relied on the material collected from the interviews with scientists and the CSOs since, to the best of my knowledge, there are no users of barcoding technology among members of the general public. Depth interview with individuals engaged in research related to the phenomena would be useful in understanding the issues and in developing an analytical framework to address the issues. Hence, on the basis of the findings of this small-scale intensive study we cannot draw generalizations, but the study raises issues that have to be explored further.

IV

Findings and discussion

The "mega hotspots" of biodiversity are located in the developing countries of the South, including India. As in many developing countries, communities in India have acquired knowledge regarding various species of crop plants, medicinal plants, and animals over time. This knowledge is based on trial-and-error to determine the usefulness or otherwise of each species. The communities have evolved their own local taxonomies that are shared among the community members.

Potential of DNA barcoding technology
My exploratory field work indicates that scientists recognize the need to describe and document the wide-ranging biodiversity that remains to be explored in India. They stated that DNA barcoding is a valuable technology for this purpose. In India, as in many other countries, there is a perception that taxonomy is a less attractive specialty (Prathapan *et al* 2006). Perhaps one of the reasons is that scientists seem to attach more 'glamour' to a research career in molecular biology (Haribabu 2000). Research relating to DNA barcoding may change the situation and fill the shortfall in the number of taxonomists. This calls for focused training programs that attract young scientists.
The scientists in the study indicated that over time, especially during the last 25 years, concerted efforts on the part of the government and the scientific institutions engaged in teaching and research in molecular biology have resulted in creating a competent community of molecular biologists in a few institutions in India[1]. According to one of the scientists interviewed, biologists in these institutions are highly productive and are in a position to train scientists from other developing countries in the science and art of barcoding as these institutions are equipped with state-of-the-art infrastructure. Because the concept of DNA barcoding is very recent, scientists in many universities and research laboratories have not started focusing on this new technology. To the best of my knowledge there are only three projects underway at present. However, the scientists expressed the view that DNA barcoding will create new interest in taxonomy among scientists. Further, scientists suggested that conventional taxonomy will not disappear, rather that DNA barcoding will be a complementary tool in the hands of scientists engaged in taxonomy.

One of the scientists who participated in the Barcoding of Life conference held in Taiwan in 2007 mentioned that barcoding will be extremely useful to identify a large number of small species. Another scientist, who is heading an *ex situ* organization supported by public funds, suggested that barcoding will be useful in assigning specimens to species. Barcoding also helps to avoid duplication of entries of varieties and landraces of crop species in *ex situ* conservation, and gene bank accessions can be verified with the help of a barcode. Further, scientists suggested that barcode technology will facilitate conservation of biodiversity as well as monitoring and detection of foreign plant and animal material in food and pharmaceutical products. DNA barcoding will help in separating the original species from look-alike species. For example, *Pterocarpus santalinus,* popularly called red sanders or red sandalwood, is highly valued for its timber. It is a rare species that grows only in the hill ranges of Southern Andhra Pradesh. If it is barcoded, the information can be used to separate the rare red sandalwood from look-alikes.

In the context of granting patents, as mentioned above, DNA barcodes are useful in establishing prior art which can be used in assessing as to what extent the novel product or process proposed for the grant of patent is a departure from prior knowledge. If the proposed novel product or process already exists as part of the prior art the proposal becomes null and void.

Institutional arrangements for accessing biodiversity
The Government of India is a signatory to the CBD and the Parliament of India has ratified the Trade Related Aspects of Intellectual Property Rights. Parliament passed the Protection of Plant Varieties and Farmers Rights Act in 2001, legislation designed to

protect plant varieties. The following year Parliament passed the National Biological Diversity Act to give effect to the CBD in the Indian context. The Act was the outcome of a process of consultations involving scientists, policymakers and CSOs, and treats all biological resources in the country as national resources. The two Acts, which extend to the whole of India, are intended to protect India's bio-resources. The Protection of Plant Varieties and Farmers' Rights Authority and the National Biodiversity Authority (NBA) have been empowered to take all necessary steps to achieve the objective of the two Acts of Parliament. The objectives of the NBA include: conservation of biological diversity, sustainable utilization of its components, and equitable sharing of the benefits arising from utilization of genetic resources.

While the NBA functions at the national level, State Biodiversity Boards (SBBs) operate at the state level and Biodiversity Management Committees (BMCs) at the level of local bodies (*Panchayat* at the level of the village, municipalities at the level of small towns) to promote conservation and documentation of biodiversity as well as sustainable use of its components.

Some of the salient features of the National Biological Diversity Act are:

- Regarding the regulation of access to biological diversity, a person who is not a citizen of India (or is a non-resident Indian) shall not obtain a biological resource occurring in India, or the knowledge associated with it, without securing the prior approval of the NBA. The same applies to any corporate body, association, or organization not incorporated or registered in India (or incorporated or registered in India but having no Indian participation). Further, no person shall transfer the results (except publication of research papers or dissemination of knowledge in any seminar or workshop) of any research relating to any biological resources occurring in India (or obtained from India) for monetary consideration or otherwise to any person who is not a citizen of India or any corporate body, as mentioned above, without obtaining prior approval of the NBA.
- According to the Act, no person shall apply for any intellectual property right (IPR) in or outside India for any invention based on any research or information on a biological resource obtained from India without obtaining the prior approval of the NBA.
- The NBA may, while granting approval for filing the application for an IPR, impose a benefit-sharing fee, a royalty, or both. The NBA may also impose conditions including sharing of financial benefits arising from the commercial utilization of such rights. This provision does not apply to those cases in which the application for the right comes under the purview of any law relating to the Protection of Plant Varieties and Farmers' Rights Act. Regarding the proceeds of the benefit sharing, the amount of money determined by the NBA would have to be deposited in the National Biodiversity Fund.
- No person who is a citizen of India or corporate body, association or organization registered in India, shall obtain any biological resource for commercial utilization or bio-survey, bio-utilization for commercial utilization without first notifying the SBB. However, this provision does not apply to the people and communities of the area, including growers and cultivators of biodiversity and practitioners of traditional medicine.

Reactions to the National Biological Diversity Act

Although the Act has been welcomed as a step in the right direction, scientists seem to differ in terms of what it will do to promote the basic science of taxonomy. Prathapan *et al* (2006) argue that the Act, by declaring the bio-resources as national resources, will curtail the freedom of scientists and discourage research in taxonomy, as species identification requires international collaborative research for comparing the specimens before assigning them to the species. They argue: "…with the introduction of the Biological Diversity Act, we have completely lost the moral authority to use these (exotic germplasm obtained earlier from other countries) without the formal permission and benefit-sharing with the respective countries of origin."

Another view within the scientific community is that DNA barcoding has to be carried out in accordance with the provisions of the Act as it provides a framework of rules regarding access to biodiversity, use of its components, and benefit sharing. Scientists mentioned that a democratic decision has to be taken regarding which species in the country have to be barcoded, given the fact that there are endemic, endangered and commercially significant species. Since the legislation treats all bio-resources as national resources, accessing the species for barcoding has to be based on formal approvals at different levels. The scientists are of the view that the barcoded information has to be kept in the public domain except in the case of some endemic species which have commercial applications. In this connection, they strongly argue that in any international collaboration Indian scientists should not part with samples (genetic material) of species to be barcoded to collaborating scientists in foreign countries. The samples should be kept in a national repository, or bio-bank and the sequence information (genetic information) may be shared with scientists in other countries.

The National Biological Diversity Act and CSOs

The CSOs seem to hold that the Act should not give exemption to the Indian scientists of corporate bodies to access biodiversity just by giving prior information to the SBBs, as mentioned above. They should seek prior permission to access biodiversity as in the case of individuals who are not citizens of India and corporate bodies not registered in India or registered in India without Indian participation (www.kalpavriksh.org). The CSOs want the same rules applied to Indian citizens and corporate bodies, believing that their motivation in accessing biodiversity may be no different from that of outsiders. One CSO, Gene Campaign, believes the Act falls short of fulfilling the national needs, suggesting that the Act hampers research and is not clear on the question of IPRs (http://www.genecampaign.org/).

It appears that there are differences within the scientific community regarding how the provisions of the Act will influence scientific research. However, this needs to be explored further. The CSOs seem to hold the view that access to biodiversity especially for corporate bodies—both Indian and foreign ones— should be based on the same rules.

Culture of conservation in India:

In India, households and communities have been conserving germplasm of crop plants, horticulture, medicinal plants and some species of animals *in situ* over the years as part of utilitarian and aesthetic values. Traditionally, in the absence of written rules, conservation of biodiversity and utilization of its components were regulated by appealing to unwritten religious norms and sanctions. For example, *Ocimum tenuiflorum,* popularly called Tulsi, has some medicinal properties. It is protected by planting it on the premises of households to have ready access to the plant for medicinal purposes. In fact, Hindus accord a sacred status to the plant and worship it so that it is not neglected. Hindus attach religious meaning to some species and hence conserve them as part of their religious practices. For example, *Aegle marmelos*, popularly called Bilva tree (also found in Nepal, Sri Lanka, Pakistan, Myanmar, Bangladesh, Vietnam and Cambodia, Laos), is conserved by planting it in the premises of Hindu temples. Some species are protected by the communities in the form of sacred groves, which may contain endangered species. Communities do not use plant species or parts of the species in the sacred groves (Gadgil and Vartak 1975, Guha 2000, and Malhotra *et al* 2002). Another example: Jaypore tract— comprising northern parts of Andhra Pradesh and contiguous parts of Orissa and Chattisgarh— is populated by tribal communities and is considered to be the place of primary origin of rice in India. The tribal communities have been conserving the landraces and varieties *in situ*. In India some species of goats and sheep reared and bred by some communities, have been shown to have genes that confer resistance against some diseases. In other words, the communities that conserved the species assumed the role of custodians or stewards.

Access and Benefit Sharing (ABS)

The examples mentioned above, suggest that any attempt to barcode such species must require the prior informed consent of the custodians or stewards. Here one may think of two kinds of purposes for which the consent is required: a) consent for barcoding of species for non-commercial research purposes and; b) barcoding for commercial research purposes. The normative basis of terms of consent obviously differs in the two situations. At present the National Biodiversity Act seems to emphasise ABS issues in the context of Commercial research. The issues relating to access to biodiversity for non-commercial research are: what are the norms that should govern the access which: a) promotes non-commercial research; b) protects the national sovereignty over genetic resources; and c) ensures non-monetary benefits, if any. Schindel *et al* (2008) in their report of the international workshop on 'Access and Benefit Sharing in Non-commercial Research' held November 2008 in Bonn[2] point out the tangible indicators of distinguishing non-commercial research from commercial research. The indicators of non-commercial research are; a) generation of new knowledge; b) collections of reference specimens that generate benefits through public domain without proprietary benefits; c) capacity building and development of human resources in using the technology in the case of developing countries that extend access to biodiversity for international research, better understanding of their genetic resources, improved basis of conserving and developing their biodiversity.

In the Indian context the National Biodiversity Authority, scientific community and the policy makers should examine whether or not these indicators are sufficient for extending access to biodiversity for international research. Regarding the third indicator of capacity building and development of human resources one can say that in India there are qualified and competent scientists and well endowed molecular biology research institutions in India and they can train scientists from less endowed developing countries, as one of the scientists engaged in a project dealing with barcoding of bird species in India mentioned. Further, institutions such as the National Bureau of Plant Genetic Resources (NBPGR) with its branches in different regions of the country, has been involved in collection of reference material, their characterization and *ex situ* conservation of their collections. At present the CBD is engaged in the process of evolving an international regime on access and benefits sharing, that is likely to culminate in the year 2010. As India's National Biological Diversity Act gave effect to the CBD, it is imperative that the Government of India as a member of Conference of Parties (CoP) communicate to the CBD process the regulatory norms that govern access and benefit sharing in the case of non-commercial research that are appropriate from the point of view of India's national interests. It is necessary at this juncture because the barcoding technology for advancing taxonomic knowledge of species and monitoring and conservation of biodiversity became a reality after the enactment of the National Biological Diversity Act in 2002.

Other issues that need to be addressed in the Indian context are related to evolving appropriate regulations to ensure that the biodiversity accessed for non-commercial research is: a) not used for commercial research at a later date is used for commercial research if it is discovered that the genetic material has commercial potential; and b) not shared with a third party. These issues have to be discussed in the Indian context. There is a need to incorporate appropriate enforceable norms in different forms of agreements regarding material transfer. Regarding the prior informed consent, in the Indian context the provisions of National Biological Diversity Act envisage regulatory roles for state agencies at different levels: local self-governments like the village *Panchayat,* in addition to the SBBs and the NBA as specified in Section 3 of the National Biological Diversity Act. However, the provisions do not specify the role of communities in the regulatory process. There is a need to evolve appropriate provisions regarding the role of the state agencies and communities in negotiations regarding Access and Benefit-sharing issues in the context of extending access to biodiversity for non-commercial research. In other words, the stewards and or their representatives must be involved in the consent-seeking process and in negotiations regarding the sharing of benefits, both monetary and non-monetary arising out of the use of components of biodiversity for research. Communities become vulnerable if they provide information for the purpose of barcoding about a species on which they depend for their livelihood. The information may be used by others, and the community could ultimately be deprived of its livelihood.

As a part of the process of democratization of barcoding technology, efforts should be made to build capacities of local communities by involving members of the communities in barcoding of the species which they have been conserving. Such involvement could expedite the barcoding of millions of species. However, the consequences of barcoding—especially of species which provide livelihood for communities— need to be addressed in consultation with community representatives before barcoding takes place. They must be informed about the benefits, both monetary and non-monetary, of barcoding of species, and their rights as stewards of the species. The barcodes of the species must be shared with the communities, and the members of the community should be trained in using the barcoded information for monitoring and development of biodiversity.

Conclusion

DNA barcoding is a relatively new technology, and to date only a few scientists have initiated work on barcoding of some species. Similarly, civil society and its organizations have little awareness of this new technology, and at present no exclusive legal or administrative framework exists for regulating barcoding technology. In this context, provisions of the National Biological Diversity Act are concerned with access and benefit-sharing norms regarding commercial research. However, there is a need to evolve norms regarding the access and benefit-sharing for non-commercial research. As scientific organizations in the country start participating in barcoding activity in a big way the barcoding technology may throw up new ethical, social, economic and political issues concerning both commercial and non-commercial research which have to be addressed by the regulatory framework. Long-term research covering different regions of the country is needed to document the issues relating to the dynamic interface between DNA barcoding technology on the one hand and ethical, social, economic and political domains on the other. The outcome of such research may either suggest suitable amendments to the national biodiversity legislation, or lead to new legislation to facilitate and regulate DNA barcoding in India. Attempts to make any necessary amendments to the legislation, or to evolve new legislation, should be initiated by Government in partnership with the stakeholders: communities that have been the custodians of biodiversity and their organizations, local governments, the scientific community engaged in barcoding work, social scientists, members of the legal profession and society at large.

Notes:

1. The Government of India established the Department of Biotechnology in 1986 and invested a significant amount of resources over the years to support research and the state-of-the-art training in molecular biology and biotechnology in the conventional universities, agricultural universities and mission-oriented research laboratories (see the website: http://www.dbtindia.nic.in/). The Rockefeller Foundation, as part of its International Program on Rice Biotechnology, supported research and capacity building in molecular biology and biotechnology during 1989-2000 (see the website: www.rockfound.org).
2. The Bonn workshop report (2008) on 'Access and Benefit-sharing in Non-commercial Biodiversity Research' was submitted to the CBD Secretariat. The Executive Secretary of the CBD circulated the report for the information of participants in the Group of Technical and Legal Experts on Concepts, Terms, Working Definitions and Sectoral Approaches in the context of the International Regime on Access and Benefit-Sharing (UNEP/CBD/ABS/GTLE/1/INF/2, November 29. 2009).

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WORKING PAPER

iBOL as an Enabler of ABS and ABS as an Enabler of iBOL

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Abstract: Despite legitimate misgivings about "thinking like an economist," such thinking elucidates how the International Barcode of Life (iBOL) can help realize the benefit-sharing mandated by the Convention on Biological Diversity for access to genetic resources. The economics of information justifies a cartel over the genetic resources and associated knowledge.

Keywords: International Barcode of Life, access and benefit-sharing, Convention on Biological Diversity, biodiversity cartel, traditional knowledge

INTRODUCTION

"Thinking like an economist" is the mantra of my profession and I cringe whenever I hear it. I count myself among the dissident economists who believe that "thinking like an economist" has enabled the destruction of biological communities, both human and non-human.[1] Nevertheless, I would be the first to say "let's not throw the baby out with the bathwater." Much of the discussion about the International Barcode of Life (iBOL) proceeds as if formal economics did not exist. Such obliviousness does not really surprise me. Since the ratification of the United Nations Convention on Biological Diversity (CBD) in 1993, I have become inured to the lack of *any* economic thinking when the Conference of the Parties (COP) meets to discuss access and benefit-sharing (ABS).[2] By examining iBOL in conjunction with my long trajectory in analyzing ABS, I hope to show that a baby can emerge sparkling clean from the murky waters of economics.

Where to begin? The preferred answer is: at the beginning. Unfortunately, space and time do not permit such thoroughness. To make my point about thinking—ugh—like an economist I will draw only from my most relevant publications which stretch back to 1992, well before ABS entered the lexicon of UNspeak (Box 1). In light of that trajectory, I hope to add value to recent texts about iBOL which have appeared in both top-tier journals and in-house publications.

The Acronyms of UN-speak

ABS	Access and Benefit Sharing
CBD	Convention on Biological Diversity
COP	Conference of the Parties
ICBG	International Cooperative Biodiversity Groups
MTA	Material Transfer Agreement
PIC	Prior Informed Consent

Box 1

IBOL AS AN ENABLER OF ABS

Precise language and a catchy introduction are *de rigueur* for *Scientific American.* The "Barcode of Life" by Mark Y. Stoeckle and Paul D.N. Hebert is no exception.[3] By way of analogy, the authors explain the use of the word "barcode" to name this multi-million dollar initiative. Just as a supermarket uses barcodes to manage inventories, biologists hope to do something similar with a database of short DNA sequences. Although analogies can be illuminating, none is ever perfect. The purpose that the patent holders of supermarket barcodes had in mind when they filed with the United States Patent Office was "to provide an automatic apparatus that will execute with precision and dispatch classifying orders which are given to it and will yield up the results of the classifying process in an intelligible manner."[4] What was the purpose that drove the barcodes of life? Creationists notwithstanding, the question shows that we are not really talking about an analogy, but a metaphor for a product of evolution, and evolution has no purpose. Therein lies an unintended consequence of choosing "barcode" as the name of the initiative: its ultimate limitation as an analogy makes one think about the very meaning of "analogy."

In biology, analogy refers to the same solution for the same problem without any shared ancestry that evidences that solution (e.g., the problem "flight" and the solution "wings" in flies, bats, and birds). It is contrasted to homology, which can be a different solution for a different problem, but inhering to a shared ancestry (e.g., the forelimbs in humans, bats, and whales, used for hunting, flying, and swimming). As we have seen, the two barcodes are not perfectly analogous, but are they homologous? The answer is again no. Inasmuch as the barcode of the supermarket is inanimate, it cannot be homologous with the barcode of life in any biological sense. Nevertheless, the two are homologous in a physical sense inasmuch as both can be quickly reduced to information. Such reduction is critical to my economic thesis that iBOL enables ABS and ABS can enable iBOL. But I am racing ahead of myself and will develop this point further after first considering some other salient points from the *Scientific American* article.

The authors offer a glistening vision of a future world where a handheld barcode reader allows, say, "a hiker on a mountain trail…insert[ing] a sample containing DNA—a snippet of whisker…or the leg of an insect…into the device, which would detect the sequence of nucleic acids in the barcode segment."[5] The romanticism of a hiker, breathing in all that fresh air, is a nice rhetorical flourish. Unfortunately, it will be met by the not-so-nice denunciation of "biopiracy." At the Inaugural Workshop Pablo Turabo pointed out the "potential roadblock for iBOL where the [CBD] in various countries prohibited the exportation of all genetic material. If not amended, these laws could make it impossible for species to be shipped from their place of origin to core laboratories such as the Canadian Centre for DNA Barcoding."[6]

An "amend[ment]" to the CBD is no slam-dunk; under the CBD, the whisker is unequivocally a genetic resource and before it can be fed into the handheld gizmo, the competent authority will ask for evidence of prior informed consent (PIC) as well as an ABS agreement. Turabo's remarks are not *en passant* and securing either PIC or ABS is not *pro forma*, as any veteran to the nine COPs will attest. So, the iBOL "Research Overview" is endearingly naïve when it closes with point six: "Members of the iBOL consortium are committed to the regulatory framework established under the Convention on Biological Diversity. Transactions between iBOL members will respect all restrictions with respect to biomaterials transfers."[7]

The supremacy enjoyed by the CBD inevitably generates scorn among field biologists.[8] I have sensed the anger, and I am only a peripheral messenger. Especially loathed is the non-governmental organization ETC (Erosion, Technology, and Concentration) which was formerly RAFI (Rural Advancement Foundation Institute). RAFI scored a major success in 2001 with the cancellation of the million-dollar Maya ICBG Project for ethno-bioprospecting in Chiapas, Mexico.[9] Chuck McManis, professor of law, relates that the acronym has since morphed into a transitive verb: being "RAFIed."[10] Fortunately, to think like an economist is to think opportunistically. The iBOL Project may correspond not only to the worthy goals of the "activists," purportedly "fair and equitable benefit-sharing," but actually become the enabler of "fair and equitable benefit-sharing."[11] The "how" lies in exploring further the homology of the barcode of life and the supermarket barcode in their shared root of "information."

By the second paragraph of the *Scientific American* article, Stoeckle and Hebert have identified the object of the barcodes as "genetic information." Over the 16 years of the CBD, biological samples have never been treated as "genetic information" despite an occasional reference to such effect. Policy discussion treats samples as if they were tangibles that *can* be tracked and monitored.[12] Thinking like an economist, another mantra comes to mind: "you cannot put a fence around information." Imagine that hiker high up in the Sierra Madre who just slipped the cat's whisker into his vest pocket. Any attempt to monitor and track the genetic resource is a Sisyphean task. Do we perform a body cavity search at the airport? Should the whisker have been sequenced on the trail already and subsequently discarded, do we scan his pen drive? Happily, there is more than one way to skin a felid or, in our cyber age, copy-and-paste a file. The first step is the requirement that patent applications disclose any species accessed in R&D.[13]

The molecular biologist interrupts and steps into the row. Why would any government want to do that? The economic answer is that incentives must be aligned between the industries that research and develop natural products and the countries that decide the fate of habitats. Industry must contribute toward the opportunity costs of conserving genetic resources, specifically the value foregone in not logging the forests, not damming the rivers, not mining the mountains, and so on.[14]

How do we align incentives? The political answer reached at the Rio Earth Summit in 1992 was: S-O-V-E-R-E-I-G-N-T-Y. Various articles of the CBD overturn the doctrine of common heritage of mankind (*res nullius*) and allow each ratified party to negotiate ABS over its genetic resources with industry. Who could object to such freedom? Thinking like an economist, I did. I predicted that such sovereignty would turn out to be a Trojan Horse, and I derive no joy from the fact that history has proved me right.[15] Let me explain the economic basis for my pessimism by way of the homology in information.

In the streets of the developing world, a thriving market exists in pirated movies. The hawker typically asks $1 per DVD which is approximately 5% of the retail price. Why not $19?…$18?...$3? or even $2? The answer is competition. Each hawker has a strong incentive to underbid other hawkers and the price drops to the marginal costs of reproduction and hawking. No monopoly rent is ever paid to the creator of the artificial information, viz., Hollywood.[16]

The same holds true for natural information. Most bioprospected metabolites are diffused across species, and most species are diffused across political boundaries. Each sovereign country underbids its neighbour and ABS falls to the marginal costs of collection plus the transaction costs of consummating an MTA. When reported, royalties are typically 1% or less.[17] Note well that the biotech executive who concludes such a deal will have "respect[ed] all restrictions with respect to biomaterials transfers" under the regulatory framework established under the CBD.[18] The scenario cannot therefore be described as biopiracy. Everything was painstakingly legalized. I prefer to call it "biofraud," a neologism for the asymmetry in the CBD: respect for a monopoly patent over artificial information for the transnational conglomerate, yet global competition over natural information for the developing country.[19] Such a steal could also be called a *negocio redondo* in Spanish.

A digression is warranted. William Faulkner famously said that history is not even past.[20] In the early days of "discovery," appropriation was through rape and pillage.[21] By the beginning of the nineteenth century plunder was no longer convenient, as the newly independent countries were also portraying themselves as victims of colonial abuse. So, appropriation evolved into successive accords, each one more confiscatory than the last, the Choctaw treaties being especially noteworthy.[22] Genetic resources and associated knowledge are now the latest and last frontier. Thinking like an economist, I will not focus on the disquieting continuity of MTAs with the history of appropriation. I will only focus on the inefficiency. Bilateral MTAs mean grossly insufficient compensation to meet the opportunity costs of conservation. As Dan Janzen has said most colourfully "[e]very corner of the world which isn't explicitly protected is going down the toilet."[23]

Thinking like an economist provides the solution.[24] Recognizing the asymmetric cost structure of information—high fixed costs, low marginal costs—the economist recommends that the government protect the innovator or the conservationist from competition. For artificial information, we have monopoly intellectual property rights (e.g., patents, copyrights, trademarks and so on) and a slew of international conventions (see WIPO).[25] For natural information, we have *nada*.

What we need to prevent a price war among sovereign countries is an oligopoly over natural information which is, in plain English, a biodiversity cartel.[26] The legal vehicle to institutionalize the cartel would be a special protocol to the CBD that would establish a cartel over genetic resources, and another over associated knowledge which is also homologous in information (see Box 2).

"The devil is in the details" is a worthy cliché. Which countries of a cartel should make a claim? How much would each get? A simple solution would be a share in proportion to habitat of the species bioprospected. If Brazil occupies 56% of the Amazonian basin and Ecuador a mere 2%, the former would get 56% of the royalty and the latter, 2% for a metabolite found in species distributed throughout the basin. In 1992, I incorporated such reasoning in my call for a "Gargantuan Database." Updating *Genes for Sale*, I would now call it iBOL[27]

ARTICLE 8(J) OF THE CBD: THINKING OUTSIDE ONE BOX…AND IN ANOTHER

Our hiker may think that traditional knowledge does not pose any problem as long as he doesn't question any indigenous person he may happen upon. Think again. A thought experiment can reveal the fallacy in such logic. Imagine he walks in the environs of an indigenous settlement. By its mere proximity, he has enhanced the probability of collecting specimens in a garden and gardens epitomize associated knowledge.

The lifetime work of the ethno-biologist Darrell Posey shows that many "primary forests" have co-evolved with communities over millennia. A conservative interpretation of Article 8(j) of the CBD is that such communities can require both PIC and an ABS agreement. However, to implement Article 8(j) multiple legal problems arise regarding

1. The status of such knowledge (published and therefore, public domain? or unpublished, and potentially a trade secret?)

2. The *persona* of the "community"—amorphous or formalized?
3. The benefits to be shared: Projects selected democratically within the community? Or by the shaman, who may be the only member with knowledge not in the public domain?
Solutions to these and other problems have been fleshed out in *The Biodiversity Cartel: Transforming Traditional Knowledge into Trade Secrets* (see note 27). Its recommendations derive from thinking outside the box in which specimens can be monitored and tracked, and inside another in which genetic resources and associated knowledge are homologous in information. Although such reduction is also a box, it is one that still yields much low-hanging fruit, if I may mix metaphors.

To respect the letter and spirit of Article 8(j), any iBOL support for a biodiversity cartel over genetic resources must also mean support for another cartel over traditional knowledge, transformed into trade secrets.

Box 2

With the cartelization of genetic resources and associated knowledge, the disclosure of any species in patent applications, samples should flow freely for the purposes of classification.

The implementation of iBOL worldwide can become the enabler for a fair and equitable ABS which industry has successfully scuttled through the COP process. The thumbnail sketch above explains how iBOL will enable ABS. Now for the second half of my title: How does ABS enable iBOL? The answer is money.

ABS AS AN ENABLER OF IBOL

When iBOL confronts the COP over PIC and ABS, pressure will mount to kowtow to industry, whose courtesans will trot out the tired plea for a "taxonomic exemption" and belittle the "activists" as obstructionists. Before being seduced by power, the movers and shakers of iBOL should beware: the opportunity costs of agreement may be iBOL itself. The decision of the Supreme Court of California in *Moore v. Regents of University of California* shows that once a sample is set loose in the U.S., there is no way to lay claim to any benefit.[28] The lesson for ABS worldwide is not to let any sample out of the country of origin even for the purposes of classification. Should samples somehow leave by hook or by crook and end up in iBOL databases, activists will chant "biopiracy" and all that excellent PR will go down Janzen's toilet.

Let's assume that iBOL somehow wrangles an exemption to PIC and ABS and turns a deaf ear to the activists. The question becomes: does iBOL really want to depend forever on the largesse of governments, each one eager to free ride off the next? To date, Canada has been quite generous. But how long will that last? And how fair is it for Canada to have to foot the bill of an international public good? What resources will have to be spent on PR just to maintain current funding levels? The biodiversity cartel is a self-sustaining mechanism that is both efficient and equitable. As long as money flows from ABS to iBOL, iBOL can become a countervailing power to the vested interests promoting the despicable bilateral MTAs.[29]

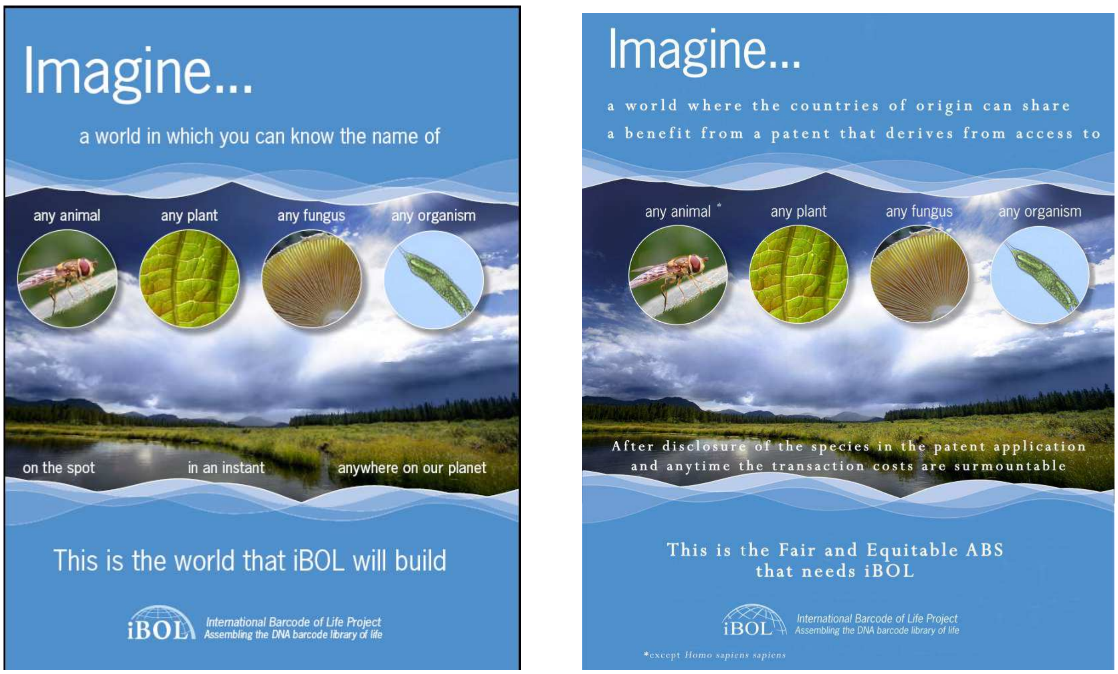
Alas, the pesky devil still hides in a thicket of details. Hazarding one last cliché, I dare say that many solutions can be pulled out of the memory hole. For example, Chapter 7 of *Genes For Sale* is entitled "The Rationale, Design, and Implementation of the Gargantuan Database" and Chapter 9, "Finance" which includes a section entitled "Who Will Finance the Gargantuan Database?" The answer is unquestionably fair: the countries that enjoy the royalties distributed. I also treated explicitly the scenario of a widely distributed metabolite for which the transactions costs of distribution outstrip the royalties collected. I concluded that, in such cases, the royalties collected "should be used to diminish the fixed costs of the gargantuan database."[30] Elsewhere I explained that to keep level the much vaunted playing fields, the royalty rate should be invariant no matter what the diffusion of the metabolite across species, and species across political boundaries, and no matter whether the remittance is to cartel members or to the Gargantuan Database.[31]

Will iBOL support a biodiversity cartel in the ongoing COP discussions about an "International Regime on ABS?" I am hopeful, not because I believe that iBOL will do the right thing—people seldom do. My reason for hope is that doing the right thing behooves iBOL, materially so. Adam Smith's most famous phrase about the butcher, the brewer and the baker, is still apt: it will not be from the benevolence of iBOL that iBOL enables fair and equitable ABS, but from regard to its own interest. Now, what could be more economic in thinking than that?

ENDING WITH AN IMAGE: THE WORD COUNT TICKS

Carl Sagan quipped that a picture (i.e., one frame) is worth not 1,000 words, but the equivalent of 10,000 words or "bytes" of information.[32] A mere 2,000 words was the limit iBOL set for this article. With this sentence and the copious footnotes, I have already surpassed that limit by 50%. So, I ask iBOL for indulgence. Once granted, I will sneak in the equivalent of another 10,000 words and have the last word photographically—Figure 1.

BEFORE



AFTER

2009. Derivative artwork (right side) by Josué Sánchez Manzanillo of the cover of the iBOL Fact Sheet (left side)

Figure 1. Suggested revision of the cover of the iBOL Fact Sheet

[1] See Stephen A. Marglin, *The Dismal Science: How Thinking Like an Economist Undermines Community* (Cambridge, Massachussets: Harvard University Press, 2008). Economics as "enabler" is the opening salvo.

[2] See, for example, Joseph Henry Vogel, "The Unspeakable Economics of ABS," *Bridges*, Vol. 12 no. 4 August 2008, 22. Reprinted in *BioRes Review*, October 2008. Available at http://ictsd.net/i/news/bridges/27572/

[3]Mark Y. Stoeckle and Paul D.N. Hebert, "Barcode of Life" *Scientific American*, October 2008, 82-88.

[4] Norman J. Silver, N.J. Venter, and Bernard Silver, 1949, "Classifying Apparatus and Method," U.S. Patent 2,612,993, filed Oct. 20, 1949 and issued Oct. 7, 1952. Available at http://www.adams1.com/shareware/2612994.pdf

[5] See note 4, 83.

[6] Mark Engstrom, Paul Herbert, and Laurence Packer, "Inaugural Workshop for The International Barcode of Life," University of Guelph, June 17-20, 2007, 6.

[7] The International Barcode of Life, "Research Overview July 2008," 14.

[8] Andrew Revkin, "Biologists Sought a Treaty; Now they Fault it," *The New York Times,* May 7, 2002, D1.

[9] Joshua Rosenthal, "Politics, Culture and Government in the Development of Prior Informed Consent and Negotiated Agreements with Indigenous Communities," pages 373-393 in Charles McManis, (ed.), *Biodiversity & Law*, (London: EARTHSCAN, 2007).

[10]Charles R. McManis, "Fitting traditional knowledge protection and biopiracy claims into the existing intellectual property and unfair competition framework," pages 425-510 in B. Ong (ed.) *Intellectual Property and Biological Resources* (London: Marshall Cavendish Academic, 2004), 460.

[11] In the case an NGO is truly nihilist, it should be dismissed.

[12] For a comprehensive analysis of the absence of the correct classification of genetic resources as information in the COPs, see Santiago Pastor Soplín and Mauel Ruíz Millar, "El Desarrollo de un Régimen Internacional de Acceso y Distribución de Beneficios Equitativo y Eficiente en un Contexto de Nuevos Desarrollos Tecnológicos," *Iniciativa para la Prevención de la Biopiratería, Documentos de Investigación*, SPDA Año III No. 9 Mayo 2008.

[13]This argument has been fully elaborated in Joseph Henry Vogel, "Reflecting Financial and Other Incentives of the TMOIFGR: The Biodiversity Cartel," pages 47-74 in Manuel Ruíz and Isabel Lapeña (editors) *A Moving Target: Genetic Resources and Options for Tracking and Monitoring their International Flows* (Gland, Switzerland: IUCN, 2007). Available at http://data.iucn.org/dbtw-wpd/edocs/EPLP-067-3.pdf

[14] For the economics of this argument, see Joseph Henry Vogel, *Genes for Sale* (New York: Oxford University Press, 1994).

[15] The comprehensive explanation can be found in Joseph Henry Vogel, "Sovereignty as a Trojan Horse: How the Convention on Biological Diversity Morphs Biopiracy into Biofraud," pages 228-247 in Barbara A. Hocking, (ed), *Unfinished Constitutional Business? Rethinking Indigenous Self-Determination* (Australia: Aboriginal Studies Press, 2005). The first published statement of sovereignty as a disaster is evident in the title of

Case VI, "Bioprospecting: The Impossibility of a Successful Case Study without a Cartel" in Joseph Henry Vogel, "White Paper: The Successful Use of Economic Instruments to Foster the Sustainable Use of Biodiversity: Six Cases from Latin America and the Caribbean," *Summit of the Americas on Sustainable Development*, Santa Cruz de la Sierra, Bolivia, 6-8 December 1996, *Biopolicy Journal*, vol. 2, Paper 5 (PY97005), 1997. Available as http://www.bdt.org.br/bioline/py

[16] Elsewhere I have used the example of music CDs. See note 3.

[17] S. Peña-Neira, C. Dieperink and G. Addink, "Equitably sharing benefits from the utilization of natural genetic resources: the Brazilian interpretation of the Convention on Biological Diversity," draft article presented at the 6th Conference of the Parties to the Convention on Biological Diversity, The Hague, Netherlands, April 19, 2002.

[18] See note 8.

[19] Joseph Henry Vogel, "Nothing in Bioprospecting Makes Sense Except in the Light of Economics," pages 65-74 in Naomi Sunderland, Phil Graham, Peter Isaacs, and Bernard McKenna (eds), *Toward Humane Technologies: Biotechnology, New Media and Ethics*, (Rotterdam, Sense Publishers Series, 2008).

In Spanish, "Nada en bioprospección tiene sentido excepto a la luz de la economía" *Revista Iberoamericana de Economía Ecológica* Joseph Henry Vogel, *REDIBEC*, No. 1, October 2004.

[20]William Faulkner, *Requiem for a Nun* (New York: Random House, 1951), 92.

[21] Plymouth is the exception and its prominence in U.S. primary education is little more than a propaganda operation. By the time the pilgrims landed in 1620, the niche had opened due to more than a century of Old World diseases spreading North from Spanish contact in the Florida peninsula. See Jared Diamond, *Guns, Germs, and Steel* (New York: W.W. Norton, 1997).

[22] Freely available on the internet, are the Treaties of "1786," "1805," "Dancing Rabbit Creek of 1830," and "with the Confederacy, 1861," http://www.uwm.edu/~michael/treaties/

[23]See note 7, 7.

[24] The economist can provide only the technical component of any complex solution. The non-technical components will emerge through what Garrett Hardin called "mutual coercion, mutually agreed upon" in "The Tragedy of the Commons," *Science* 162 (1968), 1243-1248. For such components regarding PIC and ABS, see the forthcoming anthology, Joseph Henry Vogel, (ed.), *The Museum of Bioprospecting, Intellectual Property, and the Public Domain: A Place, A Process, A Philosophy* (London: Anthem Press, 2010). Inspired by Deidre [formerly Donald] McCloskey's observation that economics needs more humor, the anthology is a romp with a fictitious octogenarian who savages the seven contributing academics about bioprospecting, intellectual property, and the public domain.

[25] See "Gateway to" in the home site of the World Intellectual Property Organisation, http://www.wipo.int/portal/index.html.en

[26] Joseph Henry Vogel, (ed.), *The Biodiversity Cartel: Transforming Traditional Knowledge into Trade Secrets*, The InterAmerican Development Bank/Consejo Nacional de Desarrollo, CARE, USAID, SANREM, and EcoCiencia (Quito, Ecuador: CARE, 2000). Available in Spanish as *El cártel de la biodiversidad*.

[27] Joseph Henry Vogel, *Privatisation as a Conservation Policy* (Melbourne, Australia: CIRCIT, 1992). The in-house publication was vetted and slightly adapted for re-publication in 1994 by Oxford University Press as *Genes for Sale*, see note 14. Perhaps I chose against the barcode metaphor in *Privatisation* based on the then current events. One of the most memorable stories of the 1992 U.S. presidential campaign occurred at a check-out counter in Orlando, FL. The barcode scanner dumbfounded George H.M. Bush. Pundits would later comment that Bush's bewilderment about a technology, hardly new even then, helped defeat him in the razor-thin race. Andrew Rosenthal, "Bush Encounters the Supermarket, Amazed," *The New York Times*, February 5, 1992, A1.

[28]*Moore v. Regents of the University of California*, 51 Cal. 3d 120, 271 Cal. Rptr. 146, 793 P.2d 479. Available at http://www.mdinsurance.state.md.us/sa/documents/MoorevRegents-SupremeCourtofCA-1990.pdf

[29] The concept of "countervailing power" owes to John Kenneth Galbraith and his intellectual descendants. See, for example, *American Capitalism: The Concept of Countervailing Power* (Boston: Houghton Mifflin, 1952). I have also used the concept for financing carbon rich but economically poor countries thorugh the bottleneck of development. See, Joseph Henry Vogel, *The Economics of the Yasuní Iniatitive: Climate Change as if Thermodynamics Mattered* (London: Anthem Press, 2009).

[30] See note 15, 87.

[31] This point is elaborated in Joseph Henry Vogel, "From the 'Tragedy of the Commons' to the 'Tragedy of the Commonplace' Analysis and Synthesis through the lens of Economic Theory," pages 115-136 in Charles McManis, (ed.), *Biodiversity & Law*, (London: EARTHSCAN, 2007).

[32]Carl Sagan, *The Cosmic Connection: An Extraterrestrial Perspective* (New York: Dell Publishing, 1973), 237-238.

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