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Item 5.2 of the provisional agenda*

DNA BARCODING AND ITS ROLE IN BUILDING GLOBAL CAPACITY IN MOLECULAR BIODIVERSITY

Note by the Executive Secretary

1. The Executive Secretary is circulating herewith, for the information of participants in the eighteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, an information document produced by the International Barcode of Life (iBOL) on DNA barcoding and its role in building global capacity in molecular biodiversity. The document describes the technical concept of DNA barcoding, its application to species identification and iBOL's activities for enhancing technical and scientific cooperation and technology transfer on molecular biodiversity.

2. The information is circulated in the form and language in which it was provided to the Secretariat.

* UNEP/CBD/SBSTTA/18/1.

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DNA BARCODING AND ITS ROLE IN BUILDING GLOBAL CAPACITY IN MOLECULAR BIODIVERSITY

SBSTTA-18 Information Document for the Parties

The DNA Barcoding Concept

DNA barcoding is an actively developing field of biology promising to revolutionize human understanding of biological diversity. Occupying a unique niche at the interface between genomics and biodiversity science, it provides molecular tools for fast, reliable identification and discovery of species using short standardized DNA fragments. It is based on the fundamental observation that biological species typically possess distinctive genetic signatures. This unique pattern can be identified by reading a short DNA sequence in a specific part of the genome termed the 'barcode region'.

The digital nature of diagnostic DNA sequence information used by DNA barcoding allows automated comparisons across major taxonomic groupings and minimizes interpretive bias. Unlike traditional morphological diagnostic approaches, DNA barcoding allows identifying species of all life stages, as well as organismal fragments, processed products, and even DNA traces in the environment. It further allows provisional taxonomic allocation of organisms unknown to science by offering a robust framework for defining operational taxonomic units that can be standardized across different applied projects. Existing computational platforms give it the ability to manage and cross-check ultra-large genomic datasets, underpinning its utility in baseline biodiversity screening of hyperdiverse and understudied groups of life, as well as whole ecosystems.

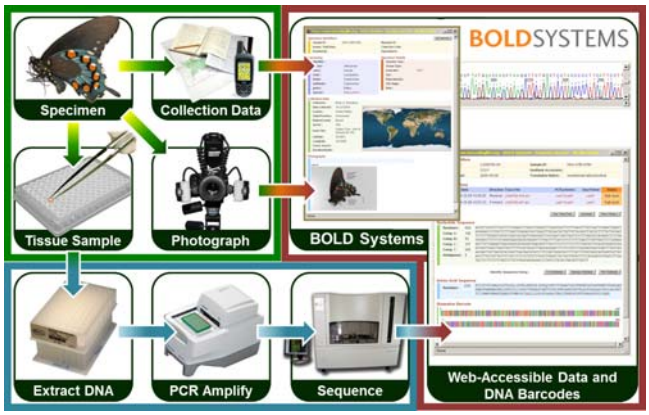

Figure 1. Simplified representation of the DNA barcoding workflow. Three major components of the workflow are outlined in colour: Green – specimen collection and curation; Blue – molecular analyses; Brown – data preservation and analysis).

As the benefits of DNA barcoding to the biodiversity science community receive wider recognition, it gains worldwide acceptance as a tool for species identification in basic, as well as applied research. This trend is manifested by a rapidly growing volume (thousands) of publications that involve or discuss DNA barcoding (Figure 1). In addition to this, DNA barcoding is increasingly viewed as a vehicle for democratizing biodiversity knowledge, engaging citizen science, and garnering keen interest from outside academia in learning about biodiversity.

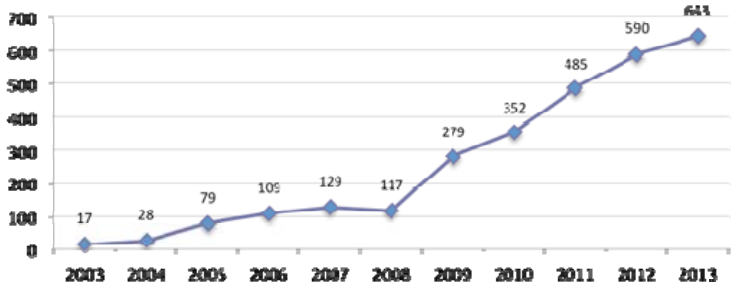

Figure 2. The rise in the annual number of publications on DNA barcoding. The rapid rise in 2008 coincides with plans to activate iBOL.

DNA barcoding applications

DNA barcoding has demonstrated utility in applied areas of key public concern where effective species identification can boost efficiency and save money otherwise spent on mitigation and damage control. These areas include:

- Agriculture and forestry – identifying and monitoring agriculture and forestry pests and biological control agents;
- Human health – identifying and monitoring human disease vectors and reservoirs; reconstructing disease transmission pathways, assessment and monitoring of natural-borne disease foci;
- Invasive and alien species – identifying and monitoring invasive organisms and their ecological impact, improving early detection and regulatory measures to curb cross-border transfer of alien species;
- Endangered species – enhancing taxonomic and ecological knowledge about endangered species and creating a diagnostic framework for monitoring and curbing illegal harvest and trade through improving forensic approaches and streamlining regulatory frameworks.
- Environmental surveillance/monitoring – helping extractive industries (oil, gas, mining), the natural resources (forestry, fisheries) and agriculture sectors to meet their environmental compliance requirements and to evaluate the efficiency of offset, restoration and remediation measures.
- Market surveillance, product ingredient authentication; detection of food contamination and substitution (e.g., seafood, meat and natural products).

The International Barcode of Life (iBOL)

The utility of DNA barcoding as a tool for diagnostic applications critically depends on the creation and maintenance of a thoroughly scrutinized digital reference library of DNA barcode sequences linked to information about authoritatively identified specimens from which they originate.

The source specimens used to build this library as well as the analytical track logs have to be deposited in nationally and internationally recognized collections and available for verification by experts while the resulting data should be openly accessible to the public, adhering to the principles of openness, transparency and verifiability.

Figure 3. iBOL logo and Map of iBOL partner nations.

This demand has led to the emergence of the **International Barcode of Life** (**iBOL**, http://ibol.org) – a global network of research institutions and government agencies undertaking barcoding. Established in 2010 as a consortium of nations committed to supporting DNA

barcoding efforts and international cooperation in the field of biodiversity genomics, iBOL presently involves over 100 institutions from nearly 30 countries. iBOL's strategic development is governed by an international Research Oversight Committee (ROC).

The core mission of iBOL is to assemble the reference library of DNA barcodes by bridging taxonomic expertise with standardized high-throughput sequencing protocols. An important by-product of this exercise is the digitization of provenance data for many specimens stored in natural history collections which helps partnering nations to meet their obligations under the Global Taxonomy Initiative (GTI). As part of its commitment to assemble and disseminate biodiversity information, the iBOL project has signed MOU's with the Global Biodiversity Information Facility (GBIF) and the Convention on Biological Diversity (CBD).

The initiative was catalyzed at and is being spearheaded by the **Biodiversity Institute of Ontario** (**BIO**) at the University of Guelph, Canada that houses its largest core sequencing facility. It also hosts the Barcode of Life Data System (BOLD, www.boldsystems.org) – the global online DNA barcode data repository (containing over 3M records for over 350K species) and analytical workbench. Information contained in BOLD is publicly accessible for DNA-based identification purposes and is exchanged with the National Center for Biotechnology Information (NCBI) GenBank. While working closely with other genomic and biodiversity data providers, BOLD is a unique online data resource in the way it packages genomic data with specimen information to facilitate taxonomic validation. It also offers a suite of analytical tools providing easy access to DNA-based identifications.

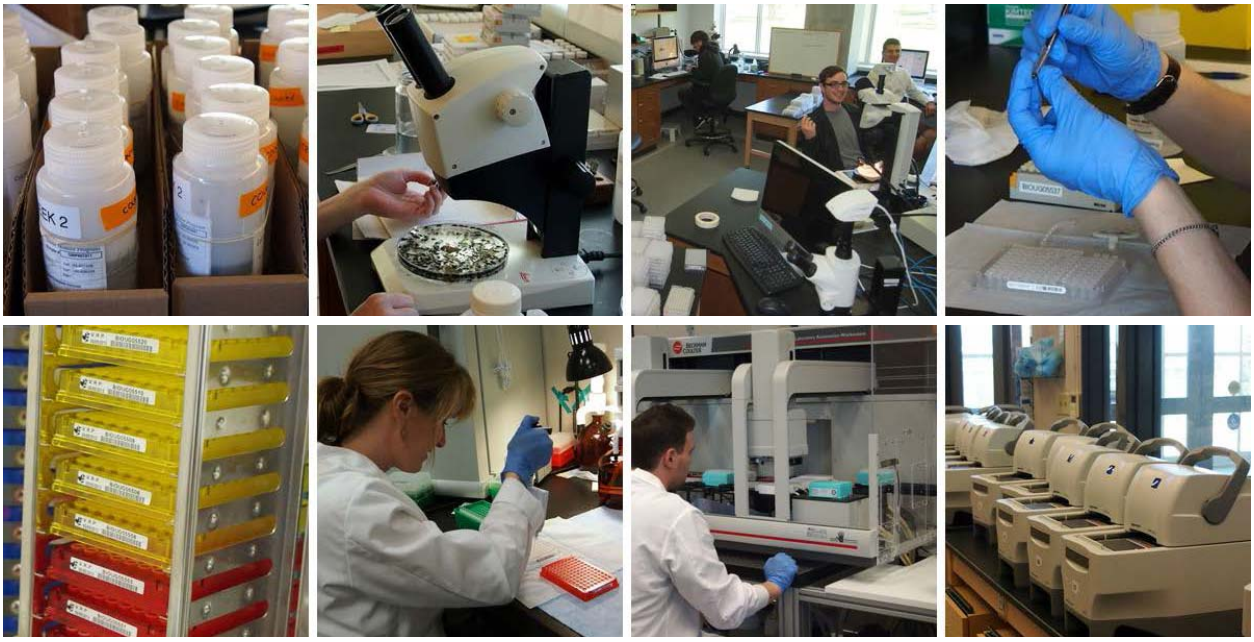

Figure 4. The core DNA barcoding facility at the Biodiversity Institute of Ontario

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Since its inception, iBOL has led capacity building, particularly in biodiversity-rich low-income nations, helping them reaffirm their international leadership in biodiversity research and conservation. Methodological advancements are published regularly and disseminated among iBOL partners; they are further made available through international workshops and hands-on training offered by iBOL's leading laboratories. This not only facilitates efficient technology transfer to developing countries, but also ensures cross-compatibility of protocols, genetic materials and information across different analytical centres.

Future prospects for collaboration between CBD and iBOL

Currently, all critical elements are in place required to complete a planetary-scale biodiversity inventory and to translate this fundamental knowledge into a diverse gamut of practical applications:

- The DNA barcoding technology has fully matured over more than a decade since its introduction and continues to refine and incorporate new cutting-edge methodological approaches, keeping abreast with current research trends in biodiversity and genomics.
- Operational frameworks have been devised for collecting, aggregating and using molecular data from biological specimens. These frameworks can be readily replicated and adopted by existing and new analytical facilities wishing to engage in DNA barcoding.
- A global DNA barcoding research community has emerged that includes internationally recognized centers of excellence with dedicated staff and infrastructure required to carry out fast and cost-effective operations at an unprecedented scale. This has led to the emergence of previously unrivalled global-scale synergies between taxonomic experts, molecular biologists, and the broad user base.
- A computational platform for aggregating and cross-referencing biodiversity genomics information has been developed that facilitates management of ultra-large volumes of DNA barcode data and provides universal world-wide access to this information.

In its early stages of development, DNA barcoding has been a predominantly academic exercise and has seen limited application. Although there is increasing interest and gradual uptake from government regulatory bodies and the private sector, these developments remain limited and not well coordinated.

These challenges can be overcome through active partnerships between iBOL and international bodies responsible for the coordination and establishment of international framework agreements related to trade and biodiversity conservation. Of particular relevance are major international treaties like the Convention on Biological Diversity (CBD), Convention on international Trade in Endangered Species (CITES), International Union for the Conservation of Nature (IUCN), and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Below is an outline of several prospective avenues for collaboration:

- Several nations are adopting this technology as part of their government regulatory mechanisms. Partnership with iBOL will help standardize the diagnostic tools and monitoring workflows for invasive, alien and endangered species to be used for biosurveillance within nations, and for control over their international transfer. At the initial collaboration stages, the existing infrastructure of iBOL partnering institutions can be used to perform analytical services that would help Parties to CBD meet their obligations.
- iBOL's experience in technology transfer and information sharing through training workshops and international development assistance will help build DNA barcoding capacity among CBD partners, with particular emphasis on developing nations. This will lead to the creation of a de-centralized but well-coordinated global network of national analytical centres that would meet local needs for molecular diagnostic applications (e.g., border inspection, product authentication, invasive species detection etc.), while helping them meet their commitments under CBD.

- There is increasing demand for biodiversity data collected during baseline ecological surveys in digital open source format, rather than as printed reports; iBOL has the technical capacity to gather and archive these data. In particular, the BOLD DNA barcode reference library can become the resource of molecular biodiversity information for the CBD, its national focal points and partnering organizations. Further development of partnerships between BOLD and global biodiversity data providers and aggregators (GBIF, GIASI Partnership, IUCN, etc.) can help build global integrated information management systems.
- iBOL can help make expert biodiversity knowledge available and usable to the broader public, thereby empowering engagement and support from stakeholders outside the biodiversity research community and providing them with the necessary tools and information.

In order to realize these prospects, it is important that information about DNA barcoding and iBOL is disseminated to the Parties. This would catalyze a discussion of the ways in which iBOL can partner with international organisations, initiatives and framework agreements in biodiversity (CBD, IUCN, CITES, GIASIPartnership, IPBES, etc.) and help Parties to meet their commitments. In particular, the data and approaches generated by iBOL can aid in implementing the Strategic Plan for Biodiversity 2011-2020 in areas where species identification is required, such as Aichi Biodiversity Targets 9 and 19. iBOL has offered partnership with the CBD Secretariat to aid CBD Parties with capacity development in the following areas:

- Research and Training (CBD Art. 12) – training experts in developing countries in DNA barcoding to empower biodiversity research institutions and government regulatory bodies in adopting this technology (e.g., to inspect goods and commodities);
- Access to and Transfer of technology (CBD Art. 16) – establish framework for DNA barcoding technology transfer between the Parties (through workshops, on-site training, etc.) to help existing biodiversity research facilities in these countries develop biodiversity genomics capacity;
- Exchange of Information (CBD Art. 17) – promote and facilitate free and open access to biodiversity information through existing DNA barcode informatics platforms (e.g., www.boldsystems.org) and by building/improving linkages to other biodiversity data portals (e.g., GBIF, GIASIPartnership, IUCN);
- Technical and Scientific Cooperation (CBD Art. 18) – expansion of the model successfully implemented among iBOL partner nations to create a consolidated global network of biodiversity genomics research facilities equipped to aid Parties in meeting their international commitments under CBD while ensuring their sustainability through addressing applied needs of stakeholders at the respective national levels.

An outline of iBOL's mission has been incorporated into the draft Global Biodiversity Outlook 4 (GBO4). Further discussions at COP12, and other follow-up meetings will help build a roadmap for future collaboration.