VII BENEFITS FOR CANADA

"Those who see problems through a molecular lens are well positioned to address some of the major problems of our time" –Paul Wender (quoted in *Nature* January 2011)

During the 1990's many business leaders were caught off guard by the internet's radical impact on commerce. Genomic approaches are now exerting a similarly disruptive impact on the life sciences. Combining both of these elements, DNA barcoding will transform biodiversity science and its areas of application by allowing the automation of species identifications. This transformation will certainly create opportunities for commercialization, but it would be wrong to neglect the fact that DNA barcoding will have broader impacts.

1. Science and Society

Hot-button issues like GMOs have often strained the relationship between citizens and scientists. However, DNA barcoding resonates in a very positive way with the public because of its perception as "green genomics" and its role in democratizing access to biodiversity information. While non-monetary benefits like enhanced social acceptance are hard to quantify, they are important considerations, particularly when one acknowledges the role that inspirational projects play in recruiting the next generation of scientists. DNA barcoding has certainly been extremely successful in both attracting highly qualified personnel to Canada and in inspiring youth's interest in science as reflected by the decision of Quebec's Museum of Civilization to include DNA barcoding as one of its six highlighted projects in a feature exhibition that will open in mid-2011.

DNA barcoding provides more than intellectual excitement. Its application allows federal Departments and Agencies to better meet their policy mandates in areas such as marketplace biosurveillance, and the detection of invasive species threatening forestry and agriculture. The Federal Biodiversity Information Partnership (FBIP), an alliance of Canadian federal Departments and Agencies, is a strong supporter of DNA barcoding for this reason. FBIP is currently lobbying for increased funding to aid barcode research programs by governmental scientists.

2. Commercialization Opportunities

There are two primary opportunities for the commercialization of DNA barcode activity. The first involves the delivery of analytical services to organizations which require barcode data. At present, this market is relatively small, but it is growing rapidly. Current demand is largely linked to the surveillance of varied food products (e.g. seafood, medicinal herbs). However, DNA barcoding is also gaining adoption as a tool for environmental assessments in varied contexts, such as water quality compliance. The second opportunity for commercialization relates to the development of a portable device for DNA barcode analysis.

2.1 DNA Barcoding Services

The CCDB has 60 full-time employees whose collective skills have allowed the development of a commercialization pathway linked to the growing demand for barcoding services. Clients at the CCDB now include varied government agencies within Canada (e.g. the Canadian Food Inspection Agency) and the USA (e.g. Food and Drug Administration, National Marine Fisheries Service). Barcoding contracts have also been obtained from the Bureau of Alcohol, Tobacco and Firearms and the National Ecological Observation Network (NEON) of the US Geological Survey.The CCDB was, in fact, the successful bidder for the first barcode contract tendered by NEON in 2010 and this could lead to a significant revenue stream by 2013 when the NEON program will require the analysis of 50,000 specimens annually at an estimated cost of $1M per year.In short, there is a growing market for DNA barcode-based identifications and Canada has a corner on this market.

Because of this growth in business, the CCDB now employs one full-time forensic analyst. The opportunities for substantial bio-surveillance work for private sector clients, especially in the mining and petrochemical sectors, recently led the University of Guelph to provide the funds required for the CCDB to hire a Director of Business Development. Dr. Peter Miller, who will take up this position in May 2011, brings a very strong background in the field of genetic approaches to biomonitoring and the overall needs of the environmental sciences community gained through more than a decade of experience.

The CCDB is not the sole organization providing a DNA barcode service. A Canadian biotechnology start-up (Sterisense) has begun marketing species identification, especially for applications in the food sector. As the scope of the barcode reference sequence library expands, so too will the diversity of applications. Because barcoding brings the full breadth of eukaryotic diversity into the purview of environmental genomics, applications in environmental monitoring will provide diverse entrepreneurial opportunities, as evidenced by the fact that consulting firms have already solicited barcoding services from the CCDB to aid their environmental impact assessments.

Because of its leadership role, the CCDB plays a very important role in training international researchers. Although most of these individuals are hosted at no charge, the CCDB has developed a formal training program with a $2000 tuition fee for governmental and private sector scientists. The first of these week-long workshops was offeredin late 2009 to 10 staff members from US federal agencies(FDA, EPA).

2.2 DNA Barcoder

The development of a device that integrates all steps of barcode analysis will represent a major advance in DNA barcoding and biodiversity science. There is no serious technological barrier; the components required for its fabrication are available. However, they require integration and, in some cases, miniaturization. The first generation of barcode readers will be table-top instruments, while second generation devices will be hand-held. Partnerships between private sector firms and academic researchers with expertise in microfluidics, sequencing technology, informatics, and DNA extraction will be required. Life Technologies is already developing a suitcase-sized portable sequencer and other platforms like real-time PCR and microarrays, both of which exploit patterns of species-specific sequence variation in the barcode library, are already available for the identification of defined sets of target species. Opportunities for iBOL-Canada in this area include both aiding in the design specifications for the portable device and in provision of the reference sequence library needed to drive identifications.

3. Canada's Contributions to International Science

Beyond the business opportunities and prestige derived from leading the world's largest biodiversity genomics program, iBOL is helping Canada build significant linkages with countries across the development spectrum. These linkages are bringing researchers, governmental regulators and policy makers to Canada from around the world to consider the applications of barcoding technology. To cite just one example, the government of Norway has committed $250M to aid forest preservation in Guyana and at least $30M of this total will be used to establish a biodiversity institute. The World Bank, which oversees these funds, has recruited the CCDB as its prime consultant in relation to the scientific goals and analytical approaches that will be employed by Guyana's new Institute.