Meeting Report

Broadening the participation of students and other non-professionals in the International Barcode of Life Project (iBOL)

Coastal Marine Biolabs, Ventura, CA
August 2-3, 2010

Executive Summary. Although significant progress has been made in establishing DNA barcoding as a research tool for advancing our understanding of biological diversity, the merits of DNA barcoding as a multidisciplinary educational platform, and its ability to invest students in deep explorations of science and nature as *citizen scientists* are largely unrecognized within the educational community at large. In light of these considerations and iBOL's ambitious goal to compile a genetic registry of Earth's plants and animals, the direct involvement of our next generation of scientists represents a top-tier priority for the international DNA barcoding community. In collaboration with the Consortium for the Barcode of Life (CBOL), Coastal Marine Biolabs (CMB) convened a small panel of scientists, educators, and media experts to discuss a framework for effectively engaging students and other segments of the general public in iBOL. During the 2-day planning meeting, participants defined realistic points for students of different ages to enter the barcoding analytical work chain, explored various approaches to recruit the involvement of students in DNA barcoding campaigns, identified prospective members of a working community of DNA barcoding laboratories/practitioners who are actively engaging students and other non-experts in DNA barcoding, and examined the educational funding priorities of various agencies/foundations and their congruency with specific barcoding-based educational activities. Meeting participants also made a number of key recommendations, including the formation of a new iBOL working group dedicated to advancing DNA barcoding as an educational tool, the creation of a reference landing site as a preliminary online vehicle to centralize network-level, education-based barcoding activities and to facilitate the exchange of educational resources, an expansion of BOLD's existing cyberinfrastructure to effectively manage and further ensure the accuracy and consistency of student-generated barcode data, and the preparation of a manuscript to highlight the merit of DNA barcoding as a teaching and learning platform for the secondary education community.

Meeting Discussions

Levels of student engagement and entry points into the DNA barcoding workflow. As a scientific enterprise, DNA barcoding is a multi-step analytical work chain that utilizes distinct technologies that in turn draw upon a fairly wide spectrum of scientific concepts encompassed by state and national content standards. Although opportunities exist for students of all ages to meaningfully participate in iBOL and derive educational benefits from their involvement, participants felt that the extent of student participation and their entry point into the analytical chain should be carefully weighed against their academic/scholastic background and their ability to generate accurate and consistent specimen and sequence data.

Participants discussed ongoing educational efforts by various groups in Canada, the U.K., and the U.S., and the nature and scope of their educational activities. Through their participation in supplemental educational programs hosted by several groups over the last several years, high school students have demonstrated an ability to generate high quality specimen and sequence data that in some cases has been incorporated into scientific publications and featured in several high

profile educational media outlets. The meeting participants uniformly agreed that collaborative strategies to recruit the direct involvement of non-professionals in iBOL should initially target this particular grade band and involve groups with demonstrable success in using barcoding as an educational tool.

Unlike their younger counterparts in K-8, many high school students have been formally introduced to the molecular biology-based laboratory techniques and associated scientific concepts that encompass the most intellectually and technically challenging aspects of the barcoding workflow. Participants felt that by integrating fundamental elements of students' formal science education within the context of a landmark biodiversity initiative of global significance, the barcoding enterprise is most likely to achieve its highest levels of educational merit and credibility (a key consideration for future funding efforts and attempts to formally integrate DNA barcoding into high school science curricula).

Although discussions focused largely on the involvement of high school students in generating and submitting reference barcodes to the Barcode of Life Data Systems (BOLD), a role for younger students in obtaining specimens and collection event details was also considered by meeting participants and deferred to future discussions. It should be noted here, however, that high school students who undertake DNA barcoding through their participation in supplemental programming may assume an important mentorship role in the engagement of younger students that can be augmented by grade level-appropriate activities and instructional materials.

Forms of student engagement. Although student engagement in DNA barcoding may assume a variety of different forms and encompass after-school, summer, virtual, and/or year-round learning experiences, meeting participants focused on strategies to involve high school students in the generation of reference barcodes for various campaigns. For this goal, the direct engagement of students by scientists within *bona fide* laboratory settings was regarded as the most straightforward and logistically feasible path to success. Indirect student engagement through professional development programming for science teachers presents a number of distinct but surmountable challenges that were extensively discussed. These include the acquisition of transportable scientific equipment for teachers to use in ill equipped science labs, the distribution of tissue samples, supplies, and reagents to program participants, logistical constraints and procedural issues associated with large class sizes (especially in public schools), and remote management of student-generated barcode data. Despite these obstacles, professional development programming provides a potential mechanism to enhance teacher capacity, engage larger numbers of students, and inspire greater levels of participation in the creation of reference libraries. Through its extensive experience with both forms of engagement, CMB provided a number of useful insights to help guide future projects that include both approaches. Lessons learned from other groups currently engaged in education-based barcoding activities will be solicited through the Barcode of Life Community Network (www.connect.barcodeoflife.org) and direct communication with various group leaders.

Alignment of DNA barcoding with key funding foci. Participation in iBOL involves the use of cornerstone technologies and fundamental scientific concepts that span a rather wide spectrum of STEM (science, technology, engineering, and mathematics) disciplines. The meeting participants discussed the alignment of various barcoding-centered educational activities with the funding priorities of various entities, particularly those that seek to prepare students for the 21st century STEM workforce. Emphasis was placed on identifying agencies and foundations that provide an appropriate level of funding to support STEM-based collaborative proposals involving the

coordinated activities of multiple groups.

CMB is currently awaiting an award decision on a collaborative proposal that was submitted as a *Strategies* project to NSF's ITEST (Innovative Technology Experiences for Students and Teachers) program in February 2010. The ITEST program solicits proposals for smaller scale *Strategies* projects that design, implement, and evaluate models for classroom, after-school, summer, virtual, and/or year-round STEM learning experiences for students and/or teachers, and more extensive *Scale-up* projects that aim to extend these models into large-scale settings (*i.e.* at the state or national level). After reviewing the proposal, the meeting participants uniformly agreed that funding support for CMB's *Strategies* project would lay the groundwork necessary to submit a *scale-up* ITEST proposal that involves a more extensive partnership network and that integrates student-generated data with other well-established resources (including the Global Biodiversity Information Facility, the Encyclopedia of Life, and others).

Over the short-term, the meeting participants resolved to identify other potential funding agencies and to collaborate on the submission of proposals that are geared toward broadening the participation of high school students in iBOL. The selection of key partners that play synergistic roles in collaborative projects was identified as a central near-term goal (see section below). In addition to agencies and foundations that take STEM teaching and learning as their central focus, others that emphasize environmental literacy or the use of digital media will also be explored as potential funding options.

Communication and Information Dissemination. Collaborative projects that seek to engage students in barcoding campaigns will require well-defined partnership networks that include expert taxonomists, biorepositories, sequencing facilities, scientists, educators, and media groups. Meeting participants emphasized the need to create an open-access, Internet-based resource to facilitate the formation of these networks and the exchange of resources and information among its constituents. A resource of this kind will also provide an effective vehicle to centralize network-level activities conducted by the proposed iBOL Working Group discussed below. This concept was proposed to the MacArthur Foundation's Digital Media and Learning competition in early 2010; although it was not selected for funding (despite being highly ranked), it proved to be catalytic in bringing the present group together and remains a key resource needed to produce a synergy between the science and education communities around iBOL.

As a first step toward accommodating these important goals, the participants proposed the creation of a *reference landing page* that will serve as a registry for groups currently utilizing (or that seek to use) DNA barcoding for educational purposes (with accompanying descriptions of the barcoding-based educational opportunities offered by each group and links to their websites), an online resource for high quality instructional materials developed by different organizations and media experts, an entry point for social media and communications forums (to coordinate online barcoding projects, tally results, and provide interpretation guidelines), and a future portal to a *pre-BOLD* user interface that contains a suite of tools to interrogate student-generated barcode data (see below).

Jeremy Friedberg (Spongelab Interactive) will assume a lead role in developing the landing page, which is slated for completion on or around September 30, 2010. Meeting participants will collaborate on initial concepts for copy, design, etc. Together with direct communication with established leaders in barcoding and education, the Barcode of Life Community Network will be

used to solicit the participation of groups that are currently using DNA barcoding as a learning tool. The location at which the landing site will reside is the topic of future discussions.

Establishment of iBOL Working Group dedicated to education and public engagement. iBOL's research and administrative activities are carried-out by 20 Working Groups that are currently organized under five central themes (http://ibol.org/research-overview/) that do not yet encompass education and public engagement. Meeting participants recommended the establishment of an additional iBOL working group that will act in the capacity of a central coordinating body to: 1) facilitate the formation of partnerships among educators, scientists, biorepositories; 2) periodically review educational strategies and evaluate successes; 3) coordinate the educational activities of existing and emerging groups; 4) propose recommendations for future educational efforts and activities, including how to develop and evaluate activities that seek to enhance public engagement in iBOL; 5) disseminate instructional resources to various educational groups; and 6) organize various network-level activities, including community meetings and public engagement events. Conceivably, a new working group dedicated to public engagement in iBOL might operate effectively under a 6th iBOL theme that encompasses the ethical, economic, environmental, legal, and social aspects of DNA barcoding.

Preparation of a* CBE-Life Sciences Education *or* PLOS Genetics *manuscript. The value of DNA barcoding as an educational platform is largely unrecognized within the educational community at large. *In lieu* of a position paper, the meeting participants agreed to collaborate on the preparation of a manuscript that introduces the educational community to the merits of DNA barcoding as a multi-disciplinary, research-based teaching and learning tool. Plans to initiate work on the manuscript were deferred until fall 2010. Both *CBE-Life Sciences Education* and *PLOS Genetics* were tentatively identified as potential target journals.

Ensuring the accuracy and consistency of student-generated barcode sequence data. Meeting participants discussed potential concerns over the accuracy and consistency of student-generated barcode data. The transparency and traceability instilled into a reference barcode by the existing information requirements of the Barcode of Life Data Systems (BOLD), in combination with the suite of data interrogation tools that BOLD currently utilizes, makes identification of data anomalies in student-generated data relatively straightforward.

Although BOLD presently allows novices to contribute professional quality data, meeting participants considered additional strategies to ensure the accuracy and quality of student-generated data. Methods to reduce the frequency of procedural errors in the laboratory have already been pilot tested by CMB and other groups. These include the cross-validation of student sequence data (*i.e.* cross-comparisons of sequence data generated by different students from the same specimen) and coding systems that decrease the likelihood of mixing samples containing tissue, gDNA, or PCR amplicons from different specimens. Participants also discussed the design and core functionalities of a *pre-BOLD* user interface that is dedicated to the remote management and analysis of student-generated records. A number of functionalities were considered, including tools to simplify the editing process and rapidly cross-validate student generated sequences. Records uploaded to a custom console of this kind would be flagged and earmarked for centralized and periodic review by a designated group of scientists, who would subject sequences to additional levels of interrogation that might include screening those that show deep divergence

from existing records for a given species. Only data that pass these additional QA/QC checks will be eligible for upload to BOLD and assigned barcode status.

Involvement of the Channel Islands National Park in education-based barcoding activities. During the meeting, the Channel Islands National Park (CINP) formally committed to extend its collaboration with CMB and its partners to support barcoding projects involving high school students. A small-scale campaign to create a reference barcode library for the 70 kelp forest indicator species currently monitored by park field biologists is already underway. We anticipate that these efforts will provide a solid foundation for a more extensive campaign that targets terrestrial species, including many of the endemic species unique to the five northern Channel Islands. Participants are optimistic that a collaboration of this kind will set a precedent for the widespread involvement of U.S. National Parks in future DNA barcoding efforts.

APPENDIX ITEM 1 (Participant List)

SCIENTIFIC PANEL

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APPENDIX ITEM 2 (Agenda)

BARCODING AND EDUCATION

Broadening the participation of students and other non-professionals in the International Barcode of Life project

Monday August 2nd and Tuesday August 3rd, 2010

Location

Coastal Marine Biolabs
1559 Spinnaker Drive, Suite 101
Ventura, CA 93001-5302

Contact Information

Linda Santschi
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Remote Access

Individuals wishing to participate in the meeting remotely via audio conferencing are enthusiastically encouraged to contact Linda Santschi by email. Please indicate the segment(s) of the meeting in which you wish to participate.

USA Toll-Free	888-557-8511
USA Caller Paid/International Toll	215-446-3649
ACCESS CODE	**2684706**

Meeting Objectives

Although rapid strides have been made in establishing DNA barcoding as a powerful new tool for species identification, efforts to exploit the remarkable educational potential of DNA barcoding have been slow to materialize. This collaborative planning meeting will convene scientists and educators for the following central goals:

1. ***To assemble an expandable core partnership network to broaden the participation of students and other non-professionals in the International Barcode of Life (iBOL) Project***

2. ***To develop a comprehensive and well-focused collaborative funding strategy to support education-centered DNA barcoding activities that enable students to make a meaningful contribution to the initiative***

3. ***To outline the core content of a position paper that effectively represents the central considerations and recommendations addressed in the meeting***

MEETING AGENDA

The agenda items listed below are intended as a guide to facilitate discussions on key topics associated with the principal meeting goals. As this is the first formal meeting dedicated exclusively to engaging students and other segments of the public in DNA barcoding, please regard the agenda as a series of potential discussion points; we anticipate revisions based upon the input of meeting participants and the availability of remote attendees.

Session 1 (August 2, 2010)

Assembling an expandable partnership network to broaden the participation of students and other non-professionals in the International Barcode of Life (iBOL) Project

9:00 AM – 12:00 PM

Welcome and introductions

Discuss meeting goals and objectives

Provide a summary of participants' education-based barcoding activities
Target age cohort, form of engagement/specific activities, extent of integration with public/private educational entities, key outcomes

12:00 PM – 1:00 PM

Lunch break

1:00 PM –

Remote attendees:

- *Sujeevan Ratnasingham (Bioinformatics Lead, BOLD)*
- *Jeremy Friedberg (Spongelab Interactive)*
- *Dan Distel and Abigail Fusaro (Ocean Genome Legacy)*

Discuss educational approaches and strategies to meaningfully engage different target populations in DNA barcoding

Define partner roles in collaborative education proposal(s) and areas of synergy among co-applicants of a comprehensive funding proposal

Direct engagement of students by partner institutions
Age cohort, educational aims, specific activities

Professional development opportunities via partner institutions

The use of social networking and other vehicles to share ideas and disseminate resources and outcomes among partner organizations

The role of biorepositories in education collaborative

Potential enhancements of BOLD cyberinfrastructure to accommodate, remotely manage, and ensure the accuracy of student-generated species and barcode data

Special Note: Russell Galipeau (Superintendent, Channel Islands National Park) and his associate, Kate Faulkner (Chief, Natural Resource Management, Channel Islands National Park), are tentatively scheduled to attend the afternoon segment of this session.

Session 2 (August 3, 2010)

Developing a collaborative funding strategy to support education-based barcoding activities

9:00 AM – 12:00 PM

Provide a synopsis of prior funding successes and pitfalls among meeting participants

Discuss alignment of barcoding educational content with STEM, environmental literacy, ICT, and other key funding foci

Identify potential funding avenues (e.g. NSF, EPA, NOAA, statewide economic workforce development agencies, Life Technologies and other corporate foundations, etc.)

12:00 PM – 1:00 PM

Lunch break

1:00 PM –

Discuss the scope of prospective funding proposal(s)

Assemble provisional timeline for preparation of proposal(s) and designate key points of contact, lead organizations, PI's, and Co-PI's

Outline the content of a position paper based on meeting discussions