

# THE INTERNATIONAL BARCODE OF LIFE



## Bringing Genomics to Biodiversity

International Consortium Initiative



Inaugural Workshop for  
**The International Barcode of Life Project**

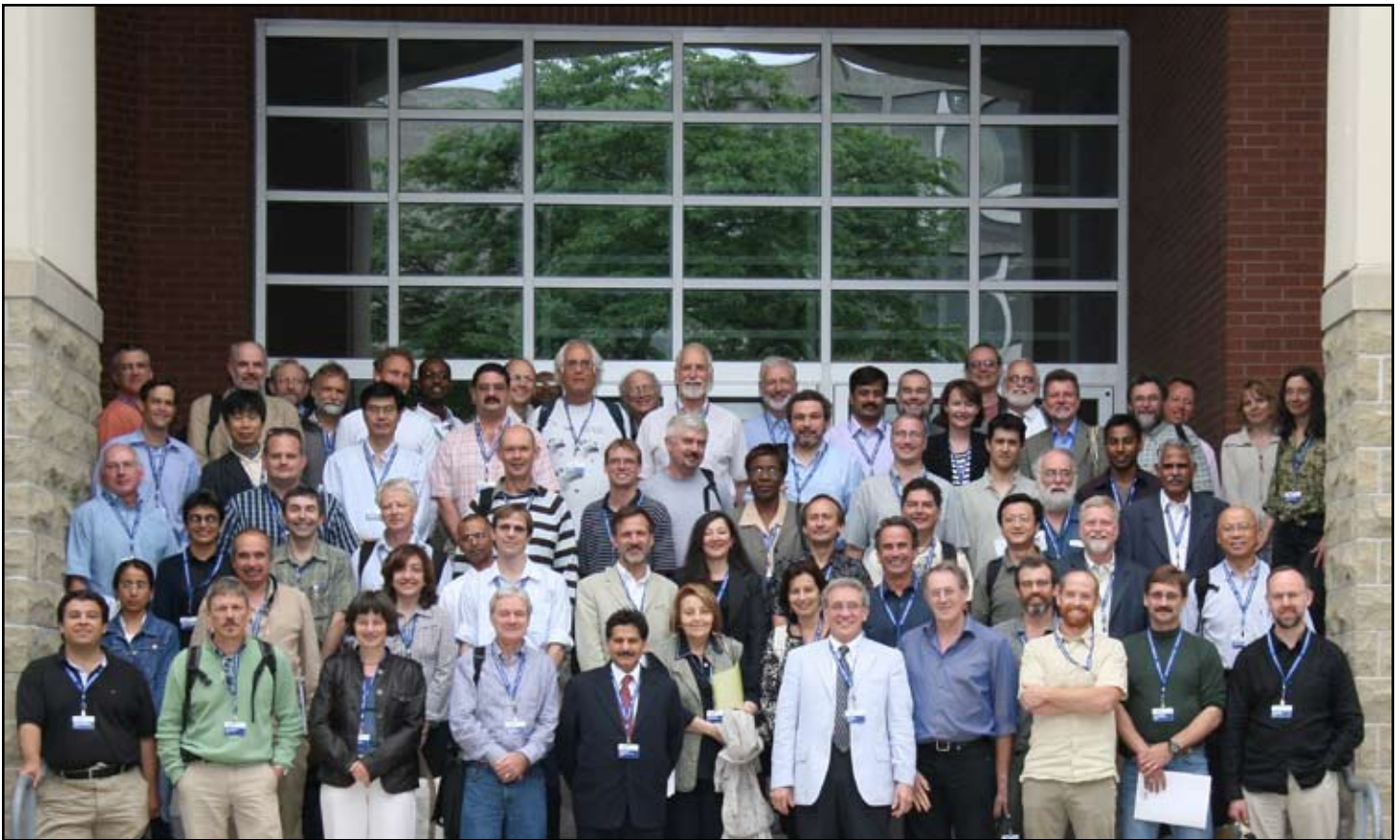
Organizers: Mark Engstrom, Paul Hebert, Laurence Packer

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University of Guelph  
June 17-20, 2007



DELEGATES TO THE FIRST INTERNATIONAL BARCODE OF LIFE WORKSHOP IN FRONT OF ROZANSKI HALL AT THE UNIVERSITY OF GUELPH.

To appreciate the attraction of the International Barcode of Life Project (iBOL), think about it as an update of the past.

**Think ~** Of an army of 21st century Darwins, hoping to set sail on an armada of technologically powered HMS Beagles.

**Think ~** In place of a lone English naturalist piggy-backing his research onto an already funded British mapping expedition, thousands of researchers from 25 countries collectively working across the globe.

**Think ~** In place of one boat, visualize a fleet of sequencers, operating sometimes in small laboratories and sometimes in robotized, DNA-analyzing factories.

**Think ~** Of the need to raise money and obtain co-operation from organizations around the world before setting sail.

**Think ~** Of a collective enterprise aimed at using museum collections and providing species information which is vitally needed to guide national mandates for biodiversity conservation and biosurveillance.

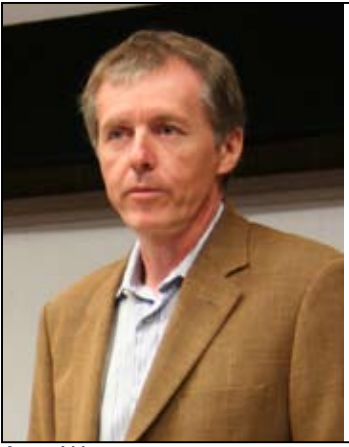
**Think ~** About aiding humanity to identify all species, and changing our notion of how a species is recognized.

This is the revolutionary framework that Alan Wildeman, Vice-President (Research) at the University of Guelph drew around the first iBOL workshop meeting in June 2007 as he welcomed delegates to the campus.

“Ever since I became aware of the Barcode of Life project, I felt that I was an observer on the deck of the Beagle as it was going forward,” he told the attendees. “Unlike traditional voyages which were governed by compasses and maps, this one is guided by computers, and genomics and partnerships. But the outcome may fundamentally change how we look at species on our planet.”

**“EVER SINCE I BECAME AWARE OF THE BARCODE OF LIFE PROJECT, I FELT THAT I WAS AN OBSERVER ON THE DECK OF THE BEAGLE AS IT WAS GOING FORWARD.”**

The new voyages of a 21st century Darwin and Beagle are a metaphor that allows one to see



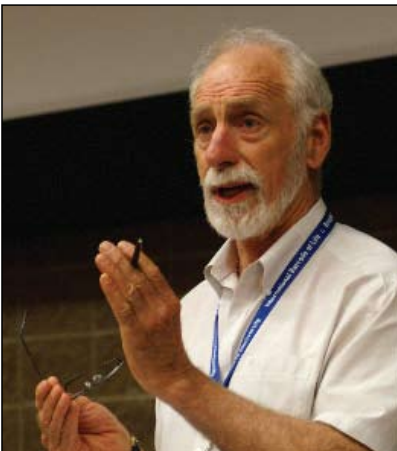
ALAN WILDEMAN

the context of the often passionate discussions, digressions, and occasional disagreements which took place at the workshop. Part of what was exciting to attendees was the grandeur of the effort. Within a year or so, could a grouping of 25 countries create a structure which would allow biologists to produce a DNA-based barcode library for 500,000 species over a 5 year time frame?

Paul Hebert, the founder of DNA barcoding, told the delegates that this vision was “slightly audacious by biological standards but not so audacious when viewed more broadly.” And the problem the proposal posed to biodiversity scientists was sociological as much as anything, because working together on expensive, collective projects “has not been part of our tribal culture.”

So how to change that culture? David Anderson, director of the Guelph Institute for the Environment, told the delegates in his introduction to the workshop that their efforts should focus on three very modern questions in order to become successful.

First, determine what was the most effective way of governing and managing the various groups which were to comprise iBOL. In essence, what should the iBOL crew look like and what should their responsibilities be? Secondly, what should the science targets be? Effectively, where should the iBOL Beagle stop and what should it be looking at? And thirdly, who was going to pay for the projected \$150 million trip and the technology/manpower the modern, species-identifying Beagle needed to accomplish it?



DAVID ANDERSON

With this as their backdrop, the first day of

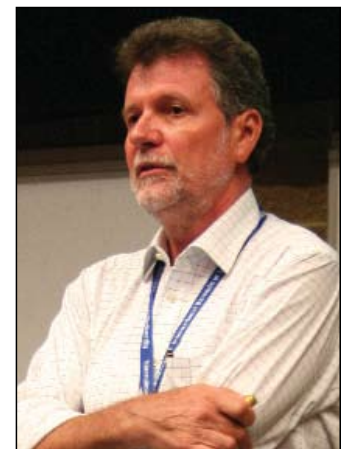
sessions addressed these questions in three distinct ways. First, was the science of DNA barcoding sufficiently advanced to allow the modern Beagles to set sail? The overwhelming evidence was, yes – and sail with ease. Hebert pointed out that since the first paper on the subject appeared in 2003 some 38,222 species and 261,187 specimens have been barcoded and many new species have been discovered. “Can we use barcoding as a screen for overlooked species – yes we can,” he pronounced.



When it comes to DNA barcoding all animals there were some issues – better primers and faster species descriptions – but in general it was clear to the scientific world that the approach was roaring ahead. “If I had been asked three years ago if things were going to be as simple as they have worked out to be, I would have said almost certainly not,” Hebert noted to the meeting participants.

Other speakers described the general success of DNA barcoding in identifying protists, macroalgae, and fungal species – although there were some technological and biological differences remaining to be worked out.

The sticking point to date has been plants. John Kress of the Smithsonian Institution said the mitochondrial cytochrome *c* oxidase I (CO1) gene used so successfully in differentiating animal species evolves too slowly to allow species identification in plants. However, searches are probing nuclear and chloroplast genes which would do the same thing. While debates are still on-going about which genes were appropriate plant barcode



JOHN KRESS

indicators, this should not delay the sail of botanists wanting to join the iBOL effort because agreement was near.

The latter part of the morning session was devoted first to describing two different approaches to what species should be barcoded within iBOL. Effectively, where should the barcode Beagle set anchor? Mark Stoeckle of Rockefeller University spoke of the societal utility of barcoding entire groups of

## BARCODING IS GOOD VALUE TO THE PUBLIC.

animals such as present efforts to barcode all the world's birds and fishes. These assemblages had been chosen for a variety of reasons, not the least of which being the immediate applications of species identification by regulatory agencies. For example, aviation authorities worldwide are interested in quickly and efficiently determining which species of bird are striking planes. In terms of fisheries management, officials want to make sure that fish markets aren't cheating the public by substituting filets of cheap fish for more expensive ones. Both applications have already proven their worth in field trials said Stoeckle, and in so doing allowed biologists to clearly demonstrate that "it (barcoding) is good value to the public."

And his remark in many ways underscored one of the absolutely fundamental differences between Darwin's voyage and that of iBOL. While Darwin was added almost as afterthought to the British navy's effort to map the global coastline, iBOL researchers were going to have to convince their respective governments that funding the project was in their national self-interest.

A second path the iBOL Beagle might take is to map all species in an entire ecosystem. In this regard Christopher Meyer of the University of California at Berkeley described how this was now underway on the small French Polynesian island of Moorea. The hope



CHRISTOPHER MEYER

was to barcode an estimated 5,000 Moorean terrestrial and aquatic species and then mount that information on the Web. He estimated the cost to be about \$100 per species, but counseled that from the Moorea perspective it was also very important to make sure that a technological infrastructure was in place to manage the huge amount of genetic information which ecosystem mapping created. "You have to lock down metadata. You have to have standardized metadata," was his mantra.

If a scientific rationale for iBOL was self evident and the destination of the voyage was reaching consensus, there was similar good news on the virtual ship building front. To begin with the technology required to quickly barcode species and store that data already existed according to



SUJEEVAN RATNASINGHAM

Mehrdad Hajibabaei and Sujeevan Ratnasingham of the Canadian Centre for DNA Barcoding (CCDB). The Guelph facility can DNA barcode a specimen in two hours at a cost of less than \$5 each and will, by 2009, be able to barcode 500,000 specimens yearly. This single facility could meet half of iBOL's goal to process 5 million specimens in 5 years.

And for scientists wanting to tap the barcoding potential of previously gathered museum collections, the Guelph facility had recently shown it could amplify a barcode from a 160-year-old type specimen and arrive at a species determination.

Existing barcode data are already available in a number of formats, both statistical and visual, on the Barcode of Life Data System (BOLD), said Ratnasingham. Further, BOLD is gaining usage as hits on the site have increased from about 300,000 in July of 2006 to more than a million in May of 2007.

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Brian Golding of McMaster University was similarly optimistic about iBOL's ability to handle the informatics requirements for the project. He pointed out that while the initiative wanted to collect 5 million specimens, the framework of BOLD had the capacity to handle 10 million records. Will there be problems accomplishing the iBOL informatics agenda – “not that I can see,” was his verdict.



BRIAN GOLDING

The goals of the iBOL project must all be considered within the context of the relentless advance of computer and molecular technology. Mostafa Ronaghi of Stanford University described a barcoding present where sequencer costs were within the \$500,000 to \$1,000,000 range. “What we are trying to do [at Stanford] is create a device which will do massive amounts of genome sequencing for about \$10,000,” he told the workshop, and he predicted that this would be possible within 5 years. Furthermore, technological advances are opening up the pathway to the holy grail of species barcoding – a handheld device from which field biologists or customs officials would obtain a species determination in minutes.

Another requirement for a successful iBOL voyage is the creation of what you might call multiple Darwins. In place of a single person collecting and storing species, iBOL must attract the interests and expertise of thousands of researchers around the world. They have to not only collect, but preserve and send off to DNA sequencing centers what they collect. But perhaps most importantly, they must do this within iBOL's budget.



PARATAXONOMISTS IN COSTA RICA

Dan Janzen of the University of Pennsylvania spoke about how Costa Rica had created



**THE HOLY GRAIL OF SPECIES BARCODING: A HANDHELD DEVICE WITH WHICH FIELD BIOLOGISTS OR CUSTOMS OFFICIALS WOULD OBTAIN A SPECIES DETERMINATION IN MINUTES.**

a corps of parataxonomists – with no formal biology background – to collect, store and mount samples. He estimated that his team had been able to collect Lepidoptera species at a cost of about \$5 a specimen.

He then went on to demonstrate that this number was roughly comparable to collection costs in the Canadian Arctic and for harvesting barcodes from Lepidoptera specimens held in private collections.

He estimated that \$25 million would enable the fresh collection of 250,000 species and 2.5 million specimens over a five year period. That is, half the goal of the iBOL project. When you allotted another \$10.5 million to barcoding specimens held in private collections, museums, or gathered via other programs, in five years he predicted one should be able to barcode 4.6 million specimens from 785,000 species at a cost of \$8 a specimen and \$42 a species. “But that does not include the taxonomic cost of working up all the new species that will be discovered,” he counseled.

Despite Janzen's optimism, a major concern throughout the meeting was that barcoding would encounter a bottleneck as the world's relatively few taxonomists found themselves overwhelmed by the curatorial and identification requirements created by the barcoding of 500,000 species. In his presentation, Freek Bakker of Wageningen University in Holland estimated that it would take upwards of a quarter of all the world's 8,000 taxonomists to create and interpret the flow of new information but that this was doable. “Can we curate all this material? Probably yes, but the iBOL network will need to be highly proactive,” he advised the meeting.



18<sup>TH</sup> CENTURY PRIVATE COLLECTION

Lee Weigt of the Smithsonian Institution was equally optimistic that 5 million specimens could be



DELEGATES DISCUSS iBOL ORGANIZATION

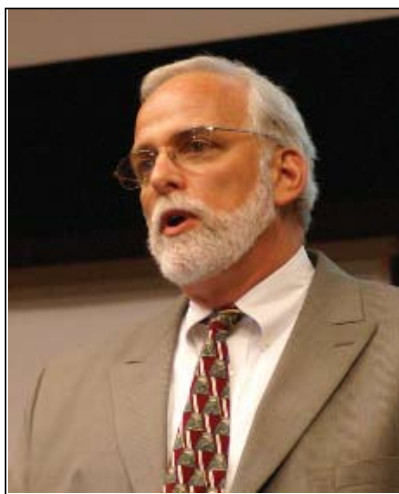
sequenced for the \$50 million allocated for this task in the budget. “It can be done,” he said and then added, “barely.” In fact, the task was only possible because, while non-sequencing

expenses of obtaining samples and getting them safely to labs continue to be expensive, sequencing itself was becoming cheaper and faster by the day.

Nonetheless, economies of scale had to be taken into account if iBOL was to stay within its budget for sequencing. While all the iBOL countries might want to do sequencing within their borders, the reality was that a battleship of a lab such as that at the CCDB could sequence a sample for about \$4 – a cost that rose to \$16 per specimen in a medium-sized lab and near \$45 in a small lab.

Finally, the first day discussed the question of who would direct iBOL governance. While Darwin was essentially only answerable to himself, iBOL had to meet the needs and interests of its member nations. It will have to monitor for the duration of the voyage whether the project is successful. It will have to ensure that money is well spent.

One clear option was to develop this capacity in close collaboration with the Consortium for the Barcode of Life (CBOL). David Schindel, Executive Secretary of CBOL, described how his organization has responded to barcoding’s rapid successes. CBOL had, in a little more than 3 years, been able to



DAVID SCHINDEL

recruit 150 member organizations in 45 countries to participate in species barcoding activities and their future planning. CBOL has worked both to create standards for how barcoding should be done and initiated projects of immediate economic or health

importance. CBOL has also begun educational outreach and sought to create regional barcoding networks – particularly in poorer parts of the world. The consortium has been able to convince regulators to adopt or consider adopting DNA barcoding as a standard for species determination.



JESSE AUSUBEL

Jesse Ausubel of the Sloan Foundation, which has funded a variety of barcoding research projects, sounded a warning about the iBOL initiative. He argued strongly that barcoding “does not need more organizations and that is the official Sloan Foundation’s view of iBOL. Instead what the scientific community requires is more and better proposals to raise money for barcoding.” His view was that the central aim of the meeting was to come up with these proposals in the next couple of days.

“The question is who has the drive and energy to develop proposals on different groups of organisms,” he told delegates.

Not surprisingly, many of the discussions which followed centered on what rapidly was seen as the most contentious issue for the iBOL launch. Scientifically it was doable. Technically it was more than doable. The manpower infrastructure was there – if just barely.

But could the assembled scientists raise enough money from what Hebert characterized as a “United Nations of Barcoding” to launch an armada of barcoding Beagles? A short answer: on one level it depended on the ability of the nations involved to integrate their fund-raising capacities with the expressed interest of Genome Canada to see Canada, and the rest of the world, launch a barcoding fleet.

**“THE QUESTION IS WHO HAS THE DRIVE AND ENERGY TO DEVELOP PROPOSALS ON DIFFERENT GROUPS OF ORGANISMS.”**

In this regard, Karen Kennedy, Director of Genome Canada’s International Genomics Pro-

grams, described for the workshop the agency's requirements for it to commit funds to a project like iBOL. To be funded, International Consortium Initiatives must have Canadian researchers at the fore, have a high profile in the scientific community, involve an international consortium with some sort of formal governance, have a financial oversight structure and cost at least \$50 million over a 3 year period. The projects also had to pass scientific and due diligence reviews.



KAREN KENNEDY

When all was said and done, there was great hope that Genome Canada would be able to raise \$25 million in support. If that amount, as Hebert anticipated, could be equaled by money from other

## A THIRD OF THE \$150 MILLION iBOL BUDGET COULD COME FROM CANADA.

Canadian sources, a third of the \$150 million iBOL budget could come from Canada.

But Genome Canada's contribution was dependant on co-funding and it quickly became evident to people at the conference that a major issue was the question of what was eligible. Paul Skelton of the South African Institute for Aquatic Biodiversity pointed out that projected funding requirements were the equivalent of the total budget of all biological funding in his country.

Pablo Tubaro of Museo Argentino de Ciencias Naturales concurred and argued that if new iBOL funding competed directly with existing taxonomic



PABLO TUBARO

funding in his country, the program wasn't going to fly. But contributions of manpower and collections and access to great areas of biodiversity were possible. But then the question – how much were these worth? And to whom? And what were the criteria to judge whether something met

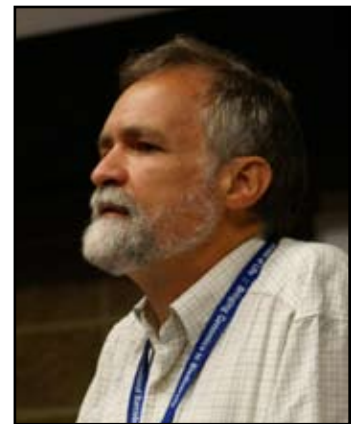
Genome Canada's standard for recognition as co-funding.

Darwin simply took samples from wherever he went. Tubaro on the other hand raised the issue of the potential roadblock for iBOL where the Convention on Biological Diversity (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 labs such as the Canadian Centre for DNA Barcoding.

**“MY QUESTION IS, DO WE REALLY NEED SPECIES NAMES FOR ALL THE BARCODES?”**

Darwin brought his collections back with him and literally spent the rest of his life analyzing and writing about them. While there are probably enough 21st century taxonomists to curate the wave

of new specimens, the laborious, still very 19th century way of identifying species and naming them was seen as an intrinsic bottleneck in the system. “My question is, do we really need species names for all the barcodes?” Wolfgang Waegle of Germany's Zoologisches Forschungsmuseum Alexander Koenig asked the delegates. In the wake of iBOL perhaps the world's biologists were going to have to revise taxonomy's centuries-long traditions and simply give a newly discovered species a provisional code.



WOLFGANG WAEGELE

Darwin and the Beagle traveled a world where nature seemed all but limitless. Collecting species from one site was as good as collecting them from another, but for iBOL to gather traction – both politically and economically – the need to seize upon projects with great public appeal was absolutely vital.

In this regard, Dan Janzen often and passionately argued that in the 21st century the mapping of centers of biodiversity didn't exist in a vacuum, but rather within the context of a natural world facing a species extinction crisis brought on by human demands – particularly the rush to extract biofuels from forest products.

“Every corner of the world which isn’t explicitly protected is going down the toilet,” he said, adding, “and if ordinary people walking down the streets, politicians, teachers in schools, and ditch diggers can’t see something of use to them in all the green stuff in nature, then it is gone.”

But ultimately, the most profound difference between Darwin and iBOL is that all Darwin had to do to gain passage was provide dinner conversation interesting enough to qualify him to be a “gentleman companion” for the Beagle’s often bored captain. What iBOL was striving to create was a world-wide Darwinian enterprise – a species identifying organization with a product, and customers, and a business plan and a management structure. And as such the iBOL effort almost screamed to the workshop a sociological truth: if 19th century science was about successful individuals, 21st century science is about successful collaborations among successful individuals.

**“EVERY CORNER OF THE WORLD WHICH ISN’T EXPLICITLY PROTECTED IS GOING DOWN THE TOILET.”**

With this in mind, the second day of the conference was devoted to a survey of where things

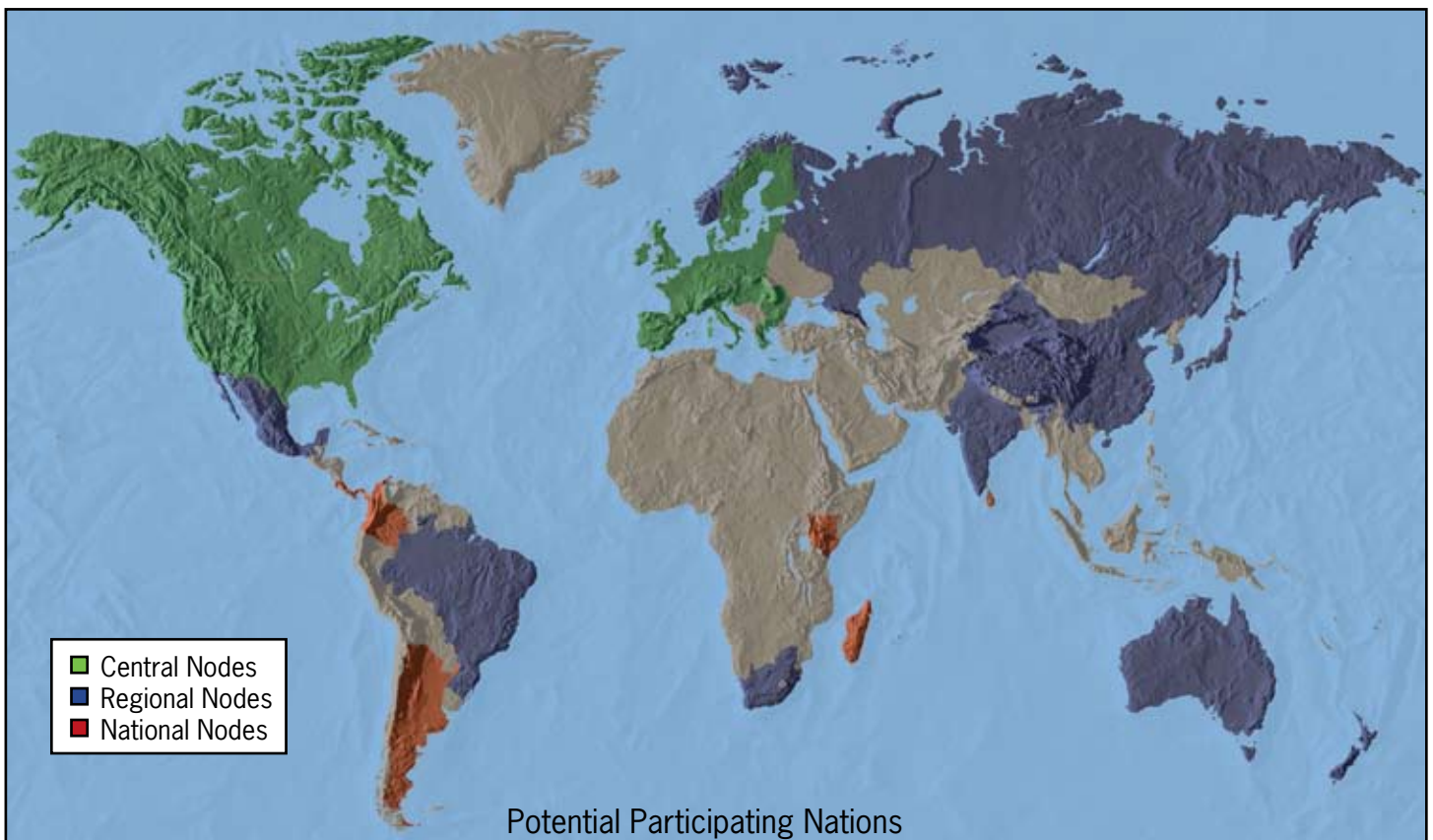
presently stood in the various countries trying to create iBOL. What barcoding activities had already been set up? What steps had been taken to begin participation in iBOL? What kind of funding possibilities existed? What institutional, legal, and technological issues might impede a country’s contributing co-funds to match the Genome Canada contribution? Would the tentative iBOL organizational model in which some countries served as central nodes, some as regional ones, and others as national nodes actually work?



DAN JANZEN

The accompanying graphic shows a general breakdown of national participation, but it is also fair to say the present status of Beagle building and Beagle crew preparation varies widely around the world.

Some places such as Canada, India, and Korea seemed well advanced to contribute to the projected iBOL schedule in terms of present projects, funding, organization and future project research.



At the other end of the spectrum were countries where the first order of iBOL business was convincing conservative local biologists that species barcoding itself was a good idea. “Very little barcoding is presently being done in Colombia,” said Mauricio Linares of the Universidad de Los Andes, but perhaps that should “be interpreted as an opportunity to do it now.”



VIRGINIA LEON-REGANON

Still other countries found themselves in a situation where the desire to sail on a modern Beagle and their ability to contribute materially to that sailing were almost in direct opposition.

“We have specimens and we have needs,” Brian Fisher of the California Academy of Sciences but speaking for Madagascar told the group, “but we don’t have any money to commit.”

**“WE HAVE  
SPECIMENS  
AND WE HAVE  
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Another clear statement on the part of representatives of many developing countries was that simply a collection base for iBOL species was not enough. They wanted access to the revolutionary sequencing technology which was making the project possible. “If we South Africans are just exporting all the time, we will never stand on our own feet,” remarked Paul Skelton. “If we are going to be partners with you, we want to be partners on fair terms.”

Again one cannot help but point out that the technology which drove Darwin was the improvement in English sailing ships – none of which changed on the Beagle during his 5 year trip.



TORBJORN EKREM

An iBOL organizational model for each country was debated throughout the session. Canada favored the creation of national committees like the one it had created, but some European countries and the United States were unsure that would

work for them.

“I don’t think we need a strongly organized network in France,” said Michel Veuille of the Département Systématique et Evolution of the Muséum National d’Histoire Naturelle in Paris. “I think we should put it at the level of Europe.”

Representatives from Mexico and Kenya generally spoke of the need to merge national initiatives into regional projects. Virginia Leon-Reganon of the Universidad Nacional Autónoma de México reported plans to develop a MesoAmerican Barcode of Life proposal to inventory life from northern Mexico to Nicaragua. A strategy to integrate the iBOL plan with current Mexican institutional commitments has been formulated, potential funders identified, and a letter of intent to join iBOL has been written.



HELIDA OYIEKE

Helida Oyieke of the Centre for Biodiversity in Kenya told of a meeting of East African countries in Kenya in October 2006, which stimulated the formation of a National Steering Committee. That October meeting also identified barcoding priorities for East Africa. However, there is little barcoding experience in the country and funding is limited.

In addition, some places had specific institutional structures which would have to be followed in order to get iBOL moving. Da-Wei Huang of the Chinese Academy of Sciences told the workshop that to get new funding in China requires that a scientific organization offers a proposal, which is then submitted to a government ministry. If it is approved, it then gets forwarded to the China Association for Science and Technology, which would finally approve it.



DA-WEI HUANG

On the funding level, Torbjorn Ekrem of Norway’s Natural History Museum pointed out potential new sources of revenue – companies drilling for oil and gas who needed species information to meet environmental impact regulations.

In addition to the contributions of individual countries to the new armada, delegates heard of the value of iBOL partnering with what might be termed ‘ships of opportunity’. Frank Bisby described the efforts of the Species 2000/ITIS programs to produce a catalogue of life which displays information about many of the world’s known species in varied formats. This year the system is up and operating



FRANK BISBY

for more than a million species and is supported by a website that includes 538,364 synonyms and 414,075 common names. In addition to relying on the expertise of 3,000 taxonomists, the program is linked to many of the organizations iBOL will be approaching.

Therefore it made sense, said Bisby, to “consider building closer links between our parallel programmes” – with taxonomic synergy. The group was very insistent that there should be integrity when it came to taxonomic names and taxonomic delineations.

Ron O’Dor detailed the absolutely immense amount of sampling which is going on in the \$500 million Census of Marine Life and what that means for an iBOL looking to save money by hooking up with existing species gathering programs. “If you are looking for specimens you have come to the right place,” he said. “And we would be very happy to work with you to supply whatever we can.”



RON O’DOR

Within the very diverse descriptions of the state of iBOL preparation, there was a single thing it seemed everyone could agree upon. iBOL needed to find that iconic project or projects that provided what you might call brand identity. “It is very important that we do something that lets us get somewhere at the end of things. A quite compelling project is really important,” said Richard Lane of London’s Natural History Museum, providing clear justification for early focus on barcode projects with strong socio-economic impacts.

The final day’s session started with David An-

person’s opening remark that “everyone is on the barcoding train and we have half a day to bring them together.”

What underlaid this was the obvious fact that in the first two days no one had announced some essential failing which doomed the iBOL initiative from the start.

**“EVERYONE IS ON THE BARCODING TRAIN AND WE HAVE HALF A DAY TO BRING THEM TOGETHER.”**

Rather, as Lane pointed out, the key issues were almost entirely organizational. What was the benefit for countries in joining and supporting iBOL? How were priorities to be set? And what was going to be the relationship of central funding nodes – Canada, the US and the EU – to the others?

After several hours of discussion, David Schindel provided a helpful summary of the path forward, and emphasized CBOL’s willingness to aid this effort. Karen Kennedy then summed up where things stood from a Genome Canada perspective. In terms of her organization’s requirements, she said that both the governance of iBOL and the funding mechanisms clearly needed more discussion and refinement.

Positively, it was also clear that iBOL should allow other countries – especially developing ones – to leverage funding, and perhaps provide access to monies that they couldn’t raise on their own. The concept of barcoding would allow countries to organize regionally around issues which were transnational.



RICHARD LANE AND PAUL HEBERT

The iBOL initiative would allow sequencing to be subsidized at central nodes, as well as provide for training, education and outreach. Moreover, it would provide structure to integrate with CBOL and achieve consistent results through oversight or advisory groups.

But there remained contentious issues. In terms of the science, it was unclear where exactly samples should come from, which samples were most important to take first, whether one absolutely



ROCKY SKEEF

had to come up with high profile, socio-economically judicious projects to make the whole enterprise fly.

Rocky Skeef, of the National Research Foundation of South Africa, mentioned the importance of partnering with existing projects in order to make iBOL appealing to often cash-strapped national funding agencies. Costs needed to be worked out both in terms of where sequencing was done and the correct mix of museum versus field collections.

It also remained to be decided whether regional networks were a better organizing structure than national committees and how the ambitions of research champions could fit in with the clear need to get governments on line. The issue of getting samples out of countries without breaking the Convention on Biological Diversity also required more thought.

Since many of the same issues applied to funding questions, it was clear that a meeting of potential funders should be held at some time in the future.

Governance questions remained, particularly in matching the needs of countries or regions to the needs of the iBOL as a whole, and in coordinating everything with CBOL. What was obviously also needed was a critical pathway for the proposal. The pathway would show people: here is what iBOL is; this is what a country must do to become involved with iBOL; here are national interests; these are good organizational and management models; these are local champions and here is what they do.

But perhaps most importantly, a timetable had to be established if the goal of a 2008 submission to Genome Canada was to be met.

Many conference participants felt that while the general outline of the project was good, it was important to address very specific issues. What constituted an in-kind contribution? What are the limits of reconstituting existing programs to become barcoding initiatives? What monetary value can be attributed to museum collections? "Canada wants to lead the endeavor, and a leader has to make clear

to its followers what to do," is how Bob Ward of Australia's Commonwealth Scientific and Industrial Research Organization typified the situation. Accordingly, there was a strong consensus that it would be helpful to have fact sheets that provided an overview of the iBOL project, a summary of eligible co-funds, and a synoptic research plan.



BOB WARD

At the end of the day David Anderson summed up the workshop by saying he thought there was one key question. What message should delegates take back home to convince their governments to participate in iBOL? And from his perspective two things stuck out. First the project lets the countries involved place themselves at the cutting edge of a science whose power is just beginning to be realized. With the Beagle paradigm in mind: if a nation was offered a berth on the modern Beagle, they would be foolish not to take it. And secondly, delegates should stress the great socio-economic benefits which were emerging from the barcoding technology. In essence, if everything worked out, iBOL might well end up offsetting all of its costs – and more – through better biosurveillance.

It is a vision Darwin, living in his very different time, would have related to. "In the struggle for survival, the fittest win out at the expense of their rivals because they succeed in adapting themselves best to their environment," he wrote.

In our modern world, when a technological upheaval occurs, it is those who adapt that prosper. In the age of the genomics revolution, iBOL can aptly be viewed as taxonomy's natural evolution.

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# THE INTERNATIONAL BARCODE OF LIFE



## Bringing Genomics to Biodiversity

International Consortium Initiative



Inaugural Workshop  
University of Guelph  
June 17-20, 2007

## WELCOME

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Dear Colleagues

Thank you for joining us for the inaugural meeting of the International Barcode of Life (iBOL). We hope this workshop will launch a research coalition that will gain activation by January 2009. If so, within five years of that date, our work will have created a barcode reference library with 5M specimen records from 500K species. We will, as well, have simplified the protocols for barcode acquisition and analysis. Clear scientific plans, the mobilization of a broad community of researchers and the acquisition of funding will all be required to achieve our goals. The critical next step lies in the activation of the National Committees which will catalyze the rise of iBOL in each country.

This workshop has varied goals. It seeks firstly to ensure that all delegates can both influence and understand the core elements of iBOL. It will also provide a forum for evaluating the readiness of our community to carry out the research and to recruit funding. Finally, the meeting seeks to ensure that all participants leave with the background needed to lead their nation's engagement in iBOL. The task that lies before us is complex and biodiversity science lacks a tradition of mega-science projects. However, we are confident that there is no magic; dedicated efforts by each of us will see iBOL gain vitality.

We are very pleased to have the chance to host your visit to Canada. We thank the meeting sponsors for their generous support which enabled this assembly. We hope that our meeting not only achieves its goals, but that relationships established over the next few days will engender longstanding research alliances and personal friendships.



Paul Hebert



Laurence Packer



Mark Engstrom

## MEETING SPONSORS

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This meeting was made possible through the support of the Alfred P. Sloan Foundation, Genome Canada, the Natural Sciences and Engineering Research Council of Canada, the Ontario Genomics Institute, and the University of Guelph.



## TRAVEL AND ACCOMMODATION

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### Transfers from Pearson Airport to Guelph

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Guelph is situated approximately 50 km west of Toronto Pearson airport; **Red Car Service** provides transfers from the airport to Guelph. As soon as you have finalized your flight plans, we will book your transportation with Red Car and provide you with a **reservation number**. Once you have arrived at Pearson Airport and have cleared Customs and Immigration, please proceed to the Ground Transportation Desk:

**Terminal 1:** When you exit baggage claim on the arrivals level, turn right and follow the signs for Ground Transportation. Proceed towards the end of the building and take the escalator (on your left) or the elevator (on your right) down one level to Ground Level. The Ground Transportation Booth is located on this level.



**Terminal 3:** If you are arriving on International flights or flights from the United States, turn left when you exit baggage claim. Proceed along the Terminal past the car rentals to Ground Transportation. If you are arriving on flights from within Canada turn right when you exit baggage claim and proceed to Ground Transportation located beside the first escalator.

Notify the receptionist of your presence and s/he will arrange for your driver to bring a car to the terminal. Do not worry if your flight is delayed as Red Car monitors flight schedules. However, if you are shifted to a different flight, please phone 01-519-824-4120 ext. 56393 so we can relay this information to Red Car. If this is impossible, just proceed to the Red Car base when you clear Customs.

### Accommodation

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The driver will take you to the Ramada Hotel and Conference Centre at 716 Gordon St., Guelph, which will provide accommodation for all delegates. The phone number for the Ramada is 01-800-563-9240.

### Reception

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We plan a reception followed by dinner at Creelman Hall, commencing at 5:00 pm on Sunday June 17. If the weather is fine, you can either stroll through campus (it will be a 15 minute walk) or await transportation outside the hotel. If you opt for the latter, the shuttle will run from 4:45 - 5:15 pm.

### Meeting Venue

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All business sessions will be held in plenary in Room 103 Rozanski Hall.

### Hotel Shuttle Times

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Sessions will begin promptly at 8:30 am on each day. You may wish to walk to Rozanski Hall as it is just a 10 minute walk from the hotel. Alternatively, if the weather is poor or you would prefer to be driven, we will run a shuttle from the hotel to the campus from 8:00 - 8:15 am. Please do not be late!

## Meals

**Breakfast:** The restaurant at the Ramada serves both continental style and buffet breakfasts.

**Lunch:** Lunches will be served in the Atrium of the New Science Complex which is a 5 minute walk from Rozanski Hall.

**Dinner:** We will travel by bus to our dinner venues on Monday and Tuesday evening. Buses will depart from the Ramada at 6:30 pm.

## Map

Below is map of the University of Guelph campus and vicinity, highlighting the Ramada Hotel, Creelman Hall, Rozanski Hall, the New Science Complex, and the Biodiversity Institute of Ontario.



## OVERALL GOALS

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*This workshop seeks to establish the International Barcode of Life Initiative as a formal, multi-national research enterprise. As such, it will not only be critical to decide upon governance and management structures, but also to consider the best ways to develop a robust scientific program and to fund this research.*

**DNA Barcoding: A Status Report**  
**The International Barcode of Life Initiative**  
**National Capacities and Funding Prospects**  
**Building Alliances**  
**Building iBOL**

**Monday June 18, 8:30 am - 12:00 pm**  
**Monday June 18, 1:00 pm - 5:00 pm**  
**Tuesday June 19, 8:30 am - 2:45 pm**  
**Tuesday June 19, 3:00 pm - 5:00 pm**  
**Wednesday June 20, 8:30 am - 12:15 pm**

## MONDAY JUNE 18

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### DNA Barcoding: A Status Report

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*The session provides a status report on the barcode enterprise. It begins by considering progress in deciding barcode target regions for each kingdom of eukaryotic life and in assembling barcode data. Subsequent presentations consider two strategies for the assembly of barcode records - campaigns with a taxonomic orientation and those with a geographic focus. The final talks in this session consider progress in expediting barcode analysis, creating an informatics workbench and establishing a broad international research consortium. This session ends with a brief perspectives presentation before moving to general discussion.*

#### **Chair: Mark Engstrom (Royal Ontario Museum)**

8:30 - 8:40	Welcome	Alan Wildeman (University of Guelph)
8:40 - 8:50	Opening Remarks	Christian Burks (Ontario Genomics Institute)
8:50 - 9:00	Goals of the Meeting	David Anderson (GIE)
9:00 - 9:10	Barcoding Animals	Paul Hebert (CCDB)
9:10 - 9:20	Barcoding Plants	John Kress (Smithsonian Institution)
9:20 - 9:30	Barcoding Fungi	André Lévesque (Agriculture and Agrifood Canada)
9:30 - 9:40	Barcoding Protists	Robert Andersen (Bigelow Laboratory for Ocean Sciences)
9:40 - 9:50	Barcoding Macroalgae	Gary Saunders (University of New Brunswick)
9:50 - 10:20	<b>Coffee Break</b>	
10:20 - 10:30	Taxonomic Campaigns (eg. ABBI)	Mark Stoeckle (Rockefeller University)
10:30 - 10:40	Geographic Campaigns	Christopher Meyer (University of California at Berkeley)
10:40 - 10:50	Barcode Protocols	Mehrdad Hajibabaei (CCDB)
10:50 - 11:00	The Barcode of Life Data System	Sujeevan Ratnasingham (CCDB)
11:00 - 11:10	Consortium for the Barcode of Life	David Schindel (CBOL)
11:10 - 11:20	Barcode Reflections	Jesse Ausubel (Rockefeller University)
11:20 - 12:00	General Discussion	
12:00- 1:00	<b>Lunch (Atrium, New Science Complex)</b>	

## The International Barcode of Life Initiative (iBOL)

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*This session begins with an introduction to Genome Canada and its International Consortium Initiative (ICI). A subsequent presentation considers the primary structural elements of the International Barcode of Life. The balance of the afternoon is directed toward an examination of the feasibility of executing the varied elements of iBOL.*

### Chair: Laurence Packer (York University)

1:00 - 1:15	ICI	Karen Kennedy (Genome Canada)
1:15 - 1:45	iBOL - An Overview	Paul Hebert (CCDB)
1:45 - 2:00	Genome Canada	Martin Godbout (Genome Canada)
2:00 - 2:45	General Discussion	
2:45 - 3:00	<b>Coffee Break</b>	
3:00 - 3:15	Assembling 5M Specimens	Dan Janzen (University of Pennsylvania)
3:15 - 3:30	Curating/Identifying 5M Specimens	Freek Bakker (Wageningen University)
3:30 - 3:45	Sequencing 5M Specimens	Lee Weigt (Smithsonian Institution)
3:45 - 4:00	Expanding the Informatics Platform	Brian Golding (McMaster University)
4:00 - 4:15	Technological Innovation	Mostafa Ronaghi (Stanford University)
4:15 - 5:00	General Discussion	
5:00 - 6:30	<b>Free Time</b>	
6:30 - 9:00	<b>Dinner and Informal Discussions (Langdon Hall)</b>	

## TUESDAY JUNE 19

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### National Capacities and Funding Prospects

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*This session evaluates the research readiness of the 21 nations involved in iBOL. These evaluations include a report on the status of each National Committee and a consideration of possible funders in each nation. The morning session begins with reports from a representative of each Central Node Nation followed by a discussion session. The same format is followed as the day advances, with reports from representatives of each Regional Node and Developing Node.*

### Chair: Raul Jimenez Rosenberg (CONABIO)

8:30 - 8:40	Goals for Day 2	David Anderson (GIE)
8:40 - 8:50	Canada	Bob Hanner (CCDB)
8:50 - 9:00	UK	Richard Lane (Natural History Museum)
9:00 - 9:10	France	Michel Veuille (Muséum National d'Histoire Naturelle)
9:10 - 9:20	Germany	Johann-Wolfgang Waegele (Zoological Research Museum Alexander Koenig)
9:20 - 9:30	Italy	Cecilia Saccone (Istituto di Tecnologia Biomedica - CNR)
9:30 - 9:40	Netherlands	Freek Bakker (Wageningen University)

9:40 - 9:50	United States	Biff Birmingham (Smithsonian Tropical Research Institute)
9:50 - 10:15	Discussion - Central Nodes	
10:15 - 10:30	<b>Coffee Break</b>	
10:30 - 10:40	Australia	Les Christidis (Australian Museum)
10:40 - 10:50	Brazil	Ana Maria Azeredo-Espin (State University of Campinas)
10:50 - 11:00	China	Da-Wei Huang (Chinese Academy of Sciences)
11:00 - 11:10	India	Wazir Lakra (National Bureau of Fish Genetics)
11:10 - 11:20	New Zealand	Karen Armstrong (National Centre for Advanced Bio-Protection)
11:15 - 11:30	Norway	Jan Lifjeld (Natural History Museum, Oslo)
11:30 - 11:40	South Africa	Paul Skelton (SA Institute for Aquatic Biodiversity)
11:40 - 12:00	Discussion - Regional Nodes	
12:00 - 1:00	<b>Lunch (Atrium, New Science Complex)</b>	

## National Capacities and Funding Prospects (continued)

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### Chair: Peter Smith (National Institute of Water and Atmospheric Research)

1:00 - 1:10	Argentina	Pablo Tubaro (Museo Argentino)
1:10 - 1:20	Costa Rica	Jesus Ugalde-Gomez (INBio)
1:20 - 1:30	Colombia	Mauricio Linares (U. de Los Andes)
1:30 - 1:40	Kenya	Helida Oyieke (Centre for Biodiversity)
1:40 - 1:50	Korea	Chang-Bae Kim (National Biodiversity Centre)
1:50 - 2:00	Madagascar	Brian Fisher (California Academy of Sciences)
2:00 - 2:10	Mexico	Virginia Leon-Reganon (UNAM)
2:10 - 2:20	Polar Barcode of Life Initiative	Torbjorn Ekrem (Natural History Museum, Trondheim)
2:20 - 2:45	Discussion - Developing Nodes	
2:45 - 3:00	<b>Coffee Break</b>	

## Building Alliances

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The balance of the afternoon session considers the relationship between iBOL and other important biodiversity initiatives. The session begins with a consideration of the role that CBOL will play in orchestrating interactions with the broader biodiversity community. Subsequent presentations focus on two particularly important initiatives - CoML and Species 2000. A general discussion follows.

### Chair: Endre Willassen (Bergen Museum)

3:00 - 3:15	Species 2000/ITIS	Frank Bisby (University of Reading)
3:15 - 3:30	Census of Marine Life	Ron O'Dor (COML)
3:30 - 3:45	CBOL and iBOL	David Schindel (CBOL)
3:45 - 5:00	General Discussion	
5:00 - 6:30	<b>Free Time</b>	
6:30 - 9:00	<b>Dinner and Informal Discussions (Millcroft Inn)</b>	

## WEDNESDAY JUNE 20

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### Building iBOL

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This session is devoted toward a consideration of strategies for development of the key components of iBOL: its science plan, its governance and management, and its funding. The morning begins with a consideration of these thematic issues in the Central Node Nations. Subsequent discussions consider the same issues in Regional and Developing Nodes. The final session of the workshop sets action plans and timelines to develop the Consortium and the proposal.

### Chair: Robert Andersen (Bigelow Laboratory for Ocean Sciences)

8:30 - 9:15	Funding Strategy - Central Nodes	Chair: Richard Lane (Natural History Museum)
9:15 - 10:00	Funding Strategy - Regional Nodes	Chair: Bob Ward (CSIRO, Marine and Atmospheric Research)
10:00 - 10:15	<b>Coffee Break</b>	
10:15 - 11:00	Funding Strategy - Developing Nodes	Chair: Jorge Tezón (CONICET)
11:00 - 12:00	Next Steps - General Discussion	Karen Kennedy (Genome Canada)
12:00 - 12:15	Summation	David Anderson (GIE)
12:15 - 1:15	<b>Lunch (Foyer, Rozanski Hall)</b>	

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The International Barcode of Life :: [www.dnabarcoding.org](http://www.dnabarcoding.org)

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