

BEACON Center for the Study of Evolution in Action
An NSF Science and Technology Center
Strategic Implementation Plan
(updated October 2010)

EXECUTIVE SUMMARY

The BEACON Center for the Study of Evolution in Action is an NSF Science and Technology Center founded with the **mission** of illuminating and harnessing the power of evolution in action to advance science and technology and benefit society. BEACON is a consortium of universities led by Michigan State University, with partner institutions of North Carolina A&T State University, the University of Idaho, the University of Texas at Austin, and the University of Washington. BEACON unites biologists, computer scientists and engineers in joint study of natural and artificial evolutionary processes and in harnessing them to solve real-world problems. Developers of evolutionary algorithms have long borrowed high-level concepts from biology to improve problem-solving methods, but have not captured the nuances of evolutionary theory. Likewise, studying the evolution of artificial systems can provide biologists with insight into the dynamics of the evolutionary process and the critical factors underlying emergent properties and behaviors. BEACON will promote the transfer of discoveries from biology into computer science and engineering design, while using novel computational methods and artificial evolutionary systems to address complex biological questions that are difficult or impossible to study with natural organisms.

As Dobzhansky famously noted, “Nothing in biology makes sense except in the light of evolution.” BEACON’s **vision** focuses that light, revealing fundamental biological concepts and illuminating the path toward computational applications. The key insight underlying the Center is that transformative discoveries in both computing and biology are possible through studying evolution *as it happens*, in both natural and digital domains. The philosopher Dennett (2002) has pointed out the algorithmic nature of evolution as a process that will occur in any system with “replication, variation (mutation) and differential fitness (competition).” BEACON aims to understand evolution in this universal framework.

In this Strategic Plan, we present **Goal Statements** for six areas: Education, Human Resources, and Diversity (EHRD), Leadership and Management, Knowledge Transfer, Integrative Research, Ethics, and Research Output. For each goal, we have identified two to six **Optimal Outcomes**, and we will measure our progress towards these outcomes using Specific, Measurable, Attainable, Relevant and Time-Bound (**SMART**) **Targets**. For each Optimal Outcome, we also identify potential **Barriers** to Success, and the **Mitigating Actions** we will take to overcome these barriers. For each Mitigating Action and additional specific **Actions** relevant to each Outcome, we identify who will serve as a **Point of Contact**, and the **Due Date** for the action.

Summary of Goals. BEACON’s **Education, Human Resources, and Diversity (EHRD) overarching goal** is to integrate cutting-edge, multidisciplinary research, education, and outreach efforts across the Center that will advance innovative training, the diversity of the Center and scientific workforce, and public education to promote greater understanding of evolution and the nature of science. BEACON’s **Leadership and Management goals** are to

envision and enable the Center's mission through inclusive and transparent decision-making as well as effective and responsible implementation; to inspire Center participants; and to facilitate collaborative efforts within and beyond the Center. BEACON's **Knowledge Transfer goal** is to develop effective mechanisms and pathways to facilitate intellectual exchanges among BEACON partners and industrial affiliates that will support the sharing of knowledge and application of new technology. BEACON's **Integrative Research Goal** is to produce transformative, synergistic research through an inclusive collaborative culture that crosses disciplinary and institutional boundaries and is embedded throughout the Center's activities. BEACON's **Ethics Goal** is to practice and promote ethical and responsible research by implementing cross-disciplinary and multi-institutional ethics programs that will inform and guide all participants of the Center. BEACON's **research output goal** is to disseminate widely an increasing quantity of original and highly regarded scientific research on evolution in action.

EDUCATION, HUMAN RESOURCES, AND DIVERSITY PLAN

BEACON's **Education, Human Resources, and Diversity (EHRD) overarching goal** is to integrate cutting-edge, multidisciplinary research, education, and outreach efforts across the Center that will advance innovative training, the diversity of the Center and scientific workforce, and public education to promote greater understanding of evolution and the nature of science. We will approach this goal in two ways: by educating a diverse new generation of interdisciplinary scientists and engineers, and through outreach to K-12 students and the general public. BEACON will contribute to the pressing national need to bolster U.S. pre-eminence in science and technology by educating people about the importance of understanding, managing and harnessing biological and computational evolutionary processes.

EHRD Optimal Outcome 1: An increased interest in STEM careers in both academia and industry. BEACON will broaden participation in STEM disciplines by introducing teachers and students, especially from underrepresented groups, to the new research opportunities afforded by BEACON's applied evolutionary tools and research programs. Two programs that will contribute towards this goal are the BEACON High School Summer Residential Program, and our digital evolution platform, Avida-ED, that we will incorporate into undergraduate biology courses and modify for use in high school classrooms. Additionally, our team includes experts in science education and outreach who will work with all BEACON researchers to adapt BEACON research for use in science classes in schools in ways that address national science standards and goals. Using these tools, we will be able to deepen students' understanding of evolution-related challenges, such as responding to the evolution of infectious diseases and limiting the evolution of antibiotic and pesticide resistance, and help them learn to protect the integrity of the scientific process.

BEACON High School Summer Residential Program. MSU's College of Engineering Recruitment, Scholarships, and K-12 Outreach Office (Drew Kim) has developed and annually promotes a number of successful and growing STEM educational initiatives which brought in 633 (49%) women and 555 (51%) underrepresented minority participants in 2008 alone. Participants in the flagship summer residential program included 51% women and 65% from underrepresented groups. Building on these successful programs, Kim will work with BEACON faculty and staff to offer a one-week BEACON High School Summer Residential Program, a new short course on study of evolution in action, computer programming, and various types of engineering, taught by BEACON and other College of Engineering faculty and staff. Thirty high school students will be recruited from partner school districts: Utica Community Schools, Lansing School District, Detroit Area Pre-College Engineering Program, Holt School District, Okemos School District, and East Lansing School District. In future years, students will also be recruited from schools near other BEACON partner universities, helping to broaden the impact.

Avida-ED. We will build on the success of our Avida-ED digital evolution project (Pennock, Ofria, Lenski) by incorporating it into undergraduate biology courses throughout the partnership. The NSF external evaluator of Avida-ED wrote: "This is one of the most successful science education materials projects with which I am acquainted." We held an Avida-ED pedagogy workshop for faculty at our first BEACON Congress, and will repeat the workshop for new participants. BEACON members will develop new exercises and updates for Avida-ED that will

be available free of charge at the BEACON website, and also in collaboration with the National Evolutionary Synthesis Center (NESCent).

We will measure our progress towards this outcome using *pre- and post-program survey instruments* to assess the proportion of participants expressing interest in STEM careers. These surveys will be administered to three groups: university students, K-12 students, and the public, which will include museum visitors and parents of K-12 participants. Additionally, we will administer the same surveys to control groups made up of the same three categories of people who did not participate in BEACON programs. We will test for statistically significant differences within groups before and after participation, and for differences between participants and the control groups. Our goal is to generate a statistically significant increase in interest among the general public and (independently) among groups already self-selected for STEM interest within the first three years, and to continue significant improvement in the years following. We will also solicit *feedback from the External Advisory Committee* to get an objective assessment of our progress towards this goal.

EHRD Optimal Outcome 2: Multidisciplinary Ph.D. graduates and post-docs placed in faculty positions at rates approaching averages across engineering, computer science, and biology.

BEACON will provide multidisciplinary training for graduate students and post-docs, and work to increase their visibility in biology and computer science disciplines. BEACON graduate students will come from many departments, colleges and partner universities, each with their own disciplinary requirements and benchmarks. BEACON will not supersede these, but operate instead as an interdisciplinary enrichment program. We will develop an integrated sequence of new courses to prepare graduate students for this new multidisciplinary research. In the first semester, each student will take either computation for biologists or evolutionary biology for engineers and computer scientists. Each group will learn about evolutionary theory and application from the perspective of the other. An associated laboratory section will emphasize real-time evolution, *in silico* for biologists and using biological organisms for engineers and computer scientists. Shingleton and Kerr have developed real-time evolution laboratories with viruses, bacteria, and fungi, as well as *in silico* modeling. Such labs not only tangibly illustrate important evolutionary concepts, but also allow students to generate and test their own evolutionary hypotheses. In fall, 2010, we are piloting these courses with MSU biologists (Computational Science for Evolutionary Biologists, taught by C. Titus Brown; Evolutionary Biology for Non-Life Scientists, taught by Alex Shingleton) under the umbrella of the interdisciplinary program in Ecology, Evolutionary Biology & Behavior (EEBB). These courses are also offered simultaneously at one to three partner institutions using distance learning technology. We will then adapt the courses for use at other partner institutions. The second semester course (pilot MSU course, Spring 2011: Interdisciplinary Research Methods with Evolution in Action, taught by Charles Ofria and Ian Dworkin) will merge and redivide the groups into small, multidisciplinary teams. The course will include additional, common lectures and student groups will work on projects under the joint supervision of computer science and biology faculty. New graduate students will learn to use state-of-the-art tools to facilitate long-distance collaboration across partner institutions; by the third year, the same or similar courses will be delivered at all partner universities using these tools.

To facilitate the placement of a new generation of interdisciplinary scientists, BEACON must not

only train them but also promote them within traditional fields. We will accomplish this goal by nominating BEACON students and scientists for awards and leadership positions within traditional disciplines (evolutionary biology, computational biology, computer science, engineering, etc.), and also by organizing BEACON-sponsored workshops within society meetings (e.g., the annual Evolution meetings) and by hosting of society workshops/meetings at BEACON.

We will measure our progress towards this outcome by *the fraction of BEACON graduate students and post-docs receiving offers of faculty positions*. Our target is a 10% increase over the baseline fraction by October 2013, and a 20% increase over baseline fraction by October 2015.

EHRD Optimal Outcome 3: Exceed national norms for diversity at all levels in the Center. The initial senior personnel at the Center are diverse, including eighteen women (25%), eight African Americans (11%), and one Hispanic (1%). Many of the participants have a history of mentoring women and minority students, and the proportion of BEACON graduate students that are women or minorities is currently at the national norms for women and Hispanics, and exceeds the national norms for Black Non-Hispanic graduate students. Our goal is to increase the diversity at the Center above our starting baseline.

Our first activity will be to collect the baseline data for our diversity measure. We will collect data on the *numbers or percentages of faculty, post-docs, graduate students, undergraduate participants, and K-12 students that are from underrepresented demographic groups*, including women, underrepresented ethnic groups, and people with disabilities. Our target is to achieve a 5% increase by October 2013, and a 10% increase by October 2015 over a baseline set by current national STC statistics.

We will also develop a database to identify and track prospective graduate students, which will aid our efforts to increase the pool of women and minority participants.

We will solicit *feedback from the External Advisory Committee* to get an objective assessment of our progress towards this goal.

EHRD Optimal Outcome 4: Increased public literacy in evolution and the nature of science. Evolution is a basic property of life and a fundamental concept in science education, but it continues to be misunderstood and rejected by a majority of Americans. BEACON's focus on *evolution in action* and pragmatic applications of evolutionary science puts us in a unique position to overcome common misconceptions about evolution and to demonstrate both its scientific significance and its practical and economic utility.

BEACON will develop and test tools and materials for public education, such as the ongoing redevelopment of Avida-ED and museum exhibits, and make materials available to the public through websites and exhibits. We will track our *development of these materials* and how often these materials are *used or accessed on websites*. Our target is to ensure that hundreds of people will be exposed to BEACON material in the first three years of the program. By October 2015, our aim is to increase by 50% the number of people exposed to these materials annually. We will

also solicit *feedback from the External Advisory Committee* to get an objective assessment of our progress towards this goal.

The main barrier to this outcome is the fact that a large fraction of the American public does not understand the scientific basis underlying evolution. We hope to overcome this barrier by providing first-hand exposure to evolution in action, and demonstrating its practical utility in computing and engineering. The Educating Director and K-12 Outreach Coordinator will be the point of contact for this action, and we plan to have the initial offerings ready by August 2011. These materials will be updated and refined continuously.

LEADERSHIP AND MANAGEMENT PLAN

BEACON's **Leadership and Management goals** are to envision and enable the Center's mission through inclusive and transparent decision-making as well as effective and responsible implementation; to inspire Center participants; and to facilitate collaborative efforts within and beyond the Center.

L&M Optimal Outcome 1. Increase in cross-disciplinary research and education. Historically, true interdisciplinary research and education has been hampered by field-specific terminology, methodology, and traditions, but especially by a lack of communication. BEACON aims to overcome this barrier by facilitating communication among scientists, cross-training a new generation of graduate students, and encouraging the submission of interdisciplinary publications and proposals for funding.

We have developed four measures to monitor our progress with this outcome:

- *Number of paper/conference submissions by BEACON authors.* In the short term, we aim to have 20 submissions/year on interdisciplinary research by BEACON authors; in the long term we anticipate at least 100 accepted peer-reviewed publications by October 2015.
- *Number of new courses.* In the first year, three new interdisciplinary courses are being introduced at MSU. In the short term, we are aiming to offer joint/related courses at BEACON partner institutions. In the long term, our goal is for one additional course to be offered per year throughout BEACON.
- *Number of students enrolled in cross-disciplinary courses.* In the first year, there will be at least 10 students enrolled in such courses; in the short term the goal is 20 students across all five partner institutions. By October 2015, we expect to enroll a cumulative total of 100 students in cross-disciplinary courses.
- *Number of funding proposals submitted.* By October 2011, we expect at least five multi-disciplinary research proposals to be submitted to outside funding sources. Our goal is for this number to increase to 10 per year in the short term and 15 per year in the long term.

L&M Optimal Outcome 2. Increase in cross-institutional research and education. In addition to increasing collaboration across disciplines, BEACON will work to increase collaboration across the five partner institutions. The primary barrier to collaboration is the difficulties inherent in long-distance communication. The new BEACON Center is equipped with videoconference facilities, and BEACON will establish a culture of collaboration to encourage sharing of Center resources.

Progress towards this outcome will be measured in the following ways:

- *Number of paper/conference submissions.* In the short term, we aim to have 20 submissions/year by BEACON authors from multiple institutions; in the long term we anticipate at least 100 accepted peer-reviewed publications by October 2015.
- *Number of new courses.* In the first year, three new courses will be introduced at MSU. In the short term, we are aiming to offer joint/related courses at BEACON partner institutions. In the long term, our goal is for one additional course to be offered per year

- *Number of students in BEACON's cross-institutional, cross-disciplinary courses.* We aim to have 10 students enrolled in these courses in 2010-11, 20 students by 2012-13, and a cumulative total of 100 across 5 years.

L&M Optimal Outcome 3. Increase in new funding sources (cross-disciplinary and cross-institutional). BEACON research funds are intended as seed money to stimulate new thinking, encourage new interdisciplinary and inter-institutional research, and to generate pilot data for new proposals for external funding.

We will measure this outcome through *number of submissions*, with a goal of 10 proposals submitted per year, and *award dollars*, with a target of \$1 million by October 2011. The primary barrier to achieving this outcome is the *current* lack of communication across disciplines. One consequence of this barrier is that researchers are not aware of funding opportunities across disciplines. The BEACON Managing Director began guiding the development of tools and information to inform BEACON participants of opportunities across disciplines in August 2010. Additionally, sessions will be held at BEACON congresses to allow participants to brainstorm around research problems caused by a lack of communication; the first congress was held August 11-13, 2010 and resulted in over 40 documented new ideas for collaborative research. We will also *solicit feedback from the External Advisory Committee* to get an objective assessment of our progress towards this goal.

L&M Optimal Outcome 4. Increase in new participants. We expect that BEACON will attract new participants, and will use that increase as a measure of success. We will track *the number of faculty* (goal: 50% increase by October 2015), *post-docs* (goal: 100% increase), and *students* (goal: 50% increase in students involved in research). Persons who transition from one BEACON institution to another (for example, grad student becomes a postdoc at a different BEACON partner) will be counted as new personnel at the destination institution. Barriers may exist in the integration of new participants into the Center; thus, travel funding will be provided to potential participants by August 2011 to facilitate communication and integration. The Managing Director will be the point of contact for this action. Finally, to begin attracting potential participants, the Managing Director and Web Coordinator will begin working together immediately to put together press releases, web announcements, and blogs about center opportunities.

L&M Optimal Outcome 5. Effective support of Center operations by Management team. To determine whether Center participants feel the Management Team is effectively supporting Center operations, we will design a *survey* for participants about outcomes. This survey will use a Likert scale to measure whether participants agree or disagree with positive statements about the management team. The short-term goal is to receive an average rating of 4 on a 5-point scale (4 = agree, 5 = strongly agree), while the long-term goal is to make improvements over the baseline. Partners may feel isolated from Center operations, so the Managing Director will take the lead on planning and creating systems for tracking and submitting data for NSF reports. These systems should enable partners to participate in reporting data. Planning of these systems began in August 2010, with full implementation due by July 2011.

L&M Optimal Outcome 6. Center is perceived by NSF as exemplary. BEACON has the potential to become an exemplary STC. This outcome will be measured in two ways. Our first goal is to receive *renewal of NSF funding*; in the short term we will aim for approval of annual continuation and to receive positive feedback on our annual reports, while our long-term goal is renewal of the grant in 2015. Secondly, we will *track the number of public mentions made by NSF* about BEACON. Our goal is two significant mentions per year. The Director will take the lead in ensuring that NSF is continually kept informed of significant BEACON accomplishments.

KNOWLEDGE TRANSFER PLAN

Industry has made extensive use of biologically-inspired computing tools, including artificial neural nets, genetic algorithms, genetic programming, agent-based modeling, differential evolution, swarm computing and artificial immune systems. Sample areas of application of evolutionary tools include data mining and symbolic regression, control of dynamic systems, combinatorial optimization for 2- and 3-D layout, plant floor scheduling, vehicle routing, and single- and multi-objective optimization for product design. BEACON's **Knowledge Transfer goal** is to develop effective mechanisms and pathways to facilitate intellectual exchanges among BEACON partners and industrial affiliates that will support the sharing of knowledge and application of new technology. To facilitate technology exchange, we will establish an Industrial Affiliates Program (IAP) open to all companies.

KT Optimal Outcome 1. Signed Intellectual Property agreements with Industrial Affiliates.

Reaching an agreement on Intellectual Property (IP) contracts can be challenging, but BEACON participants have had previous success in this area, and can work to overcome company unwillingness and the burden on researchers by creating a boilerplate agreement to be used by our industrial affiliates and all of our Center participants. We will track our progress towards this outcome through the *number of IP agreements signed*. Our goal is to acquire five industrial affiliates by October 2011, and 10 industrial affiliates by October 2013.

KT Optimal Outcome 2. Industry-provided challenge problems (i.e. "Real World" problems) and data with feedback.

Instead of working with "toy problems," BEACON aims to work on real problems with real data provided by industry. Rather than working with proprietary data, we will ask our industry partners to provide "sanitized" data that will allow us to provide a real solution to a real problem, without requiring companies to disclose any proprietary information. We will measure our progress by the *number of instances that challenge problems, data, and feedback are received from industry partners*. Our goal is to receive two challenge problems from industry by October 2011, and five by October 2013. The Industrial Affiliate Coordinator will overcome industry partners' skepticism about the benefits of doing so by showing demonstrable results from prior collaborations as part of ongoing communication with industry.

KT Optimal Outcome 3. New collaborative research with industry partners. BEACON will conduct collaborative research with partners in industry, and submit papers for peer review. To overcome lack of resources and enable such research, we will identify potential funding sources for industry partners and possibly provide bridge funds in order to get these collaborations started. To demonstrate our success and attract new partners, we will create a webpage describing BEACON's industrial affiliations and the resulting projects.

We will measure our progress towards this outcome by the *number of publications*. Our target is the submission of at least two papers resulting from new collaborations with industry partners by October 2012, and at least five papers total submitted by October 2013. Additionally, we will track the *number and amount of joint grant proposals submitted*; our goal is one joint grant proposal between BEACON participants and industry partners to be submitted by October 2012, with at least three submitted by October 2013.

KT Optimal Outcome 4. Dissemination and use of BEACON tools and data. We will measure the *number of downloads* of BEACON tools/data (relative to baseline, with the target of a 10% increase in downloads by October 2011 and a 25% increase by October 2013), the number of citations (5% increase by October 2011, 10% increase by October 2013), number and amount of monetary gifts and contracts from industry (target of at least one monetary gift/contract by October 2011, and three by October 2013), and the number of internships and sponsoring companies (increase to at least three by October 2013). The current lack of sufficient documentation may inhibit success, so the Managing Director and the Web Coordinator will work to use BEACON resources to develop and maintain quality tools for documentation. A BEACON-wide committee will be established to facilitate packaging, managing, installing, and distributing evolutionary computation tools, including development guidelines, testing, version control, and documentation and examples. This committee will be established through the Education Director, the Managing Director, and the Web Coordinator by August 2011, with work ongoing. Prior to the August 2010 meeting, the Director and the Executive Committee began creating audio-visual material to briefly describe BEACON for visitors and potential industry partners. This introductory material is targeted for availability in January 2011.

KT Optimal Outcome 5. Spinoffs formed. Another optimal outcome of successful knowledge transfer to industry will be the formation of companies based on BEACON work (e.g. Red Cedar Technology, co-founded by Director Erik Goodman). Our measurement of success will be the *number of spinoffs formed*. The target is to form the initial spinoff(s) within the first 10 years of the Center's existence. Deciding when IP is suitable for commercialization and knowing how to get started are the main barriers to this goal, and BEACON can point people to appropriate resources (e.g. incubator office) and organize seminars. The initial seminars will be organized by August 2011 by the Industrial Affiliates Manager, the Managing Director, and the Director.

KT Optimal Outcome 6. Adoption of new BEACON-developed technology by industry. We will track the *number of instances of BEACON projects, processes and techniques adopted by industry*, with the target of adoption by three companies within five years. BEACON management and MSU and partner university resources must be marshaled to make this path desirable and available to BEACON faculty. The Management Team and BEACON Faculty will work with Industry Partners to demonstrate the benefits of adopting BEACON technologies and applying them in solution of their problems.

INTEGRATIVE RESEARCH PLAN

BEACON's **Integrative Research Goal** is to produce transformative, synergistic research through an inclusive collaborative culture that crosses disciplinary and institutional boundaries and is embedded throughout the Center's activities.

IR Optimal Outcome 1. New research collaborations and proposals. We will track the *number of interdisciplinary/multi-institutional research projects and publications*: by October 2012, each institution should have at least one new multi-institutional and maybe interdisciplinary collaboration; all institutions will have at least two publications in press and one submitted external proposal by October 2012. We will also track *service by faculty on doctoral research committees across disciplines and institutions*: by October 2011, each institution should have at least one multidisciplinary doctoral research committee associated with BEACON.

Building and coordinating research across geographically dispersed teams can be quite difficult. The Thrust Group and Cross-Cutting Theme Leaders will work continually to ensure more face-time and fewer emails among participants, to allocate travel funds for building relationships among participants, and to coordinate seminars between partners. Engaging graduate students and post-docs in interdisciplinary research can also be challenging, as these trainees tend to be closely connected with a single lab and unaware of training opportunities outside of their advisers' disciplines. BEACON students and post-docs will be required and encouraged to spend time acquiring skills in laboratories outside their disciplines. The Education Director and the Graduate/Post-doc Development Coordinator will play key roles in assisting these participants in finding opportunities.

An important tool in facilitating integrative research will be the Toolbox workshops, developed at the University of Idaho (<http://www.cals.uidaho.edu/toolbox/>). These workshops encourage researchers to communicate about the philosophical basis of scientific research, help collaborators identify and examine research assumptions, and are ultimately designed to increase mutual understanding in interdisciplinary research. The Toolbox team ran pilot workshops at the first BEACON Congress in August 2010, and the Executive Committee is currently developing plans to incorporate these workshops into BEACON training. The PI attended a planning conference organized by the ToolBox creators in October 2010, to further this objective.

IR Optimal Outcome 2. New paradigms for research in organic and digital domains. BEACON is pioneering the study of evolution in action using a model that joins biological evolution, digital evolution, and evolutionary applications, to their mutual benefit. In contrast, traditional "disciplinary" scientific meetings typically feature one of these areas, but not the others. BEACON will seek to organize meetings or new sessions that expose each of these audiences to the relevant work of the others.

We will measure our progress by tracking *the number of new sessions at scientific meetings or scientific meetings hosted at BEACON* (BEACON participants will submit proposals to scientific societies for workshops or symposia or to organize conferences related to Evolution in Action by October 2013), *the number of new journals and societies*, and *new or increased funding for*

biocomputational research. We will also solicit *feedback from the External Advisory Committee* to get an objective assessment of our progress towards this goal.

We will host the Artificial Life (“ALife”) conference at BEACON in August 2012, which will greatly increase BEACON’s visibility.

BEACON participants may show reluctance to spend time developing symposia for scientific meetings, but the Management Team and other BEACON faculty will ensure that assistance and support is provided by BEACON administration and by colleagues with shared or complementary interests. In the past, there has been a lack of effort to increase multi-disciplinary and multi-institutional publications; the Education Director and faculty participants will work to change the training expectations of grad students and post-docs to include new biocomputational curricula and rotations in laboratories outside their own disciplines.

IR Optimal Outcome 3. Increase in publications related to evolution in action. We will track the *number of BEACON faculty participants writing such publications and the number of non-self citations of their work.* By October 2011, our aim is for the *proportion* of multi-disciplinary and multi-institutional publications to have increased by 10%, and by 30% by October 2013. We will also measure *the number of science publications about Evolution in Action authored by researchers outside of BEACON* (we anticipate two or more appearances in the first three years), and the *links to BEACON* (by October 2013, at least one new multi-institutional/interdisciplinary result should be covered in high-visibility scientific reporting, e.g. the New York Times or the Discovery Channel).

Currently, the public media has a resistance to covering evolutionary topics. The Managing Director and the Education Director will work to emphasize the utility of studying evolution in action by facilitating communication with journalists, bloggers, TV shows, etc. Specifically, they will identify key press contacts and call them to inform them of the Center’s work, and provide them with material to help them “see” evolution in action. They will also host media and demonstration days. This will be an ongoing goal.

To increase the coverage of biocomputation in the media, the Director, Managing Director, and Education Director will identify key individuals and venues through which to pitch biocomputational evolution in the popular science media. “Informed” science journalists may be invited to BEACON congresses. Additionally, the Thrust Group Leaders will generate a list of journals where a special issue on BEACON would be strategic, as well as a list of editorial contacts. These lists will be ready by December 2010, and then will be updated continually.

IR Optimal Outcome 4. Development and dissemination of new curricula and resources to train multidisciplinary scientists in evolutionary biology and computational evolution. As part of BEACON’s mission, we will develop new materials for training multidisciplinary scientists, including upgrading Avida and Avida-ED. We will distribute these materials within and beyond BEACON.

To measure our progress, we will track the *number of requests for information.* Our target is for downloads of Avida/Avida-ED and/or other similar resources to increase by 10% by October

2011, and by 30% by October 2013. During 2010-2011, BEACON will develop a research-based course and modules. By October 2012, internal dissemination among BEACON partners will be achieved. From then until October 2015, the focus will be on external dissemination. We anticipate difficulties in committing resources (specifically, time) to developing new research-oriented curricula, and so the Education Director will work to ensure that all senior faculty participants contribute to the development of such curricula by August 2011. The Education Director will identify and create a repository of existing modules for such scientist training, and will work to develop a fully functional BEACON webpage with internal and external material by August 2011.

ETHICS PLAN

BEACON's **Ethics Goal** is to practice and promote ethical and responsible research by implementing cross-disciplinary and multi-institutional ethics programs that will inform and guide all participants of the Center.

Ethics Optimal Outcome 1. Center participants will understand shared and discipline-specific practices of Responsible Conduct of Research (RCR). The Graduate School at MSU currently uses a combination of online training and face-to-face mentoring through CAFFE (Center for Academic and Future Faculty Excellence). The partner universities will evaluate whether to use CAFFE for their own BEACON graduate students or whether to use their university's pre-existing online training modules. BEACON will track the *percent completion of online training courses and face-to-face mentoring by participants*. Our goal is for 75% of participants to complete online training courses and receive the required mentoring by August 2011, and 100% of participants of more than one year to complete online training courses and mentoring by October 2012. We will also track the resulting *change in frequency of ethics violations*. Year 1: Ethics violations will be less than 50% of baseline incidence; Year 3: Ethics violations will be less than 10% of baseline incidence.

We anticipate difficulties ensuring compliance with RCR training, as students and researchers may find the training requirements burdensome. The Managing Director will be responsible for implementing the following policies: BEACON will withhold any renewal/continuation funds until all team members of the applying team have completed RCR training; and new project staff must document completion of RCR training within three months of joining the project. These policies will begin at MSU in November 2010, and partner institutions must comply by August 2011. The Managing Director will also be responsible for tracking documentation of RCR compliance. BEACON will coordinate across institutions to either approve existing RCR courses at partner institutions, or to share MSU online RCR courses at the partner institutions.

Ethics Optimal Outcome 2. Center participants will embody general scientific norms/virtues, including objectivity, integrity, community, and transparency. We will measure *baseline and follow-up participation in a Scientific Virtues workshop*. By October 2011, we will study the feasibility of a Scientific Virtues workshop at an annual meeting. By October 2012, if feasible, we will run a pilot Scientific Virtues workshop. Currently, there is no schedule/timeline/process for developing this workshop. The Toolbox Project (<http://www.cals.uidaho.edu/toolbox/>) team from University of Idaho ran pilot training sessions at the August 2010 Congress, and Dr. Pennock and this team will determine the plausibility of implementing this workshop long-term, and the timeline for development. If the workshop is deemed feasible, it will be implemented in August 2011. Additionally, faculty, students, and post-docs will gather at a weekly BEACON meeting to discuss research progress and to have a social hour, every Friday at BEACON headquarters beginning October 29, 2010. The research discussion will rotate through four themes: Thrust Group 1, Thrust Group 2, Thrust Group 3, and BEACON-wide. Students and faculty at partner institutions will participate in the research discussions by videoconference and are encouraged to replicate the social hour at their own institutions. Such activity will encourage the development of a BEACON community.

Ethics Optimal Outcome 3. Respect for views and ideas “horizontally” and “vertically.”

BEACON will encourage collaboration and respect for ideas both “vertically” (that is, between people of different ranks) and “horizontally” (that is, across disciplines). This outcome will be measured by the *number of Toolbox seminars and trials* and by the *number of BEACON participants who get cross-disciplinary training*. In August 2010, the Leadership and EHRD teams participated in the Toolbox Workshop, and will use the results to generalize plans for Toolbox training. Pilot workshops were conducted for three multidisciplinary research teams at the BEACON Congress in August 2010. By October 2013, our goal is for greater than 50% of BEACON participants on multidisciplinary teams for more than one year to have participated in the expanded toolbox effort. The Toolbox team began putting together plans with the management team at the Congress in August 2010; this effort is coordinated by O’Rourke, Pennock, and the Director. The Director attended a conference organized by O’Rourke in October 2010, to plan next steps.

Ethics Optimal Outcome 4. Participants have access to shared resources and mechanisms to negotiate intellectual/philosophical differences. We will measure *the fraction of participants that are aware* of resources for such negotiation, using a survey. By October 2011, we aim to achieve 50% awareness of resources. By October 2013, our aim is to increase that awareness to 75%.

RESEARCH OUTPUT GOAL

BEACON's **research output goal** is to disseminate widely an increasing quantity of original and highly regarded scientific research on evolution in action.

Research Output Optimal Outcome 1. Original research by BEACON members on evolution in action will be prominent in the evolution literature. Our progress towards this goal will be measured by *the number of publications in peer-reviewed journals, presentations at scientific conferences, and grant proposals submitted*. Our goal in the short term is 150 publications, 150 conference presentations, and 40 grant proposals submitted per year in the first two years. By October 2015, our goal is to increase these numbers by 50%.

Research Output Optimal Outcome 2. BEACON research output will be perceived as making an important contribution to the literature. We will measure our progress towards this goal by soliciting *feedback from the External Advisory Committee*, who will provide an objective view of our progress.