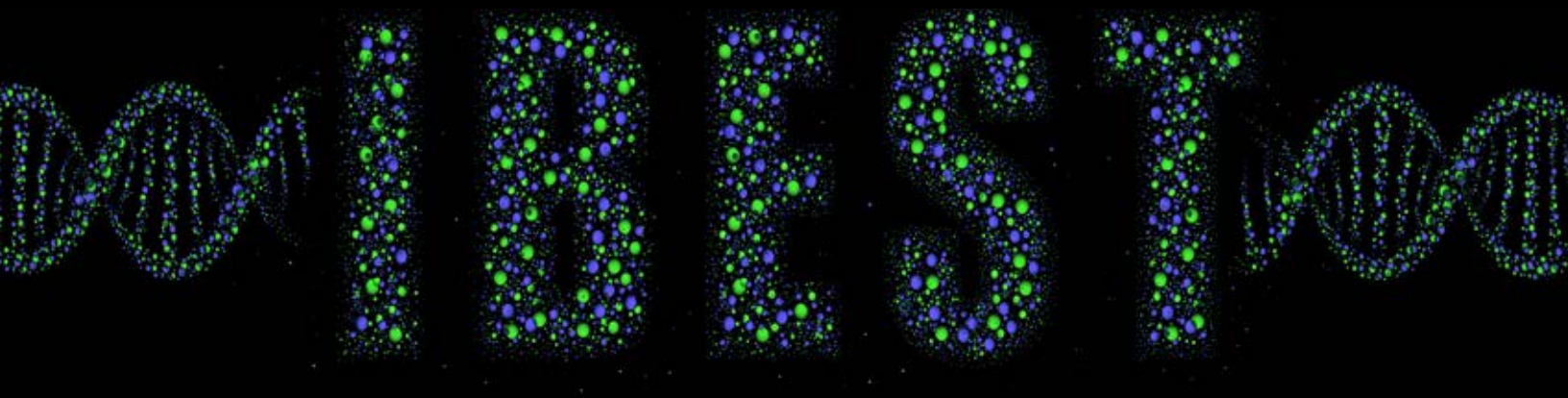

Institute for Bioinformatics and Evolutionary Studies
2013 Annual Report

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OVERVIEW

The Institute for Bioinformatics and Evolutionary Studies (IBEST) is at the heart of a 'signature research area' at the University of Idaho: real time evolution. The institute – one of only three at the University – was formed on July 1, 2011 following a competitive internal selection process. This prestigious designation is accompanied by significant institutional support in terms of funding, space and personnel that will provide for financial stability and a framework for IBEST longevity and the continued success of IBEST.

The institute was built on a financial foundation provided by the Center of Biomedical Research Excellence (COBRE) awards from the NIH-IDeA Program. Ongoing COBRE funding will enable us to implement a plan to transition the IBEST Genomics and Computational Resource Cores and administrative support capabilities to a point where they can be sustained by a combination of grant support and university funds. As a research institute IBEST will receive a portion of the earned overhead from new grants from research related to the theme of 'real time evolution' as well as direct institutional support that will primarily be used to subsidize core facility operations and for the salaries of administrative staff. This financing will allow us to broaden our scope to include research unrelated to human health.

Participants in IBEST are nested within a vibrant community of scientists in which intellectual interactions and collaborations are many and varied. We encourage and foster interdisciplinary collaborations that blend the expertise of evolutionary biologists, ecologists, molecular biologists, biochemists, biophysicists, mathematicians, statisticians, and computer scientists to examine the underpinnings of evolutionary biology. This constitutes an important competitive edge to investigators because we can address research questions that are intractable to scientists from a single discipline. This emphasis on interdisciplinary research and the research infrastructure we have built have proven to be important elements in the recruitment and retention of faculty, postdoctoral scientists and graduate students because comparable educational and research opportunities do not exist at many other institutions. This is leading to an expansion of research topics pertinent to real time evolution, which broadens the impact of IBEST on campus. In this way, IBEST is distinctive insofar as it is not a simple small set of individual investigators that work independently within a more or less well defined discipline. Instead, a network of collaborations has emerged that attracts participants because IBEST has created a collegial research culture that facilitates thinking outside the box, unselfish sharing of knowledge, expertise, and know how. In addition IBEST provides access to advanced research infrastructure that is made accessible by partnering with exceptionally qualified technical staff dedicated to facilitating the success of investigators and their research projects.

Mission

The mission of IBEST is to:

- Facilitate interdisciplinary research on evolutionary processes at different levels of biological complexity ranging from studies on the molecular processes of evolutionary change to the adaptation of organisms on a landscape level.
- Establish and nurture strategic collaborations or partnerships with research groups across the United States and abroad.
- Maintain and enhance the capabilities of core facilities for DNA sequence analysis, bioinformatics, and optical imaging and facilitate their use by investigators across campus.
- Promote graduate and undergraduate education in bioinformatics and computational biology at the University of Idaho.

This mission is wholly consistent with Goal 2 of the University's Strategic Plan. This plan calls for expanded opportunities for ongoing interactions among faculty, increased financial support for graduate and undergraduate interdisciplinary research, increased national and international visibility of the University's contributions to interdisciplinary scholarship, partnerships with other educational institutions to expand resources and expertise, the submission of large, interdisciplinary research proposals, and sustaining successful projects that are already funded.

Interdisciplinary research on real time evolution

Evolution is the process by which the inherited traits of organisms change through successive generations.

This encompasses changes in gene frequencies from one generation to the next in a population, the emergence of novel traits in organisms, and the descent of different species from a common ancestor. Studies of evolution provide insight to the history of life, patterns and the extent of biodiversity in different habitats, the mechanisms that underpin the emergence of disease, and much more. The extensive data sets collected by biologists in contemporary studies of natural and experimentally evolved populations enable mathematicians, statisticians, and computer scientists to quantify the probabilities of various evolutionary events and develop models that can subsequently be empirically evaluated and refined by biologists. Many of these studies are facilitated by recent advances in technologies for DNA sequencing and transcriptome analysis as well as the increased speed and capacity for data analysis. This allows investigators to explore evolutionary biology in ways that were never before possible. We seek to build upon the past successes of the Initiative for Bioinformatics and Evolutionary Studies – the predecessor of the institute – that were made possible by teaming computational and empirical scientists to exploit technological advances in interdisciplinary research on evolutionary processes.

There are three points worthy of being highlighted. The first is the increasing breadth and scope of research being done by IBEST investigators. While research on the molecular processes of evolutionary change and experimental evolution remain strong, there are increasing numbers of projects that focus on community and landscape-level evolutionary processes. We will continue to foster and encourage these because evolutionary processes play out at various levels of temporal and spatial complexity that range from speciation and adaptive evolution within populations at different spatial scales, interactions between populations that range from co-evolutionary processes to community-level ecological interactions, to broader scale within and between landscapes. The broader scope of research will bridge research between disciplines and lead to integration of concepts and principles from and even broader spectrum of disciplines. Second is to note the quality and quantity of research being done by IBEST investigators. While it is difficult capture this on paper, it is reflected in the statistics and metrics found in this report, and the increasing stature of IBEST in the broader research community. Third, there are efforts underway to recruit several new faculty whose research interests will align with those of other IBEST faculty

Administration

Dr. Larry Forney serves as the Director of IBEST and has overall responsibility for strategic planning, IBEST finances, oversight of IBEST Core facilities, supervision of administrative and core facility staff, coordination of research and education programs affiliated with IBEST, and responsibility for compliance with federal, state, and university policies and regulations (see Organization Chart on opposite page). The Research Oversight Team, the Internal Advisory Committee, and the External Advisory Committee advise him. Dr. Forney devotes 35% of his effort to being Director of IBEST and in this capacity he reports directly to the Vice-President for Research and Economic Development.

Research Oversight Team

The Research Oversight Team (ROT) serves as the executive board of IBEST and provides advice to the Director on the development of strategic plans and implementation of IBEST policies and procedures. In addition, ROT members work to ensure cross-communication among researchers, identify potential linkages between research projects, stimulate collaborations with investigators elsewhere, and mentor junior faculty in the development of their research programs. Drs. Foster, Sullivan and Wichman are currently members of the Research Oversight Team. These individuals devote 5% of their effort to service on ROT.

Key Administrative Staff

IBEST operates with a very modest administrative staff of three people. This is possible because they are consummate professionals who play a positive and critical role in the work of IBEST; demonstrate creativity, collegiality, and commitment to excellence; and work above and beyond normal job responsibilities. Each year the University of Idaho recognizes the contributions of outstanding individuals who exemplify these qualities. One such award is the Outstanding Team Award that was awarded in 2013 to Lisha Abendroth, Rob Lyon, Ann Norton, Rose Poulin, Whitney Schroeder, Matt Settles. These individuals simply make the success of IBEST possible. Their nomination letter expressed it well:

> "These individuals have worked as an "up tempo" team with a "can do, will do" attitude to launch IBEST as one of only three research institutes at the University of Idaho. They have successfully coupled teamwork, professionalism, and collaborative problem solving to exceptional dedication and determination and this has enabled the IBEST community to make significant progress."

This was, and remains, very true.

Rose Poulin, IBEST Business Manager. Rose joined the Institute for Bioinformatics and Evolutionary Studies in January 2012 after fifteen years of service to the University of Idaho College of Natural Resources. She is the resident management wizard[1] for all things business at IBEST. When she is not working with her magic wand on budgets or grant proposals submissions, miraculously completing unthinkable quantities of work on tight deadlines and calmly resolving seemingly catastrophic events[2], Rose enjoys flowers, gardening, travel and beautiful sunsets.

Lisha Abendroth, IBEST Program Coordinator. Every chicken coop needs a mother hen and Lisha has been ours since 2010. She is the dynamic energy force that keeps things happening at IBEST by being proactive, taking initiative and heading off unexpected problems before they arise. She coordinates key IBEST events such as the IBEST seminar series, the Inland Northwest Genomics Research Symposium and is the machine that moves the BCB graduate program. She keeps things fun at IBEST and never forgets to celebrate special occasions. Lisha is the mother of two young boys and spends all of her free time attending sporting events and happily performing the duties of her second full time job as a Domestic Goddess. She received a UI Outstanding Employee Award in 2012 in the Technical/Professional category with an overwhelming number of nominations from faculty, students and staff.

Whitney Schroeder, IBEST Administrative Assistant. Whitney joined the IBEST team as an Administrative Assistant in May 2012 and quickly became known as the IBEST Auxiliary Brain. As the Institute's Marketing and Communications Administrator, she is not only a writer and editor extraordinaire, but also the creative and artistic force behind the IBEST websites, brochures, the Clocktower on-line reporting system, and report designs. As the Scheduling Guru, she coordinates all things IBEST, keeps the Director mostly on-task (the deviations are not from a lack of trying), and insures that we are all exactly where we are supposed to be and mostly on time. Often she is the face of IBEST the world sees, and that's a blessing. We're searching far and wide for the limit to her talents but we haven't succeeded. On rare days off, Whitney is an adrenaline junkie who loves whitewater, running, and horseback riding on Moscow Mountain.

Former UI President Duane Nellis presenting the IBEST staff (absent Ann Norton and Matt Settles) with the Outstanding Team Award.

1
A wizard is a person that is aware of his or her surroundings and is able to control the environment with a mere thought. This person usually has a great deal of understanding of how things in this world operate, how people think and act, and how to communicate on all levels with people and animals. Wizards are spiritual in their own way. They are at peace with themselves, and they do not entertain immaturity. They also have a great deal of patience. Wizards are usually solitary because of how rare they are. If you know a Wizard, you will know that they are respectful, honorable, and compassionate and are a fountain of useful information. Feel fortunate if you happen to meet a true Wizard.

2
Being "Rosed" is an especially saccharine experience that makes unpleasant information or instructions almost welcome. Often it is accompanied by a time-delay in which a person only realizes later what has happened to them. Those of us who have experienced it many times realize it is a major reason why Rose is so effective

External Advisory Board

We continue to rely on our four-person External Advisory Committee (EAC) to shape our vision of IBEST, provide advice on administrative challenges, and to develop strategies to capitalize on new opportunities in our research. The EAC provides advice on both 'global' and 'local' issues. Global issues include potential strategic alliances with individuals and groups outside the University of Idaho and identifying emerging and important research opportunities. Local issues include plans for targeted recruitment of faculty with complementary expertise, how to maintain a well-balanced portfolio of research projects within IBEST, and one-on-one advice to IBEST investigators. In the past the last of these has occurred following oral or poster presentations by investigators or lab group members in which EAC members have shared their knowledge of emerging ideas and coached faculty regarding potential new lines of investigation. Typically these exchanges occur as part of in-depth discussions during our annual meeting with the EAC and are highly valued because members of our EAC are exemplary scientists with decades of experience and broad understanding of science related to IBEST.

The EAC consists of distinguished faculty with expertise in research fields allied to those in IBEST, and experience in the administration of interdisciplinary academic research programs. The faculty and students of IBEST meet with the EAC each fall semester. A written committee report is provided to the Vice-President for Research and Economic Development and the leadership of IBEST, included in our annual COBRE report to NIH, and shared with key administrators at the University of Idaho. The following individuals are the current members of the EAC:

Dr. Warren Ewens
Christopher H. Browne
Distinguished Professor of Biology
University of Pennsylvania
Fellow of the Royal Society

Dr. John Roth, Chair
Distinguished Professor
University of California-Davis
Member of the National Academy of Science

Dr. Bruce Levin
Samuel C. Dobbs Professor of Biology
Emory University
Member of the National Academy of Science

Dr. Michael Turelli, Vice-Chair
Distinguished Professor
University of California-Davis

Internal Advisory Committee

The Internal Advisory Committee (IAC) consists of four Deans or their designees who are selected by the Vice-President for Research and Economic Development. The Internal Advisory Committee meets at least annually with the IBEST Director, Research Oversight Team, and others as appropriate to review accomplishments, programs and policies, and to provide strategic advice on future opportunities and directions. Recommendations approved by majority vote of the IAC are forwarded in writing to the Vice-President for Research and Economic Development for further consideration. The following individuals are the current members of the IAC:

Dean Paul Joyce, College of Science, Chair
Dean John Folz, College of Agriculture and Life Sciences
Dean Kurt Pregitzer, College of Natural Resources
Dean Larry Stauffer, College of Engineering

CURRENT RESEARCH

Investigators can submit their research proposals to extramural agencies through IBEST if they are clearly related to the IBEST theme of 'real time evolution'. In doing so the administrative staff of IBEST does as much as possible to alleviate the administrative burden of proposal submission and grant award management faced by principal investigators. To do this they provide support to investigators in formulating budgets, completion of various proposal forms, and so forth, then they shepherd the proposal through the pre-award division of the UI Office of Sponsored Programs (OSP). When a proposal is funded, the administrative staff works with the post-award division of OSP to set up project budgets, oversees purchasing and accounting of expenditures, assists in the recruitment and appointment of personnel, advises PIs on budgetary issues that arise, and if necessary assists in the preparation of annual reports.

An accounting of the grant proposals submitted, grants received, and grant expenditures is provided in the tables in Appendix 1. More than $6.12 million in research funding was requested in FY12-13, which illustrates the high level of activity by faculty to secure extramural funding. Grants totaling $3.56 million were awarded during the same time period. Actual grant expenditures totaled $3.16 million, which was accompanied by $990,446 in earned F&A (indirect costs) to the university.

Major Research Initiatives

NIH Center of Biomedical Research Excellence (COBRE)

The Center of Biomedical Research Excellence (COBRE) for Research on Processes in Evolution at the University of Idaho has received $21,649,028 in funding over 10 years from the NIH IDeA program. This funding has been critical to the growth and success of IBEST and enabled us to conduct leading-edge interdisciplinary research in computational and evolutionary biology and to mentor early career faculty to develop nationally competitive, independently-funded research programs. Under COBRE, we also established and expanded the Computational Resources and Genomics Resources Core facilities at the University. These facilities provide a diverse array of advanced instrumentation and computational resources as well as technical support to investigators that are well beyond what could be supported by single investigators or small groups. The capabilities and services of the cores have come to be integral parts and essential resources for on-going and proposed research programs.

Having established sustainable research programs, we sought a third phase of COBRE funding to further strengthen our two research cores and transition them to sustainability in a way that will continue to support the research of IBEST in the future. This proposal was submitted in July 2011 and following peer-review we have been informed that the proposal will be funded beginning in February 2013 for a five-year period and bring an additional $5,096,846 in funding to the university.

The funding will support the Computational Resources Core through purchases of previously leased equipment, upgrades to networking infrastructure, expansion and improvement of data storage and backup capabilities, and hiring of an Assistant Systems Administrator and a Systems Programmer. Support to the Genomics Resources Core will be used to purchase instruments for short-read DNA sequencing, real-time PCR, and automation of emulsion PCR (emPCR). In addition, the funds will be used to hire bioinformatics analysts, pay portions of equipment service and maintenance agreements, and purchase materials needed for protocol development and evaluation. Reports on the operations of these cores can be found in later sections of this report.

This final phase of COBRE funding, along with institutional investments in IBEST as a strategic institute, will ensure that the core facilities become self-sustaining and that we maintain the momentum of the highly competitive research programs built during the first ten years of COBRE funding.

The COBRE has fundamentally changed the way biomedical research is done at the University of Idaho. This shift in culture is exemplified by the explosive increase in the use of next-generation sequencing and microarray technologies to explore biological diversity and evolutionary processes, and the ever-increasing demand for computational resources for biophysical studies, comparative genomics, phylogenetics, mathematical modeling, and statistical analyses. This expansion of activity has been driven by the coalescence of investigators around the scientific theme of the COBRE and ready access to the sophisticated technologies available through COBRE supported core facilities. The uses and applications of the core resources are becoming increasingly intertwined as sophisticated computer modeling informs empirical research, and data-rich genomic analyses and population genetics studies demand advanced computational capabilities for analyses. These interdisciplinary research projects are at the forefront of understanding fundamentals of host-pathogen interactions, adaptive evolution of organisms, and several other areas. Since its inception the COBRE has mentored early career faculty to research independence, attracted new faculty into biomedical research, awarded pilot and technology access grants, developed undergraduate and graduate education programs, and formed important partnerships with investigators at other institutions throughout the nation.

COBRE transition funding will also support three pilot grant programs for biomedical researchers: a Research Pilot Project Program, IBEST-INBRE Technology Access Grants, and Travel and Collaboration Grants. The first two programs will enable faculty to generate preliminary data that will make them more competitive for external funding, and the third will enable them to develop collaborations that support research.

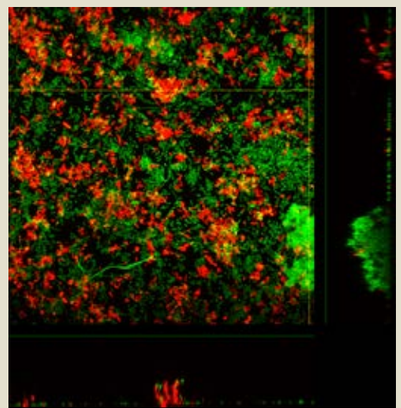
Persistence of Antibiotic Resistance Plasmids in Wound Biofilms

Eva Top, Professor, Biological Sciences
IBEST Core facility user

The Centers for Disease Control and Prevention just released a report entitled "Antibiotic resistance threats in the United Sates, 2013" that begins with "Antimicrobial resistance is one of our most serious health threats". A few years ago the Department of Defense encountered the growing problem of combat wounds caused by multi-drug resistant (MDR) bacterial pathogens in military hospitals. The DoD solicited proposals for research in this area and we were awarded $997,826 for our proposed research on the persistence of antibiotic resistance in biofilms.

The rapid spread among bacteria of plasmids that carry the genetic information responsible for MDR plays a critical role in this health crisis. Plasmids are mobile DNA molecules that replicate separately from the chromosome. Moreover, bacteria often form biofilms in wounds; slimy layers of bacteria that stick together and are even harder to eradicate than free-living cells. Since health care professionals are running out of antibiotic choices to treat MDR bacteria, we urgently need new therapies to prevent the future spread of multi-drug resistance. To do so, we first need to improve our insights into the mechanisms of plasmid persistence in biofilms.

Our project has three objectives: **(i)** Compare the persistence of MDR plasmids in populations of clinically relevant bacteria grown in biofilms and well-mixed liquid cultures; **(ii)** Compare the evolution of plasmid persistence in bacteria grown in biofilms and well-mixed liquids; **(iii)** Characterize evolutionary changes that occur during stabilization of plasmid-host pairs under both conditions. The initial findings indicate that MDR plasmids are retained longer in *Acinetobacter baumannii* biofilms than in mixed liquids; and that host-plasmid coevolution in liquid batch cultures results in rapid improvement of plasmid persistence in this species. Insights gained from our work will support research into novel drug therapies that are based on restricting the dissemination and stable replication of MDR plasmids.



Cells of the bacterium *Pseudomonas aeruginosa* in a biofilm. Cells with an antibiotic resistant plasmid fluoresce red. Upon transfer of the plasmid to a plasmid-free cell (green) the recipients fluoresce orange.

Why Idaho, why IBEST?

IBEST has been indispensable to this research since COBRE funding has allowed me to develop this research area at the University of Idaho, and IBEST core facilities are critical to the success of this project. For example, we use the flow cytometer in the IBEST OIC to determine the number of plasmid bearing fluorescent cells in samples, and use the resources of the GRC and CRC for high-throughput resequencing of many evolved bacterial genomes to identify mutations that allow a plasmid to be stably maintained in a novel bacterial host. Without the Core Directors who are always available to help and come up with new ideas, this grant would probably not have been written and certainly not have been funded.

Other major research initiatives

- Became a founding partner in BEACON, an NSF Science and Technology Center for the Study of Evolution in Action whose investigators approach evolution in an innovative way to bring biologists, computer scientists, and engineers together to study evolution as it happens and apply this knowledge to solve real-world problems. BEACON is headquartered at Michigan State University with partners at University of Idaho, North Carolina A&T State University, University of Texas at Austin, and University of Washington

- Teamed with investigators from the University of Maryland and other institutions as part of an NIH funded STD-Cooperative Research Center on the EcoPathogenomics of Chlamydial Reproductive Tract infection (EPCRTI). The objective is to discover essential correlates of chlamydial infection of the human reproductive tract, conduct fundamental studies aimed at vaccine development, and characterize pathogenic mechanisms at play in the complex, natural environment of the female genital tract to identify targets for chemotherapeutic interventions.

- Developed a unique interdisciplinary graduate program in Bioinformatics and Computational Biology that provides students a strong intellectual foundation in three focus areas: Computer Sciences, Biological Sciences, and Mathematical Sciences, and an opportunity for truly interdisciplinary research experience.

- Hosted the Inland Northwest Genomics Research Symposium a regional one-day genomics research symposium that will be held annually at the University of Idaho. The symposium provides the research community an opportunity to learn more about IBEST core facilities, potential uses of innovative new technologies and approaches to data analysis, increased awareness of leading edge research projects at both the local and national level, and insights into emerging technologies. In 2013 the symposium had 149 attendees.

Dr. Leroy Hood presenting at the 2013 Inland Northwest Genomics Resources Symposium.

Current and pending research funding

IBEST investigators have teamed to receive research funding from the NIH-COBRE program, other NIH programs, NSF, and other sources. Since many of these projects are interdisciplinary collaborations between biologists and mathematicians, statisticians or computer scientists, many projects require the resources of both COBRE-supported core facilities. This funding has led to a rapidly increasing number of interdisciplinary publications and presentations at scientific conferences (see Appendix 2), the recruitment of exceptional graduate students and postdoctoral scientists, and expansion of research infrastructure. This has been strengthened by incorporation of the interdisciplinary Bioinformatics and Computational Biology (BCB) graduate program under the IBEST umbrella.

We believe that the research programs of IBEST are becoming "autocatalytic" because faculty find themselves immersed in a supportive research environment that has both the intellectual and physical resources needed to conduct competitive biomedical research that is competitive for extramural funding.

Future Prospects

IBEST faculty continue to aggressively pursue extramural funding and they have been successful (see Appendix 1). This is a testament to the quality of the faculty, students and research staff affiliated with IBEST. However, the competition for research funding continues to grow and the percentage of grants funded of those submitted continues to decrease, lingering between 5-10% (depending on the program) at NSF and NIH. To continue our success we will have to seek opportunities such as those described below that well match the strengths of the interdisciplinary research done within IBEST and build on past successes. In addition we will have to build on the opportunities provided by the BEACON Science and Technology Center, the larger collaborative grants exemplified by the "Workflows for the Tree of Life" NSF grant, and the Cooperative Research Center on Sexually Transmitted Diseases focused on the ecogenomcis of chlamydia infections. In addition we continue to nurture the Bioinformatics and Computational Biology (BCB) graduate degree program, and the partnership with Washington State University for Undergraduate Biology and Mathematics research program. These programs are described in more detail elsewhere in this report.

NEW MAJOR RESEARCH INITIATIVES

The extensive data sets that biologists collect in contemporary studies of natural and experimentally evolved populations enable mathematicians, statisticians, and computer scientists to quantify the probabilities of various evolutionary events and develop predictive models. These can be used to identify key variables that affect the outcome of evolutionary events and explore untested possibilities, which can subsequently be empirically evaluated and refined by biologists. This creates a continual feedback loop between empiricists, computational scientists, and theoreticians that tightly integrates research among multiple disciplines. This integrative approach to evolutionary biology studies has become a hallmark of IBEST research programs that creates unique advantages in competition for extramural funding. These teams can continue to exploit technological advances in genomics and computational sciences that allow exploration of genetic and functional diversity at multiple levels from individual cells to communities and across various spatial scales. Our research capacity in this area can be sustained and further grown because of the business plans we have developed for the continued operation, renewal and expansion of the genomics and computational resources core facilities that are critical for these studies.

New Centers of Biomedical Research Excellence

The National Institutes of Health continues the Institutional Development Award (IDeA) program, which broadens the geographic distribution of NIH funding for biomedical and behavioral research. The program fosters health-related research and enhances the competitiveness of investigators at institutions located in states in which the aggregate success rate for applications to NIH has historically been low. The program also serves unique populations—such as rural and medically underserved communities—in these states. The IDeA program increases the competitiveness of investigators by supporting faculty development and research infrastructure enhancement at institutions in 23 states and Puerto Rico. The Centers of Biomedical Research Excellence (COBRE) program is a major component of the IDeA program. Funding from this program supports thematic, multidisciplinary centers that augment and strengthen institutional biomedical research capacity. Expanding and developing biomedical faculty research capability and enhancing research infrastructure, including the establishment of core facilities needed to carry out the objectives of a multidisciplinary, collaborative program, accomplish this. Each institution within a state can have three COBRE grants and proposals are due in February of each year.

Each COBRE must be led by an established biomedical research scientist with expertise central to the research

theme of the center, relevant peer-reviewed funding and has demonstrated administrative leadership and mentoring experience. Research done in the COBRE includes three to five individual research projects supervised by a single junior investigator that are independent but share a common thematic scientific focus. The center must identify at least one mentor for each junior investigator, and a development and mentoring plan addressing how the junior investigators will transition to competitive grant support from NIH institutes and centers or other Federal or non-Federal agencies or organizations.

In recent years our efforts to formulate ideas for new COBREs has been stymied by the lack of junior faculty whose research programs coalesce around a common scientific theme and they had not previously received NIH funding. This situation has changed in the past year as a result of newly recruited faculty that have been or are now being recruited to the University.

There are currently two cluster hires underway to hire five faculty in various disciplines. One of these is a cluster hire of three faculty in the Departments of Mathematics, Statistics, and Physics. This is a broad search, but the advertisement in Science read as follows:

> "The University has a strong commitment to interdisciplinary studies, particularly evolutionary and computational biology. Through the Institute for Bioinformatics and Evolutionary Studies (http://www.ibest.uidaho.edu/) the University has invested in high-level genomics, computing, imaging, and mass spectrometry facilities to support research in these areas. We seek motivated faculty who have demonstrated that they can work across disciplines and can collaborate broadly. Applicants must have a demonstrated interest in complex systems."

The review of applicants by an interdisciplinary search committee will begin November 1. The second cluster hire is just being organized. In this search we aim to recruit individuals with expertise in immunology and infectious diseases to the Department of Biological Sciences. An excerpt from an early draft of the advertisement reads as follows:

> "The University of Idaho seeks to expand our expertise in host-microbe interactions by hiring two Assistant Professors in the Department of Biological Sciences that have expertise in infectious diseases or immunology. These two talented researchers will join a vibrant research community and contribute to teaching in the WWAMI regional medical education program, a partnership between the University of Washington School of Medicine and the states of Washington, Wyoming, Alaska, Montana and Idaho. The University has a strong commitment to interdisciplinary studies, and has invested in high-level genomics, computing, imaging, and mass spectrometry facilities to support research in these areas. We are particularly interested in faculty who have demonstrated that they can work across disciplines and can collaborate broadly."

This search is being fast-tracked with the goal of completing the search before the end of spring semester 2014.

In addition to these new positions we have recruited Dr. Christine Parent to the Department of Biological Sciences. She is received her PhD from Simon Fraser University and completed a postdoc at the University of Texas and U.C.-Berkeley. She is interested in understanding the processes involved in adaptive radiation and how this influences the formation and maintenance of biodiversity. She is also interested in exploiting experimental and theoretical (modeling and simulation) approaches to investigate patterns of diversification on islands over larger time and spatial scales.

The recruitment of several junior faculty provides the pool of talented junior faculty needed to successfully compete for new COBRE grants, and plans are being made submit two proposals; one in 2014 and one in 2015.

2014: A new Center of Biomedical Research Excellence systems biology of infectious disease

The goal of this COBRE, which will be led by Dr. Holly Wichman, will be to build strength in the area of systems biology related to interactions that occur in infectious disease at all levels of organization, from molecular interactions through population level interactions. Our understanding of infectious diseases could be greatly advanced by focusing on the role of interactions in their within-host dynamics, emergence, spread, and control. There are at two reasons why interactions in infections disease might be a good unifying theme for a large center grant:

First, there are many potentially important interactions in infectious diseases. For example, disease severity is a function not only of virulence of the virus or bacteria, but also host factors like genetics, the innate and adaptive immune systems, age, gender, nutritional condition and individual's micro-biomes, environmental conditions, etc.

The second reason to focus on interactions is that the modeling approaches for studying interactions span many scales and this can help bring cohesion across projects and sub-projects. It turns out that models for studying species-species interactions in an ecological context are very similar to the models for studying epitasis at the genetic level. Experimental strategies that measure interactions at the genetic level will be closely related to the design one might use at the level of the organism.

2015: A new Center of Biomedical Research Excellence on host-microbe interactions

The goal of this COBRE, which will be led by Dr. Larry Forney, will be to build strength in the area on host-microbe interactions. However, the exact projects incorporated into this COBRE will depend on the interests and expertise of faculty that are now being recruited to the University. However, the theme will likely focus on the human microbiome with projects that might range from how perturbations of the human microbiome early in life (e.g., repeated use of antibiotics) affects the development of the innate immune system, adaptive evolution during host switching by pathogens, the development of ecological network models that can be used to assess risk to dysbiosis or infection, understanding drivers of genomic diversity in commensal bacterial, theoretical and empirical studies on community assembly (especially immediately post-partum), the role of the gut-brain axis in modifying behaviors, and others. The possibilities are almost endless.

This theme would complement research on the human microbiome that is already underway at the UI on the human vaginal microbiome, human breast milk, the infant gastrointestinal tract, inflammatory bowel disease, and dietary effects on intestinal neuropathy. Other work is being planned (e.g., see the Keck Foundation proposal below). Despite the keen interest on the human microbiome by the medical community, there are currently no COBREs focused on research in this area. Thus, it seems like a propitious time to develop a COBRE in this area.

Keck Foundation

Biomedical research is increasingly focusing on microbial symbiont communities – ecosystems of microbes that live in or on the human body and affect all aspects of human health. At the same time, traditional ecology has built a rich understanding of the ecosystem processes at a macro-scale, but micro- and macro- ecosystems differ in important ways such as differences in the patterns of energy flow, trophic structure, and horizontal gene transfer. Scientific research at these scales has been largely separate, but both fields could benefit immensely from insights gathered by the other.

We are developing plans to request funding from the Keck Foundation to determine how our understanding at the macro-scale can inform the micro-scale, and vice versa, by applying novel models of systems-level community structure and function data gathered with modern metagenomic and transcriptomic technology from ecosystems at both scales. We propose to develop a phylogenetically-based modeling framework for predicting community assembly and ecosystem function, and apply statistical techniques for distilling the key features of otherwise intractably complex models. We will apply these methods to empirical data from two pairs of micro- and macro-systems: (i) Swiss lake plankton communities and the human vaginal microbiome, both of which provide replicated time-course data on community composition and stability; and (ii) Idaho mountain plant communities and the salmond gut microbiome, where primary productivity and nutrient cycling are key aspects of ecosystem function. These studies will provide insight to whether microbial endosymbiont communities are ecosystems in a traditional ecological sense, and whether the tools and concepts developed in a macro-scale context can be fruitfully applied to the micro-scale and vice versa. Bridging this gap has the potential to transform both our biomedical understanding of microbial impacts on human health, and our basic ecological understanding of large-scale ecosystems.

The goals of this research will be to develop a model framework for predicting patterns of community assembly and ecosystem function. We will combine phylogenetic comparative methods that model the evolutionary history of taxa with network models of interactions among taxa in a community. The models will be applicable to the relationships and interactions of either species or genes and allow predictions of the emergent properties of community structure and function including the relative species abundance distributions; community stability, resistance, and resilience; and ecosystem productivity and metabolic nutrient cycling.

Members of the research team include the following IBEST faculty:

- Paul Hohenlohe (Principal Investigator; Asst. Professor, Biological Sciences and Statistics); theoretical and empirical evolutionary genomics
- Erkan Buzbas (Asst. Professor, Statistics); development of highly complex multivariate models.
- Larry Forney (Distinguished University Professor, Biological Sciences); microbial ecology of human vaginal microbiome and the salmonid gastrointestinal microbiome.

- James Foster (Professor, Biological Sciences) who has expertise in microbial metagenomics and bioinformatics.
- Luke Harmon (Assoc. Professor, Biological Sciences) is an expert in phylogenetic comparative methods for ecology and evolution.
- David Tank (Asst. Professor, Biological Sciences) is a plant systematist with expertise in phylogenetic methods.

Philosophically Informed Agent-Based Modeling and Its Applications

Bert Baumgaertner, Assistant Professor, Philosophy
New faculty member, fall 2013

A lot of mathematical modeling in the biological and social sciences focuses on the level of groups - details about the individuals that make up the population tend to be ignored or abstracted away. Another kind of modeling, called agent-based modeling, goes the other way. These models explicitly represent each individual or 'agent' of a population, and include details about how individuals interact with each other and with an environment. This is often referred to as a 'bottom-up' method because patterns at the population level emerge from the micro-level of the individuals.

We use agent-based models to increase our philosophical understanding of cutting edge research in the bioscience, we are looking at their use in simulating evolutionary processes related to bacteria. We are drawing specifically from an area where agent-based models are used to study how cells of the bacterium *Escherichia coli* seem to have 'coordinated' their rates of fimbriation (growing hair-like structures on the cell surface). The more of them that fimbriate, the more nutrients they get from their host, but only up to a point. If too many of them fimbriate, they trigger an immune response, which causes all of them to die. Researchers want to figure out how these bacteria manage to find the optimal level of getting lots of nutrient without going over the edge. To do that they use agent-based models to test out their ideas. What we are looking at are the background assumptions being made at both the population and individual levels of these models. What we are finding is that the models assume there can be interactions between properties of the population and features of individuals. What this means philosophically is that the agent-based models are being used to do research that includes multiple levels of organization. This is important because agent-based models tend to be regarded as 'bottom-up' models - models that proceed from only a lower level of organization.

In turn, this improved understanding of how the models are being used can inform how the scientists proceed in their research. For example, one methodological strategy that many scientists use is reduction. That is, they try to understand a phenomenon by breaking it down into organized parts that interact with one another. If that is the aim of the scientists, then one of the next steps they can take in their research is to revise their models so that it only includes information about individuals (and not information about the population, since that is what they are trying to reduce). Then by comparing their simulations with empirical data, they can test out whether their previous assumptions about the population were superfluous, or whether there is an important emergent property at the population level that cannot be reduced.

Why Idaho, why IBEST?

In the few short months that Bert has been at the Univeristy of Idaho, IBEST has already made an impact on his research, and promises to continue doing so. The IBEST lunches on Thursdays have provided numerous opportunities for Bert to interact with scientists from a broad range of disciplines, including biology, computer science, statistics, and mathematics. In fact, Bert gave a presentation at one of these lunches and has benefited from the feedback he received on the work discussed above. Perhaps even more important, the interactions that IBEST fosters have lead to several collaborations, as well as an invitaiton to participate as a co-investigator in a Center of Biomedical research Excellence (COBRE) proposal that is being coordinated by Holly Wichman. By being a member of this really great team, he benefits from mentoring opportunities, not to mention the philosophical benefits of directly working side by side with scientists. This experience is important for his continued development as a scientifically minded philosopher. Another example of a collaboration fostered by IBEST includes work that Bert has started to do with Steve Krone in the Department of Mathematics, that takes advantage of his expertise in opinion dynamics with issues related to climate change.

In addition to collaborating on these new projects, IBEST has also fostered a relationship that lets Bert extend his previous work. For example, he is working with Robert Heckendorn in computer science to extend the computational models of opinion dynamics Bert has already built. This collaboration is particularly important because it demonstrates how computational methods can be brought to bear on philosophical issues relating to knowledge and belief. Similarly, Bert is also benefiting from interactions with Erkan Buzbas in the Department of Statistics who happens to be a particularly philosophically minded scientist.

OTHER IBEST INITIATIVES

Technology Access Grant Program

IBEST has partnered with the Idaho-INBRE to administer and fund the Technology Access Grant Program. This is essentially a pilot grant program that provides funding to investigators so they can conduct exploratory studies using the technologies and technical support of the IBEST Genomics Resources Core, Computational Resources Core, and Optical Imaging Core. These grants are intended to help investigators produce preliminary or proof-of-concept data needed for competitive external proposals. The reasoning behind the program is that the high costs of using the technologies available in the core facilities may often constitute a 'barrier to entry' that preclude such studies. This is often compounded by the fact that many PIs are not familiar with the technologies available and may be reluctant to invest precious research dollars to evaluate new or alternative approaches that could nonetheless provide significant benefit to their research. This program is also seen as a way to stimulate interest in use of the core facilities over the longer term. Armed with preliminary data some fraction of the PIs awarded will go on to submit research proposals that (if funded) will exploit the fee-for-services of the cores and become a revenue source. Finally, these Technology Access Grants essentially subsidize the operations of the core facilities, since the grants are used to purchase services, and revenues generated flow into the service centers and a portion is used to pay staff salaries and instrument service contracts.

Proposals are accepted at anytime during the year and the review process is simplified and expedited. The amount of each award depends on the analyses done, but typically range from $5,000 to $10,000. Amounts up to $15,000 may be awarded if the need is justified based on project requirements. Applicants consult with the appropriate IBEST Core facility director prior to submitting their proposals to obtain advice on experimental design, sample preparation (when appropriate), specific information on the cost of analytical or computational services, and data analysis services. With advice from the core director the investigator determines the services required, but the core director alone determines the costs of these services in compliance with University of Idaho policy.

Application and Proposal Review Procedures

The application procedure is uncomplicated and the expedited review process typically requires 7-10 days. Applications consist of a cover letter that briefly states how the proposed research is related to human health or consistent with the real time evolution theme of IBEST or cell signaling, the scientific theme of INBRE. It must also include a specific plan for preparing research proposal(s) to secure extramural funding from NIH or other federal agencies and related to the Technology Access Grant request; and explain how the investigator will comply with the necessary university and NIH regulations concerning research on Human

Fly viruses!

From August 18th through 21st, the first meeting of the Drosophila – Virus Working Group was held at the University of Idaho. In attendance were Marta Wayne (University of Florida), Robert Unckless (Cornell University), Andrew Routh (Scripts Institute), Jim Bull (University of Texas) and the University of Idaho group consisting of Holly Wichman, Tanya Miura, Martina Ederer and two undergraduates, Justin Anast and Rebecca McKenzie. This meeting complements a BEACON-sponsored project to develop a new model system for experimental evolution of viruses in a eukaryotic system. The ideal system would have well-characterized genomes for both the host and its viruses; good genetic tools for both host and virus; a good understanding of the host immune system; a rapid generation time and large population size of the host. Drosophila and its viruses are an obvious choice, but surprisingly little work has been done to develop such a system. The goals of the Working Group are to establish a community with common research interests, to develop shared protocols and reagents for several Drosophila viruses, and to explore opportunities for collaboration. All attendees gave presentations with frequent interruptions and extensive discussion. Topics included: an overview of the project goals (Wichman), experimental evolution of Sigma virus (Wayne), FHV evolution in cell culture (Routh), viruses from natural populations of Drosophila (Unckless), viral co-evolution (Miura) and virulence evolution (Bull). We also had progress reports from the Idaho team. All attendees agreed that we should make this a regular event. The meeting was jointly sponsored by BEACON and COBRE.

Subjects, Animal Care and Use, or recombinant or infectious biological agents (if appropriate). The proposal itself is no more than two pages in length, and includes descriptions of the background and significance of the proposed research, experimental design, analytical or computational services, and data analysis services that are needed. Finally the proposal must contain a budget limited to $15,000 that includes a description of the specific services to be obtained. Budgets must include official quotes generated by the core facility director. Only costs incurred by the Core Facilities may be included. All other costs (i.e., sample collection and DNA or RNA extraction and purification) are borne by the investigator.

IBEST and INBRE require all recipients of a Technology Access Grant to cite this support in publications that emanate from this funding. For reporting purposes, IBEST and INBRE will also require information about all publications, presentations, and grant submissions that result from this funding.

The IBEST Research Oversight Team and an external reviewer (arranged by Idaho-INBRE) evaluate each proposal in terms of scientific merit and the potential to form the basis of a competitive proposal for extramural funding. Ranking will be based on (in descending order of importance): (i) potential to lead to new extramural funding from NIH or federal agencies or foundations, (ii) scientific merit, (iii) likelihood of publication, and (iv) the likelihood of future core facility usage. Preference is given to junior investigators who are developing their research program and established individuals who wish to extend their research program into a new area.

Four Technology Access Grant Awards have been made so far in 2013 (see Appendix 3).

Pilot Grant Program

We propose to implement a Research Pilot Project Program that has two major objectives: (a) to increase the number and success rate of grant applications submitted to NIH and other federal and private funding agencies by faculty at the University of Idaho for biomedically relevant research in the fields of computational and evolutionary biology, and (b) by doing so increase the usage of the core facilities as investigators conduct research that relies on the resources available in these cores. The Pilot Project Program is modeled after our current pilot project program, but with improvements proposed based on experience. It will consist of the following three types of grants, (i) Pilot Research Grants (maximum $75,000 each), which will fund research for one year (renewable to maximum two years); (ii) IBEST-INBRE Technology Access Grants (maximum $15,000 each), which will enable investigators to conduct pilot experiments using the technologies and technical support of the Genomics Resources Core and the Computational Resources Core; and (iii) Travel and Collaboration Grants (maximum $2,000 each), to promote or accelerate fruitful collaborations with researchers worldwide. The first two of these will allow faculty at the University of Idaho to gather preliminary data needed to prepare competitive grant applications to NIH and other funding agencies. The Grants will help recruit existing faculty members to areas of biomedically relevant research in computational and evolutionary biology, and also allow faculty already involved in biomedical research to initiate new research programs in these fields. In addition, the increased usage of core facilities that these pilot project programs will bring about (especially the) IBEST-INBRE Technology Access Grant Program) is an obvious benefit as we seek ways to expand the user base and move toward financially sustainable core facilities.

Travel and Collaborations Grant Program

The Travel and Collaborations Grant Program allows investigators to explore new collaborative research opportunities, spur the productivity of an existing collaboration, or facilitate the preparation of research grant proposals. These awards can also be used by IBEST faculty to attend scientific conferences that focus on topics outside of their area of research; this will add breadth to their expertise. For example, an evolutionary ecologist might attend a conference on bioinformatics, or a statistician might attend a conference on infectious diseases. The intent is to expose individuals to new fields of investigation in order to identify new opportunities and potential collaborators. The individuals who wish to avail themselves of this opportunity can request these funds in a brief letter to the Director that explains why the proposed travel would be beneficial. Following the conference the attendee will be required to make an oral presentation as a “science update” at an IBEST Lunch. These small grants will typically not exceed $2,000, and we expect to award three such grants each year each year. Dr. Holly Wichman received one such award in 2013

Novel Approaches to the Genomic Basis of Complex Traits

Paul Hohenlohe, Assistant Professor, Biological Sciences
IBEST Pilot Grant Recipient

Genes interact with each other through regulatory networks and in their physical proximity in the genome. Genomic technology now allows investigators to map genetic interaction networks at a fine scale, and generate whole-genome sequence information across individuals and populations, promising a fuller understanding of gene interactions. This project seeks to integrate this mechanistic understanding with a population-level view of complex trait evolution. The goal is to understand how selection and demographic factors influence genetic variation, when that variation exists in known contexts of regulatory networks and chromosomal linkage, and how complex phenotypes evolve as a result. The approach taken here differs from previous work using experimental microbial evolution to study the genetics of complex traits.

Experimental evolution has a rich history, but it has hitherto focused primarily on single populations under directional selection and the dynamics of new mutations. In contrast, the history of complex traits in humans and most other natural populations is one of large amounts of standing genetic variation, geographic population structure with gene flow, and environmental heterogeneity that exerts divergent selection. In this project we seek to more closely align experimental evolution conditions with this biological reality.

We are currently disentangling the different forms of quantitative genetic variance that result from the salt-glycerol tolerance network in yeast. In a laboratory yeast population that we created by crossing two divergent strains, we are measuring both additive and epistatic genetic variation for growth rate under different environmental conditions of salt and glycerol. By estimating genetic variance at multiple generations, we are able to directly study how the break-down of genetic combinations from the parental strains affects the distribution of phenotypes across the population. We have also used next-generation Illumina sequencing of recombinant spores to produce a fine-scale map of recombination rate variation across the genome, specific to this cross of yeast strains.

Using the same recombinant yeast crosses, we are also conducting experimental evolution of pairs of populations under divergent selection with gene flow, a critical scenario for understanding the structure of genetic variation across human populations. We are identifying the optimal parameters for experimental evolution in order to target the processes that have the strongest effect in shaping variation around genes under selection. Combined with the estimates of additive and epistatic variance described above, these experiments will provide a comprehensive picture of how genetic regulatory network architecture and the physical organization of the genome interact to produce genetic variation in complex traits across populations.

Why Idaho, why IBEST?

IBEST has played an integral role in supporting this research. Dr. Hohenlohe was recruited and funded by IBEST as new faculty. The vibrant and collaborative environment of IBEST has been critical in fostering this research program, including mentoring from senior faculty in all aspects of establishing a new laboratory and securing funding. This project has and will continue to rely on the equipment and staff of both the Genomics Resources Core (GRC) and the Computational Resources Core (CRC). For example, the Illumina MiSeq in the GRC provided rapid, in-house, next-generation sequencing for the recombination rate mapping described above. In a related project, a graduate student in the lab has made substantial use of the CRC for high-throughput simulation modeling of genetic regulatory networks and multivariate adaptation.

Support for establishing this research program also facilitated a new project, funded with a total of $2.25 million from the joint NIH-NSF program in Ecology and Evolution of Infectious Disease. With collaborators at other institutions in the U.S., the U.K., and Australia, we are investigating the genetics and epidemiology of Tasmanian devil facial tumor disease. This disease, one of only two known transmissible cancers in the animal world, poses a serious threat of extinction to the species

Our role will be to conduct next-generation sequencing of large numbers of samples from devil populations before and after infection, to identify genetic variation for traits related to disease susceptibility. These data will be combined with extensive field data and sequencing of tumor strains to build predictive epidemiological models of disease spread, better understand the genetic evolutionary processes of tumor and host, and to inform management of remaining wild populations of the devil.

Inland Northwest Genomics Research Symposium

This year the first annual Inland Northwest Genomics Research Symposium was held on the University of Idaho campus. The symposium was a one-day lecture format event that included concurrent presentations by IBEST core facility directors, technology representatives (e.g., Roche 454, Qiagen, Nimblegen), regional researchers, and national researchers who utilize the cores in their research projects. The symposium boasted a keynote address by Dr. Leroy Hood, a pioneer in the systems approach to biology and medicine and key developer of the DNA gene sequencer.

The objectives of the Symposium were to provide the University of Idaho research community an opportunity to learn more about IBEST core facilities, potential uses of newly introduced technologies and approaches to data analysis, increase awareness of leading edge research projects at both the local and national level, and to provide insights into emerging technologies. It provided opportunities for local researchers to interact with invited nationally renowned scholars and interact with technology representatives. The Symposium provided benefit to IBEST cores by increasing awareness of their capabilities and highlighting local research programs that utilize core services.

The symposium had 149 attendees. Of those 86 were from the University of Idaho, 26 were from Washington State University, with the remainder coming from further away (see map, and Appendix 4 for more details).

IBEST Seminar Program

The IBEST Seminar Series attracts top scientists from across the nation and world to the campus of the University of Idaho (see Appendix 5 for a listing of seminars in 2012). These seminars are used as a core element of a graduate seminar course (BCB 501), and are open to the public; often more than 50 people attend them. The persons invited typically spend two days on campus meeting one-on-one with faculty members or small groups of students and postdocs. These formal seminars and informal interactions expose IBEST personnel to the research interests, ideas, and expertise of leaders in the field. Over the years we have realized an indirect benefit of our seminar series in that invited speakers return to their home institutions and spread the word about the impressive work we are doing and the collegial and collaborative atmosphere within IBEST. This has bolstered our reputation in the scientific community and helped us recruit students. Often these seminar topics relate to a common theme. Past themes have included studies of adaptive evolution in natural populations, mathematical modeling of evolutionary processes, next-generation DNA sequencing technology and tools for the analysis of genomics datasets.

Program for Advanced Study of Evolution and Computational Biology

A specific objective of the University's 2011-2015 Strategic Plan is to enable faculty, student, and staff engagement in interdisciplinary scholarship and creative activity. The strategies to accomplish this include expanding opportunities for ongoing interactions among faculty, students, and staff to identify areas of common interest, and increasing support for graduate and undergraduate interdisciplinary research and creative activity.1

IBEST can significantly contribute to achieving this objective. To do so we must overcome the challenges we face by virtue of being at a small university with a limited number of faculty members that conduct research in areas pertinent to 'real-time evolution'. We propose to launch the Program for Advanced Study of Evolution and Computational Biology. This program will be designed to expand the intellectual capital of IBEST and opportunities for collaboration by increasing interactions with faculty at other institutions. The details of this program are being developed, and two proposals (that are not mutually exclusive) are under consideration. One strategy is to invite leading investigators in the field of evolutionary biology, computational biology, and bioinformatics to campus for extended visits of 1-4 weeks. This will permit them enough time to more deeply explore areas of common interest. Some individuals might be repeatedly invited. A second strategy would be to invite 4-6 individuals for an extended workshop in the summer (possibly 1-2 weeks in length) for brainstorming approaches to investigating key unanswered questions. The benefits of these strategies include the infusion of new ideas and expertise, lasting collaborations that generate funded research programs, new opportunities for the placement of undergraduate and graduate students, and a pipeline for the recruitment of the best graduate students and postdoctoral students from leading programs world-wide.

We envision that over time the Program for Advanced Study of Evolution and Computational Biology will create a 'virtual institute' with members located in various academic institutions and national laboratories throughout the U.S. and other countries by creating a web of collaborative partnerships. Technological advances in telecommunications have reduced geographic barriers to intensive and highly interactive research collaborations, and the University of Idaho is well-equipped with broadband Internet and the physical infrastructure (web-casting, video conferencing, etc.) to take advantage of opportunities for collaborations with leading scientists no matter where they are physically located. Importantly, the 'virtual institute' created by the Program for Advanced Study of Evolution and Computational Biology will grow the research expertise at the University of Idaho without actually having to recruit and hire faculty at the institution, overcoming a significant challenge.

Communication within IBEST

Communication in various forms—face to face and virtual meetings, conferences, email, vendor presentations, networking, and others—is required to stay abreast of new scientific opportunities, technologies, and methods that emerge in areas related to IBEST research programs. Over the course of the last ten years we have instituted additional successful mechanisms to increase awareness and to promote collegial interactions and support among IBEST researchers. These include the IBEST Lunch, the IBEST Annual Retreat, and an IBEST seminar program. We will continue these in the years ahead.

IBEST Lunch

The IBEST Lunch Series is the hidden key to our success. Each week at the same time and same place IBESTians – which include all individuals affiliated with IBEST including faculty, students, postdoctoral fellows and technicians – meet one hour for lunch. This occurs every week, all year long. These lunch meetings come in four basic flavors: (a) an IBEST investigator presents an informal "science update" on their work, (b) invited speakers present formal seminars; (c) core facility directors update IBESTians on new capabilities and changes to operating procedures; or (d) informal discussions occur at round tables of eight or more people. There is no doubt that this regular opportunity to meet fosters team-building and is highly effective as a means to communicate scientific advances, solve problems, and launch collaborations.

Affiliation with IBEST

There is no roster of faculty affiliated with IBEST and we have deliberately avoided creating one. To do so would require that we set some sort of criteria and a more or less arbitrary threshold for 'membership'. This exclusionary maneuver would do nothing to achieve our goal of facilitating research and education in the intentionally broad realm of 'real-time evolution'. The closest we have come to a membership is an email list-serve that is used to disseminate announcements of seminars, IBEST Lunch topics, student thesis defense dates, and the like.

Instead we espouse an open organizational structure where people can self-select and 'vote with their feet'. We extend offers to join us for IBEST Lunch with colleagues for free-ranging discussions that have often led to new collaborations, access to mentoring and advice, increased awareness of research programs related to their own, and the services and infrastructure available through IBEST Core Facilities. From there they can become 'regulars' and attend every week, choose to come occasionally, or decide that it is not worth their while. Ultimately, engaging with others and the programs of IBEST is by personal choice.

Drs Wichman, Joyce, Krone and Mendes-Soares enjoying IBEST Lunch.

Imaging Vision's First Synapse

Peter Fuerst, Assistant Professor, Biological Sciences
IBEST-INBRE Technology Access Grant Award Recipient ($8,460)

The combination of genetic techniques and high-resolution imaging has greatly advanced the field of neuroscience in the last decade. In this proposal we set out to identify the mechanism by which the cell signaling hub of our species' primary sense is organized. This work will advance our understanding this complex and facilitate the development of better treatments for visual dysfunction. This research will largely be conducted by undergraduate researchers and will give them an introduction to experimental neuroscience. Therefore funding of this proposal has facilitated University research, future granting efforts and undergraduate research endeavors.

Cell signaling involves the recognition of signals by cellular receptors that are translated into information through signal transduction. Within the nervous system, cell signaling is mediated by specialized signaling nodes, synapses, which convey information between neurons and their target effectors. Synapses are therefore the primary mechanism by which information is conveyed to and from the nervous system, and a better understanding of their developmental organization and function is essential to treat human disorders that involve synapse dysfunction. The cone synapse is responsible for gathering information for our sense of day-time color vision. The cone pedicle consists of the synaptic terminal of a cone photoreceptor and the dendrites of multiple bipolar and horizontal cells. The mechanism underlying organization of the cone synapse remains largely unknown yet a better understanding of this process is highly relevant to the treatment of retinal degenerative diseases in which degeneration of distinct components of the hub leave portions of functional visual circuitry intact but unconnected to active circuits. Therefore understanding mechanisms dictating how these hubs are formed will give us insight into how to best protect and regenerate the structures that give rise to vision.

Research towards understanding organization of the cone pedicle is done using a mouse model. The mouse has several advantages as a model in pursuing this research. The structure of the mouse eye is similar to that of the human eye, and unlike models such as the ground squirrel, in which most photoreceptors are cones, the mouse retina is composed of a small number of cones, which allows them to be visualized distinctly in space. Mice are also easy to work with and a large number of mutant and transgenic mouse lines are available with which to image specific cells types (i.e., transgenic mice expressing green fluorescent protein in a specific cell type) or in which certain genes or pathways are deficient (i.e., bax mutant mice lack developmental cell death in the nervous system allowing one to visualize how defective neural circuitry, that would otherwise not be easily detectable, develops). In this study our primary objective is to understand how the cone pedicle forms during development.

Why Idaho, why IBEST?

I have broad interests and was attracted to the Department of Biological Sciences by the diversity of research done by faculty members, the strength of the department in developmental neurobiology, the commitment of the UI to interdisciplinary research, and by the opportunity to be part of the WWAMI medical education program.

My research program is a good example of how IBEST can benefit faculty in research areas that are not directly aligned with its core research focus. IBEST has benefitted my research group in several ways. First, by partnering with INBRE, IBEST makes technology access grants available to researchers conducting studies in the field of cell signaling. These technology grants are incredibly helpful in developing new research directions and a number of my peers have benefitted greatly from them. The technology access grant my lab was given has permitted a number of undergraduate students to take part in very high-end neuroscience research. These studies have been very successful and will result in a number of publications with undergraduate authors. These studies will form framework for renewal of the NIH grant that is currently supporting our research team. Second the IBEST's imaging core, which my lab uses for these studies, is very helpful in providing the instrumentation to conduct our research. It is vital that this core is administratively overseen and it speaks to IBEST's commitment to the University community that they contribute this oversight. Third, IBEST supports extensive expertise in the fields of genomics and bioinformatics. This expertise allows researchers to partner with the IBEST staff to develop 'omic type approaches to our research questions. Finally the strength in evolution that the IBEST has helped to develop on this campus allows us to take novel approaches to our research that our peers in the field of neuroscience might not consider, and will make our research program more innovative than it would otherwise be. In sum IBEST has helped to develop a keystone signature area for the University of Idaho that benefits the entire academic community.

STRATEGIC PARTNERSHIPS

BEACON

The BEACON Center for the Study of Evolution in Action is an NSF Science and Technology Center founded in 2010 with the mission of illuminating and harnessing the power of evolution in action to advance science and technology and benefit society. NSF STCs are multi-institutional consortia funded for 5 years with a possible renewal to 10 years at $5M per year. BEACON is a consortium of universities led by Michigan State University, and including IBEST at the University of Idaho along with the University of Texas at Austin, the University of Washington, and North Carolina A&T State University. 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.

The key insight behind BEACON is that studying evolution as it happens, in both natural and digital domains, leads to transformative discoveries in both computing and biology. 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 promotes 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.

The overarching goal for BEACON is to unite biologists with computational researchers and other scientists and engineers to better understand fundamental evolutionary dynamics by combining theory and experimentation on actively evolving systems, both biological and computational. The Center helps researchers overcome disciplinary biases and limitations in order to explore the sophistication and universality of evolution. Supported studies use a wide range of natural organisms (from simple bacteria like *Escherichia coli*, to complex vertebrates, such as spotted hyena) coupled with novel evolutionary computation systems that allow both experimental and applied research. As a bridge between these domains, we also use digital organisms, which are self-replicating computer programs that undergo open-ended evolution. Such digital evolution systems are powerful research tools that make transparent the evolutionary process while giving researchers unparalleled control over their experiments.

BEACON promotes research on "Evolution in Action" that crosses academic areas (biological, artificial, engineering) and thematic boundaries (networks, communities, and behavior) by providing competitive research grants to participating institutions. Ideally the projects funded transcend geographic boundaries and engage investigators from multiple participating institutions.

Although evolutionary science is the fundamental explanatory principle in biology, it continues to be widely misunderstood and even rejected by a majority of Americans. BEACON provides extensive public outreach and undergraduate research and education to address this problem. Our strategy is to provide hands-on tools such as user-friendly digital evolution software whereby museum attendees, elementary school students, and the general public can observe and perform experiments on actively evolving systems. We combine these techniques with new evolution-in-action experiments on natural organisms to train our own students and post-docs as well as to improve education and outreach efforts through curricular development and educational tools.
For more information see: http://beaconcenter.org/

Highlights of BEACON activities in IBEST

To date, BEACON has provided $2,198,392 in competitive funding to IBEST, for 21 projects that have supported 26 faculty members, 21 graduate students, 14 postdocs, and 10 undergraduates. It has installed a Tandberg telecommunications room, which is used for weekly research meetings of all BEACON participants and for delivery of three MSU courses to UI BCB students, and for other ad hoc telecommunications needs (see Appendix 6).

IBEST personnel attend weekly research seminars conducted jointly with all BEACON institutions via the telecommunications facility. IBEST personnel present seminars regularly. IBEST personnel also attend the annual BEACON Congress in East Lansing, MI.

BEACON partnered with IBEST to sponsor a Fly Virus Meeting this year. We funded travel and lodging for visitors, and meals for attendees. This very successful meeting jumpstarted a project to develop fly models for real time evolution of viruses in the Wichman and Miura labs. We also extended funding this year for a BEACON funded project in the Heckendorn lab on robotics to explore evolutionary algorithms for disaster evacuation planning. Other research project titles are available on request.

IBEST BEACON actively promoted recruitment and retention of underrepresented groups, as well as K12 and

public outreach. Robert Heckendorn introduced BEACON to the new UI Diversity Office this year and has been meeting with Native American liaison faculty. Terry Soule and his lab developed The Ladybug Game as a tool for elementary school education, and are working with Julie Fisk at MSU to develop a museum kiosk version. Melissa Kjelvik is using The LadyBug Game in seminars for elementary school teachers. This summer Terry Soule taught a week-long coding camp for middle school girls on the Coeur d'Alene campus of UI. Paul Hohenlohe taught a data analysis workshop at the University of Puerto Rico. Prof. McGowan and his lab gave a presentation on "animal athletes" at the Palouse Discovery Science Center's annual Science Festival.

BEACON administrative staff

Dr. James A. Foster is the Partner Lead and represents the University of Idaho on the BEACON leadership team, and serves as a member of the BEACON Executive Committee. Dr. Robert Heckendorn represents the UI on the BEACON Diversity and Human Resource Development committee, Dr. Terrence Soule serves on the Education and Outreach committee, and Ms. Rose Poulin serves on the Financial Committee and implements student hires, purchases, and oversees local finances and reporting. BEACON provides salary support for all these personnel.

Strategic Analysis

BEACON's emphasis on "evolution in action" is naturally synergistic with IBEST's theme of "real time evolution." BEACON has been a significant opportunity for IBEST investigators by providing the resources and opportunities for collaboration that allow them to enhance and expand their research programs. IBEST faculty have regularly been awarded competitive BEACON funds at higher rates than other BEACON institutions and several BCB students have received BEACON support. Foster's position on the BEACON executive committee assures that IBEST will have a voice in BEACON decision-making.

The key weaknesses of BEACON have been our poor success at involving U.S. citizens from underrepresented groups. This is why Dr. Heckendorn joined the management team this year to increase or efforts in this area. Opportunities for improving BEACON's contribution to IBEST include: engaging more UI faculty with interests in applied evolution (e.g., conservation genetics and evolutionary engineering). Our success with BEACON provides the experience and credibility that might increase competitiveness for other inter-institutional program project grants.

Idaho IDeA Network of Biomedical Research Excellence

This COBRE and the Idaho IDeA Network of Biomedical Research Excellence (INBRE) Program work together closely and well. Both receive funding from Institutional Development Award (IDeA) Program of the National Center for Research Resources (NCRR) and both are based at the University of Idaho. The Idaho INBRE has the express purpose to increase Idaho's competitiveness for federal biomedical research funding by stimulating research at educational institutions, providing state-of-the-art research facilities, improving the caliber of research faculty, and by preparing the next generation of scientists. INBRE creates an environment in which Idahoans with the talent and desire to solve health problems may conduct research, and to do so has built an unprecedented network of research and educational collaborations among 10 institutions in Idaho.

COBRE scientists (including the PI of this proposal) serve on the INBRE Senior Advisory Research Committee (SARC), which specifically oversees the research activities of the Idaho INBRE Network. The SARC advises the INBRE Director on the distribution and use of resources related to research throughout Idaho, monitors mentoring relationships, reviews non-competing renewals of INBRE-funded investigators and oversees the appointment of new faculty participants. Similarly the scientific advisor of the COBRE Computational Resources Core (Foster) serves as the Director of the INBRE Bioinformatics Network. COBRE faculty members also mentor undergraduate students who are INBRE Summer Fellows and participate in the INBRE Summer Research Conference as invited speakers.

Conversely the Idaho INBRE Program has historically provided substantial funding to support the IBEST Bioinformatics Core (now named the IBEST Computational Resources Core) by providing funds for hardware, as well as salary support for the Core Director and a Bioinformatics Coordinator who tutors and assists novice users of the core in the use of bioinformatics applications. The Idaho INBRE Program has equipped the IBEST Computer Classroom with 25 Apple IMac computers for student use. The Classroom has been transformed into a state of the art facility with these high-end workstations, and high definition presentation and teleconferencing capabilities that are used for bioinformatics and computational training.

Here we propose to extend this partnership by co-funding the IBEST-INBRE Technology Access Grant Program. By doing so we accomplish two objectives: the first is providing investigators from ten institutions in Idaho access to state-of-the-art research facilities, and the second is 'priming the pump' to increase the number of core facility users over the longer term. IBEST and the Idaho INBRE program will jointly administer this program as described in the Research Pilot Project Program section of this proposal.

STRATEGIC REINVESTMENTS

During the past year a total of $485,231 in earned F&A funds have been strategically reinvested in research and research personnel related to the IBEST theme of 'real-time' evolution (see Appendix 7). Based on the premise that human resources are the most critical our priorities have been placed on funding new faculty salary and research program start-up funds ($155,437) and the support of BCB graduate students ($111,500). In addition we have committed to provide $165,000 in research program start-up funds to a new Biology Department faculty member in FY14-16. Other investments were made that provide broad benefit to IBEST affiliated faculty, their departments and colleges.

Institutional Support

The Office of Research and Economic Development (ORED) provided $210,000 in direct support of IBEST in FY2013. These funds have been primarily used to subsidize core facility operations and for the salaries of administrative staff.

ORED has also paid the salaries and fringe benefits of persons directing the Mass Spectrometry and the Optical Imagining Cores as well as the service contract costs on instruments in these facilities.

An additional $125,000 provided by ORED has largely been used to support the BCB graduate program (stipends, travel grants, office supplies).

Return of earned F&A to IBEST

In accordance with agreements that pre-date founding of the institute IBEST has received 25% of the F&A earned from expenditures from the COBRE grant, grants that were direct spin-offs from COBRE, and the BEACON grant. For FY11-12 this totaled $235,080. Of this, 30% was passed on to principal investigators and their co-investigators (20%), and their home departments (10%); see Appendix 8 for details. These funds were intended to help offset the real costs of research incurred by departments and investigators that are not or cannot be expensed to grants. We anticipate that a comparable distribution formula will be used in the future, but under the institute charter it can be adjusted as appropriate.

Under the terms of the institute charter IBEST received 50% of the F&A earned on expenditures from grants awarded after July 1, 2011 that are related to the theme of 'real time evolution'. The first fiscal year after founding of the institute (FY2012) ended on June 30, 2012 and the UI is in the final stages of distributing earned F&A to administrative units. The amount of earned F&A returned to IBEST for FY2012 was $236,766. The amount of earned F&A that IBEST will receive from grant expenditures in FY2013 has not been finalized, but is expected to be slightly more than $300,000.

Students walk to class outside the University of Idaho Life Science Building.

Influence of forest fragmentation on the genetic diversity and reproductive ecology of mid canopy tree species in the Caribbean lowlands of Costa Rica

Lisette Waits, Professor, Fish and Wildlife Sciences
IBEST-INBRE Technology Access Grant Award Recipient ($4,460)

We study the genetic diversity and gene flow patterns of mid-canopy tree species in the Caribbean lowlands of Costa Rica using different ages of trees (adults vs. seedlings) that represent before and after habitat fragmentation to evaluate changes over time. Identifying changes in genetic diversity and gene flow as a response to human-caused landscape change provides a powerful approach for understanding the interaction of plant dispersal systems, landscape, and microevolutionary processes, all of which provide insights relevant to evolutionary biology. In addition we compare the performance of two types of genetic markers (SNP and microsatellite loci) as tools for understanding patterns of gene flow. Later this information can be applied to many other systems to answer real time evolution questions. This represented the first application of SNP markers to address questions of genetic diversity and gene flow for tropical understory tree species.

Our short terms goal has been to identify genetic markers (SNPs and microsatellites) for two tropical forest understory tree species (*Symphonia globulifera* and *Quararibea bracteolosa*) using next generation sequencing technologies and technical support of the IBEST Genomics and Computational Resources Cores. These genetic markers will be used to characterize genetic diversity and structure and to infer contemporary and historic gene flow patterns for understory tree species across the San Juan La Selva biological corridor in northeastern Costa Rica.

Why Idaho, why IBEST?

IBEST-INBRE Technology Access Grant funding was used for exploratory analyses to identify genetic markers and type those markers within a subset of individuals. Data generated from this funding was used in multiple grant submissions to the National Science Foundation including the Coupled Human Natural Ecosystem panel (November 2012), a dissertation Improvement grant (November 2012), and a population ecology pre-proposal (January 2013). After receiving a NSF Coupled-Natural Human Ecosystems grant for $248,733, we plan to continue this work with the IBEST genomics resources core facility and staff. The IBEST group and facilities provide a unique opportunity for collaboration and training in new techniques that made this interdisciplinary research possible.

EDUCATION

BIOINFORMATICS AND COMPUTATIONAL BIOLOGY (BCB) GRADUATE PROGRAM

The BCB program plays a unique role within the university and worldwide because it prepares graduates who are at the forefront of a booming field, that of bioinformatics and computational biology. We expect the demand for competent graduates with a BCB degree to further increase over the coming decades. Indeed, there is no end in sight in the tremendously rapid growth of large genome sequence and other complex biological datasets generated by the ever-changing technologies that are becoming more cost-effective by the day. For example, it is relatively easy and inexpensive today to generate sequence data; the big question is how to use them in a way that will significantly advance our understanding of basic and applied biological concepts in a variety of areas of science, from evolutionary biology, environmental sciences, agriculture and aquaculture, to human health. The major challenge today for mathematicians, statisticians, computer scientists and biologists is to develop ingenious ways to analyze AND interpret the daunting data sets in ways that will not just incrementally increase our understanding, but allow big leaps forward.

To address this challenge investigators will need to be fluent in more than one disciplinary 'language', so they can communicate about the goals, discuss experimental design, data analysis options and technical limitations, and interpret the end result of a large data analysis exercise with all caveats in mind. A division of labor that hands off data sets from a biologist to a computer scientist or mathematician will not result in the same creative and appropriate solutions to organize, analyze, display and interpret data as a true collaboration among people who can speak the same language. Our unique contribution to this exciting area of science is to provide BCB students with a strong shared educational foundation and a required rotation in a research group outside their area of expertise. In combination with in-depth training in one specific area (Biological Sciences or Computer Sciences/Mathematics/Statistics) and conducting cutting edge research, this formula makes the students fluent enough to successfully interact with collaborators in the other disciplines and thus perform true interdisciplinary research.

BCB Vision Goals and Impact

Technological advances in the last two decades have created an avalanche of biological data, and this challenge will only increase in the immediate future. The manipulation, analysis and interpretation of large, complex datasets are thus central to much of biology. To address this challenge investigators commonly resort to a division of labor between data generation and data analysis. For example, biologists generate massive genomic datasets and bioinformaticians develop programs to organize, analyze and display data. However, it has become increasingly clear that success in science requires an integrative approach that unites experimental design, data collection, analysis and interpretation in a common framework. To meet this need the University of Idaho launched the Bioinformatics and Computational Biology (BCB) interdisciplinary graduate program in 2003. This program includes faculty with expertise in the biological sciences, mathematics, statistics, and computer science.

Instead of training students to be skilled in one specific area, we equip students with a set of quantitative tools and conceptual skills that prepare them to integrate theoretical and empirical research endeavors. Our approach focuses on critical thinking and problem solving that can be applied across the spectrum of challenges in biological research: from developing mathematical models, to organizing and analyzing data, to understanding issues of biological complexity. In addition, the BCB program requires research rotations and core courses that facilitate both "breadth" and "depth". The technology of the day is fleeting, but mastering the timeless principles that underlie solutions to biological problems enables scientists to tackle new questions and incorporate new technologies without reinvention.

With the advent of next generation sequencing and next generation bioinformatics approaches, we now require "next generation" scientists. Our vision is to bring together computational and empirical approaches in a unified, interdisciplinary graduate training program focused on evolutionary processes. Our primary goal is to train a new generation of scientists with the quantitative skills to merge empirical and theoretical approaches and have a profound impact on STEM (Science, Technology, Engineering and Mathematics) graduate training. The BCB approach to graduate education is a three-step process: building a strong foundation, gaining interdisciplinary breadth and depth, and conducting cutting edge research. A detailed description of our unique program can be found on our newly revamped webpage http://www.uidaho.edu/cogs/bcb.

Our performance demonstrates that we have delivered on the promise of a highly marketable transformative graduate education. The 20 PhD students who graduated between 2006-2013 have gone on to postdoctoral positions at prestigious institutions, including the University of Chicago, Yale University, and University of Michigan,

and from there many have secured tenure track faculty positions at institutions with higher national profiles than the University of Idaho.

BCB Alignment with the University Strategic Plan and UI Priorities

The mission of BCB directly mirrors Goal 1 of the University of Idaho Strategic plan. We have created an adaptable, integrative curriculum at the graduate level to prepare scientists for continued success in a rapidly changing world. We have developed co-curricular activities that are tightly integrated with our current program. This BCB program is also wholly consistent with Goal 2 of the Strategic Plan of the University in that it expands opportunities for ongoing interactions among students and faculty, increases financial support for graduate and undergraduate interdisciplinary research, enhances national and international visibility of the University's contributions to interdisciplinary scholarship, and builds partnerships with other educational institutions. It also is catalyst for the submission of other large, interdisciplinary research proposals and sustaining successful projects that are already funded. As part of BCB training, students partner with faculty to experience the rewards of outreach and engagement (Goal 3) and become members of a well-established research community that is vibrant and open, and that teaches and fosters ethical conduct in science (Goal 4).

Current Status of BCB Program and Budget Summary

We currently have nineteen students in the program. This year we have admitted four students into the BCB program and we expect five students to graduate in this academic year. BCB is a very cost-effective program with a small operations budget. This is possible because it partners with other departments for course delivery. For example, Mathematical Genetics (Math 563) is a course required of all BCB students and is offered by the Mathematics Department and cross-listed with Washington State University. Similarly, the BEACON program provides opportunities for online course delivery from Michigan State University and is available to our students without cost. Since BCB has no teaching assistantships it relies heavily on grant dollars to support its students. The small amount of fellowship funds provided by the University ($34,000) is strategically used to supplement existing funding, thus enabling faculty to support more students. Because the fellowship dollars are complimented by grant dollars it yields a much greater return on the small investment. IBEST currently provides $105,500 to support BCB students, while $137,500 is from NIH grant funds, and $58,000 is from NSF grant funds. The remainder of the student support consists of university funds, the USDA and various other funding sources, including industry. Last year and this year, only one student was supported on a teaching assistantship. Through strategic use of these funds we are able to provide students with attractive financial support that includes payment of a stipends, medical insurance, tuition, and fees.

BCB Student Tyler Hether takes a break from his work to smile for the camera.

NSF Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences

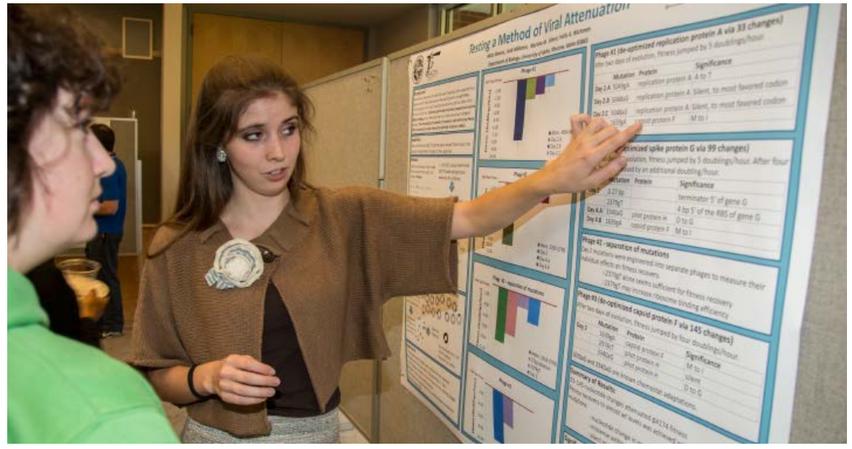
The University of Idaho (UI) and Washington State University (WSU) have established a collaborative program offering interdisciplinary training opportunities for undergraduates in mathematics and biology. The program capitalizes on extensive collaborations between mathematics and biology faculty at both institutions, providing undergraduates an educational experience well beyond what would be possible at either institution alone. IBEST has been central to developing many of the collaborations between math and biology faculty which are foundational to the success of the UBM program.

The goal of the Undergraduate Biology and Mathematics (UBM) program is to enhance undergraduate education and training at the intersection of the biological and mathematical sciences, and to better prepare undergraduate biology or mathematics students to pursue graduate study and careers in fields that integrate the mathematical and biological sciences. The central activity is mentoring teams of undergraduate students (usually two individuals) in long-term interdisciplinary research projects that expose students to contemporary mathematics and biology and address research questions with modern research tools and methods. Projects are therefore designed to be genuine research experiences rather than rehearsals of research methods. Projects also involve students from both mathematical and biological sciences and include joint mentorship by faculty in both fields. It is expected that projects will strengthen the research and education capacity, infrastructure, and culture of the partner institutions, the University of Idaho and Washington State University. To this end, projects should create models for education in the mathematical and biological sciences and influence the direction of academic programs for a broad range of students.

The UBM program has completed its third year. To date, UBM has funded 14 students (12 women and two men), and many of these students were enrolled in the program for two full years. This long-term research experience is designed to facilitate the realization of research objectives, and emphasis is placed on publication and presentation at scientific meetings. Students have presented their work at institutional (UI and WSU), regional (Pacific Northwest), and national scientific meetings, and in one case published a peer reviewed journal article. Other article submissions are currently in preparation.

Several students who have completed the program have enrolled in graduate programs in mathematical biology. Recruitment of students has been broad, particularly from the biological sciences. The program now includes mentors and students from three colleges at the UI (Agriculture, Science, Letters Arts and Social Sciences).

We have also begun institutionalizing the curricular aspects of the UBM program at the UI. A new degree track in Mathematical Biology has been approved in the Mathematics department. The new option is slated to go before the University Curriculum Committee this Fall, and should be placed in the 2014 University Catalog. The creation of this option in Mathematical Biology is consistent with the University of Idaho's strategic plan. In addition, the UBM program has proven to be a useful track of preparation for our graduate program in Bioinformatics and Computational Biology. We have recruited one of the UBM graduates (Ailene MacPherson) into the BCB program.



The Annual IBEST Science Expo is a great place for undergraduates like Katie Slavens to gain experience presenting their research.

CORE FACILITIES - OVERVIEW

Consultation and Mentoring

There are four campus-wide core facilities administered by IBEST. Two of these cores, the Computational Resources Core and the Genomics Resources Core have been built primarily with funds from the COBRE on evolutionary processes. This grant, now in its 11th year, has entered phase III that focuses on transitioning core facilities developed during Phases I and II to become self-sustaining by obtaining funds from other sources such as user fees and institutional support. Two other cores, the Optical Imaging Core and the Mass Spectroscopy Core, were established through other grants and have existed for many years on campus. These two have been heavily subsidized by the University and have not operated as fee-for-service core facilities. About one year ago administrative oversight of these cores and their operations was transferred to IBEST, which was tasked with developing and implementing plans to make these cores more cost effective and self-sustaining. By achieving this we could insure the continued operation of these cores and the stream of benefits they provide to University investigators. Accordingly we have worked to develop 5-year plans for these core facilities and here we report their progress in year 1 of this plan.

There are three critical elements of these plans. (1) Each core has had to critically assess the needs of investigators and match them to the capabilities of the cores. Said differently, we have had to conduct a cost-benefit analysis in which the costs and time associated with maintaining instruments is balanced against the size of the user base, prospects for increased usage, and possible benefits in terms of future extramural funding. (2) We have emphasized the need to differentiate ourselves from other core facilities by focusing on exceptional client service, tailoring what we do to match their needs, and filling their knowledge gaps. These strategies are explained more fully in each core facility report to follow. (3) Each core director has been expected to think strategically about cost-benefit issues, structuring their fees to be fair and affordable, devise ways to stay current in the face of advances in technologies, to be keenly aware of their balance sheet (expenses and revenues), and so forth. In other words they have been asked to take an entrepreneurial approach to managing their cores with the goal of insuring the relevance and long-term viability of their core.

Not your average core facilities

The IBEST core facility directors and other staff extensively informally consult with and mentor faculty, students and research staff. This is done on an ongoing basis. Unlike many core facilities at many other academic institutions we provide one-on-one consultation with investigators at the very earliest stages of project planning help them define their research objectives and identify resource needs. Advice is offered on study design, sample collection and processing, expected data needs, timelines, and desired outcomes. This blending of core facility expertise with that of project investigators eases access to core facility resources and facilitates their use. In this way core facility staff become a part of the research team, and not simply providers of services. This teaming throughout the entire project lifespan provides huge benefits to investigators providing them with “in-house” expertise in the application of advanced technologies on an “as needed” basis from core facility staff. This has proven to be critical for many IBEST investigators, particularly for biologists who lack expertise in the analysis of data from high-throughput genomics technologies yet wish to avail themselves of the advantages these technologies offer in terms of the breadth, depth, and detail of the studies that can be done.

We have seen that the core facilities can serve as “intellectual hubs” to stimulate cooperative research, solve common problems, and develop approaches that are widely applicable within IBEST. This occurs because IBEST cores provide research services and technical expertise to multiple IBEST investigators that have common needs although their research programs address quite different questions. As a result, core staff serves as a community resource by sharing information among IBEST investigators. This rapid dissemination of information allows IBEST investigators to conduct their research more efficiently and effectively without having to reinvent wheels, or trouble-shoot problems that have been solved by others. This collaborative approach avoids duplication of effort, increases cost effectiveness, and speeds progress. It also highlights the importance of having highly trained research scientists on the staff of these core facilities.

iLab Solutions for core facility management

The IBEST core facilities have contracted with iLab Solutions to develop and implement customized web-based software for core facility operation. This system will streamline core facility operations, boost efficiency and save money by freeing up the Core Director’s time to do the scientific work of the facility, ensure prompt billing and payment for services and provide a consistent online scheduling system for core users.

iLab Solutions is the global leader in providing web-based core facility management services to academic research institutions. The functionality includes request management, equipment reservation and usage tracking, project tracking, billing and invoicing, and reporting. iLab has extensive experience providing enterprise-level solutions at major research institutions, including integration with institutional financial systems and identity management systems. iLab’s dedicated implementation team and full customer support result in high adoption rates. Over 400 core facilities across more than 45 institutions in North America and Europe rely on iLab.

IBEST COMPUTATIONAL RESOURCES CORE (CRC)

Executive Summary

The Computational resources core (CRC) strives to be the premier computational facility for life sciences in the Pacific Northwest. Widely regarded as one of the best supporting facilities in the nation, we have many customers at the University of Idaho and throughout the United States who use our resources and expertise to facilitate scientific discovery through the use of technology. Our core provides an invaluable resource to the University of Idaho and supports tens of millions of dollars in federally funded projects that have led to hundreds of publications in high profile journals. In addition to the research benefits, the core is also widely used in the recruitment and retention of quality faculty, staff and students.

This business plan has been prepared for the purpose of gaining both financial and ideological support from the University of Idaho and the Institute for Bioinformatics and Evolutionary Studies for our vision for sustainability. Over the past 10 years, we have received significant financial support from the NIH Center of Biomedical Research Excellence (COBRE) program in the form of grants that have allowed us to build and maintain a multi-million dollar facility with state of the art equipment. With the assistance of the recently funded final phase of the COBRE grant and the support of IBEST and the University of Idaho, over the next few years we will transition our core to be a fully self-sustaining center.

Although we have been collecting fees for our services on a limited scale, adoption of our current sustainability model has been slowed due to reasons described later in this report (*See Services and Financial Projections*). We have identified the problems with the previous sustainability model and we propose a thorough revision. By implementing the new sustainability model and fee structures, an increased focus on marketing, and through financial support to cover portions of unbillable staff salaries we can make the transition to sustainability by 2017 and phase out federal support and reduce the requirement for university support.

The objective will be to perform a significant ramp up of our updated plan leading to complete sustainability by the end of fiscal year 2017. Our financial projections show that we will be able to pay down existing negative carry-forward balances and begin to make investments in personnel and equipment in 2018 provided we receive the continued support of the university and institute both financially and administratively.

Facility Description

The IBEST Computational Resources Core (CRC) serves as the computational backbone for evolutionary and computational biology research at the University of Idaho. It provides investigators with state of the art high performance computing and large data storage capacity for use in analyzing and managing large volumes of research data. Users of the core run jobs that may use hundreds of processors in parallel or large memory allocations and take weeks to complete. The CRC is explicitly designed to manage the complex computational and storage requirements for the IBEST researchers and core facilities with very high data reliability and availability. Unlike other external or commercial resources that are available, the CRC has a vested interest in the success of our researchers and students. We work closely with our

customers in a support role to ensure that they are effectively utilizing the systems.

Staff

The CRC brings years of experience and knowledge to bear on modern biological problems. The CRC staff often work directly with the researchers to optimize hardware and software to meet project requirements. They provide training and support at a level that is unique to Universities of our size. Three full time staff members manage the CRC infrastructure. They report to the Director and are advised by Dr. James Foster who serves as the Scientific Advisor. The core staff members are:

Core Director / Lead System Administrator

Mr. Robert Lyon is responsible for overseeing all core systems and personnel; design of high-performance computing and cloud computing systems, data storage systems; developing custom management tools and facility web sites; programming and scripting; consultation; core facility grant reporting, and strategic planning to meet the future needs of the facility and researchers.

System Administrator

Dr. Benjamin Oswald manages our monitoring systems; performs application installation and support; account management; support system management; HPC system support; teleconferencing; classroom scheduling and support; customer training; and technology/networking support for researchers and labs.

System Administrator

Mr. Brian Cheldelin is responsible for data center networking; HPC cluster operations; manages storage and backup systems; support system management; application installation and support; system monitoring; customer training; and technology/networking support for researchers and labs.

Faculty Science Advisor

Dr. James Foster contributes to assist in strategic planning efforts and provides technical advice on the hardware, software, and techniques that are most appropriate for the research done within IBEST. Dr. Foster was Director of the core from 1999, when he established it, until 2011 when he transferred administrative responsibility to Mr. Lyon.

Infrastructure

The CRC contains an advanced mix of high performance computing clusters, powerful servers and reliable data storage components as well as the knowledge and technical skills required to compress years of analysis into days. Our data center is a 1400 square foot facility in Room 124 in McClure Hall on the University of Idaho campus that has been specifically designed and renovated for the core. This room has a dedicated UPS with three-phase power and four-forced air handlers attached to redundant university chilled water systems. Optical fiber and copper interconnects provide high-speed data transfer for server and storage intercommunication and communication to the university backbone that is connected to the high-speed Internet 2 network. Our primary systems include the following:

High Performance Computing

CRC has two distinct compute clusters for research and the genomic data analyses. The main cluster provides 512 processor cores and over 2 terabytes of system memory, with 40Gb/s QDR Infiniband connections providing a fast, low latency data transmission. The second cluster, comprised of older equipment, accommodates processing during peak demand times. The CRC also maintains eight servers for applications that do not take advantage of the parallel cluster resources or require large amounts of shared memory for analyses such as genome assemblies, distance-based phylogenetic analyses and simulations. The most powerful servers in this group contains 256 times the system memory of a standard desktop (1TB or 1024GB) and is used heavily for hybrid sequence assembly of next-generation sequencing data.

Private Cloud Systems

The CRC has recently implemented services that allow us to leverage the flexibility of cloud computing. These specialized systems are customized to meet the specialized needs of investigators working in the rapidly expanding fields of bioinformatics and next-generation DNA sequence data analysis. Our cloud environment is based on standard virtualization practices and open source management tools that mimic the well-known companies such as Rackspace and Amazon. This specialized group of systems comprises components designed for commodity and high performance data processing.

Data Storage

The CRC maintains two kinds of data storage. The first of these include computational storage (198 TB gross) comprised of fast but more expensive disk arrays, and commodity storage on several control systems that are linked together through a special type of file system. The second is for long-term data archiving and backup storage (284 TB gross). This storage group comprises fast disk arrays for quick access to shared data, as well as commodity storage and tape robots for offsite storage of important data. In addition the core provides solutions to maintain data integrity and restoration.

Support Systems

The CRC maintains its own support infrastructure because this scale of core operations falls well outside that of the University of Idaho Information Technology and Enterprise Computing services. These include several servers for data storage and authentication of user accounts, domain name resolution, Internet address assignment, and secure connections to our private networks. The core also provides web and database services for online documentation and data sharing.

Education and Training

To support educational programs and inter-institutional collaborations we maintain several teleconferencing enabled conference rooms and a state of the art technology classroom. The classroom is used extensively by instructors from the College of Science and the College of Natural Resources, and has the only high definition projector and screen on the UI campus. The classroom also has teleconferencing system, which allows us to offer workshops and classes from and to collaborating institutions such as Michigan State University, University of Texas at Austin, University of Washington, and North Carolina Ag and Tech.

Services and Strategic Advantages

Without our services, the University would not be able to support the quality research in its signature area of real-time evolution that has brought national recognition to the Idaho. Spearheaded by IBEST, this signature area explores the complex realm of evolutionary processes that can have a major impact on human health, agriculture and ecological systems.

Unlike our commercial counterparts or the national computational facilities whose focus is only on providing computing resources, our services are geared towards the assisting the researcher. We provide the expert technological support and training as well as the state of the art equipment so researchers can focus on what they do best. Our researchers enjoy a close working relationship with our staff to help them efficiently use technology and turn years of research into days. This level of research provides the University with millions of dollars in federally funded projects and national recognition from hundreds of publications in high profile journals. University leaders will regularly use the core in the recruitment and retention of quality faculty, staff and students.

System Support

Provides system access on a shared basis. These services are billed on a fixed fee, which is a significant change in the means used to collect fees for services. The system support services include:

- Access to experienced personnel to guide researchers in optimal utilization of the CRC systems.
- Support in installing and configuring applications
- One account with access to all shared systems. Includes clusters, standalone systems, and cloud systems.
- Up to 2 TB of data storage and backup with more upon request.
- Initial training and access to workshops

Project Support

Some projects may require dedicated support beyond the general support services. The project support fees are billed by FTE and include:

- Dedicated system administrator support to provide custom scripting, application install.
- Installation of custom services specific to the project. Custom services will be retired at the end of the project.
- Multiple accounts.
- Reserved systems dedicated to specific projects.
- Data storage, archival and back up.

Custom Support

Billed hourly this service provides:

- Custom scripting
- Programming

We currently serve 174 faculty members, students and staff members both on and off campus and we are closely tied to the Genomics Resources Core in that we provide dedicated equipment and support for their data scientists.

Assessment of Capabilities

Strengths

- State of the art facility.
- Professional staff that work well with the researchers.
- Personnel changes and additions have resulted in a more balanced workload and complimenting abilities.

Weakness

- Full transition to sustainability has not started.
- We are vulnerable to the loss of critical knowledge as employees move on to higher paying jobs.
- The loss of a single employee would strain our ability to adequately provide exceptional services to our customers.

Opportunities

- We have seen an increase in external customers who are willing to pay for services. These customers can be used to 'fill in the gaps' and take some of the operational funding burden off of local customers.
- Work with UI departments and colleges to implement a 'volunteer' program to train students and populate a hiring pool used to find potential candidates for full time and temporary staff.
- Implementation of a new fee structure which will simplify billing, accounting and cover most of the personnel and part of our equipment costs.

Threats

- Difficulty in recruiting trained staff due to significantly lower than market salaries.
- Looming restrictions on the salaries that can be offered to new employees will be a significant barrier to hiring qualified employees.
- Pressure to keep up with leading edge technology in a tenuous funding climate.
- Cost recovery has the potential of eroding our current customer base.

Future direction

The field of genomic research is a rapidly growing field with shifting technology requirements. Over the next few years we will be focusing on improving our network and storage backbone since changes to these areas will increase overall performance and will be agnostic to shifting compute requirements.

To evaluate future additions to computed services and infrastructure, we will need to answer the following questions:

- What is the customer problem that needs to be solved?
- Do the customers recognize that they have the problem you are trying to solve?
- If someone were to solve the problem, would they be willing to pay for it?
- Would they be willing to purchase the service from us?
- Can we build a solution to the problem within time and budget constraints?

Once those initial questions have been answered and the service implemented, a group of early adopters will be identified and selected from customers with similar problems. Their experiences will determine whether or not the service has solved the initial problem. If the problem was not solved, the service will be immediately retired. Services that partially solve problems will be evaluated on a case-by-case basis to determine the impact of the discrepancies to the problem as a whole with the Director making the final decision.

Opportunities and Risks

In determining future expansion of our customer base, we expect that most growth will come as a result of customers who have used the facility. As such we make the following assumption in our marketing strategy: Since higher education is a primarily transient environment, the faculty, staff and students will recommend the facility as a low-cost and relevant place to perform their analysis to co-workers and research partners as they move on to new universities or industry jobs.

Most of our marketing efforts will be focused on ensuring that our current customers have an exceptional experience, so that they retain their accounts once they leave and convince others that we are the best choice for computational resources for the life sciences. To measure the effectiveness of our assumptions we will add additional questions to the account request forms which will query new users on how they have heard of the facility and who they heard the information from.

Other avenues for marketing will include:

- Regional and national core facility directories.
- Presentations and posters at regional and national conferences.
- Identifying and implementing partnerships with private industry in areas of mutual or complimenting interests.

Value Metrics

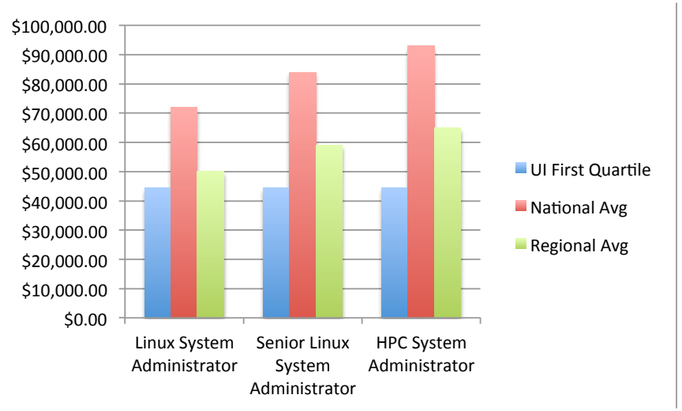
Determining the metrics for the evaluation of the overall value and growth of the core requires us to identify risks and make certain assumptions. The assumptions are flexible and will be challenged and updated on a regular basis to ensure that the original hypotheses are in line with what the raw data is telling us.

To determine whether the core facility and individual services are really delivering value to the customers the following assumptions will be made:

- The core facility is useful to the research community if the facility and/or individual staff members are named in publications; services are included in budgets for submitted grant proposals; and funded grants are received.
- Useful facilities will see an increase in the number of researchers requesting and maintaining paid long-term accounts for themselves and their students and staff.
- An individual and sustainable service that the facility provides is useful to the research community if we measure at least 60% usage across all customers.

To measure the value we will collect the appropriate data from reports, usage statistics and other sources. We will use the IBEST reporting tools as one metric. Other useful metrics include the raw accounting and usage data collected by the core. These will constitute 60% of data used to determine the success or failure of core services. Customer feedback surveys will make up the remaining 40%, their results will receive an overall weighting based on the number of respondents to minimize any bias effect from a vocal minority. The customer surveys will also act as a deciding factor when raw data is inconclusive or shows borderline usefulness. Services and systems that do not meet the usage criteria will be scheduled for decommissioning.

Identified Risks



Though the new fee structure is simpler to manage and maintain, it is not without risk. One benefit of the previous method, was that it allowed users to pick and choose the types of equipment they would use, which would make the plan flexible to meet the immediate needs of the customers. With the new plan users will spread the bulk of the costs for administering the bulk of our shared resources, which may push some of our moderate users to find other resources. When surveyed, 60% customers, when asked what they would do if the core was not available said that they would perform their analysis on laptops or desktops or purchase their own systems. These numbers show the potential for losing current customers if they see the cost/value ratio as being to low.

To ensure that we are able to retain as many of the current users as possible, a significant amount of lead up time will be given before the full transition has occurred. This time will allow the current customers to find sources of funding either from departmental support, existing grants or technology access grants provided by IBEST to incubate ideas that will lead to funded projects.

Potentially the greatest risk with the strategy will be our ability to retain and hire experienced staff. The sustainability plan depends on recruiting and maintaining experienced staff to ensure customer satisfaction. Changes to the University of Idaho's classification and compensation system being contemplated severely limited the quality and experience level of individuals who we can attract and hire. Recently the University has grouped all IT personnel into a single subjective category. This classification would only allow us to offer $44,000 (without special authorization) to incoming staff. To put this in perspective, a Computer Science graduate with no experience averages an annual salary of approximately $58,000 nationally and $53,000 regionally.

Experienced personnel will be even harder to recruit. Since IT staff experienced high performance computing, are rare to the region, we will need to attract talent nationally. An experienced system administrator who specializes in this type of computing will typically average $93,000 annually (See Appendix 10). Considering that the cost of living in Moscow is only 3.8% lower than the national average, a candidate would need to accept a cut in pay of almost 50% to accept a position at the University of Idaho. Even though there are many benefits to working in a small core facility, most individuals would not be able to accept those terms.

Although there are no current mechanisms available at the University level to mitigate or address this risk, there may be opportunities to lobby the administrators at the university to provide spousal placement at the university for the recruiting of staff with uncommon skill sets or create a series of exceptions to classification and compensation regulations in the same way they assist recruitment in Athletics.

Financial Projections

Financial Overview and Explanatory Narrative

According to our projections we will be able to reach sustainability by the end of the COBRE III grant in 2017. The ramp up to fee-based use of the systems will occur during FY13-14 and the analysis of unbilled paid services currently being used show that we will meet or exceed the estimated projections for 2014. The current figures represent a conservative estimate of a gradual adoption through non-subsidized sources, though we are currently in discussions with IBEST leadership to frontload all current users into the system through IBEST subsidies, which would significantly reduce the amount of time required for full sustainability.

Fee structure

Our proposed services are notable divergence from our previous plan referred to as the 'Feedback Lifecycle' model for sustainability. We found that implementation was slow for two main reasons:

- We made the assumption that any work that was being done on our current systems could easily be done in a private 'cloud' based environment and charged on a component basis.
- Hiring efforts to bring on new personnel to manage the cloud infrastructure and develop the required complex accounting tools were unsuccessful due to the University of Idaho's restrictions on compensation. Two very qualified candidates did not accept the position and went on to work at Boeing and a regional engineering firm who could pay significantly more.

Based on system support instead of component based billing, the new fee system will address several problems. It does not require the addition of a complex system accounting and reporting structure and gives our customers flexible access to all of our resources instead of a smaller subset. Lastly, a system support fee structure brings us more in line with NIH core facility costing guidelines since component based billing can be easily misconstrued as double billing for grant funded equipment. This cost recovery method also facilitates simple billing that can be ramped up over the third phase of COBRE and allow us to recover our operating costs while phasing out federal and University support. Our new services emphasize the integral role our expert staff plays in the success of our customers in addition to the flexibility and innovation that has made our facility invaluable to research at the University of Idaho.

Financial Projections

To meet future projections, stabilize net income and recover the current negative balance, we will need to forego increases in operating expenditures by maintaining existing staffing levels, not purchasing equipment on the service center budget, and increase sales revenue in fiscal years 2015-2017. We estimate that to meet projected revenue levels we will need to add the following:

- 2015 – Increase project support revenue by 5% and retain a total of 22 paid user accounts. This year marks the first positive yearly net income that will be applied to the outstanding negative carry forward balance.
- 2016 – Increase project support revenue by 5% and retain 55 paid user accounts. Negative carry-forward balance is cut in half.
- 2017 – Increase project support revenue by 5% and retain a total of 87 paid user accounts. First positive carry-forward balance.

Years 2018-2023 show a projected net gain of approximately $80,000 per year that will be used to hire new personnel or, if grant funding cannot be acquired, lease new equipment to replace aging equipment. Each year following will require a 4% increase in revenue to replace ORED funding and respond to cost of living increases for core staff. To remain sustainable we will need to maintain at least 100 paid accounts on our system, which represents approximately 50% of our current user base.

Funding Request

In FY2014 we will need to obtain $52,054 from IBEST to reach our goal of being sustainable in 2017. These funds will be used to pay a portion of full-time staff salaries including 30% effort of the core Director and 20% effort of the system administrators. This effort represents the time spent performing administrative duties, consulting, maintenance of technical expertise, and exploration of new technologies as described in the employee job descriptions. In addition to the full time staff, we also request a modest subsidy enabling us to fund temporary student help. As we become fully self sustainable, we will attempt to roll these costs into our user and project fees and decrease the amount by 4% annually for subsequent years. In addition to the support from IBEST, we will continue to require the state line funding that pays a portion of the director's salary and the remaining COBRE commitment.

IBEST GENOMICS RESOURCES CORE (GRC)

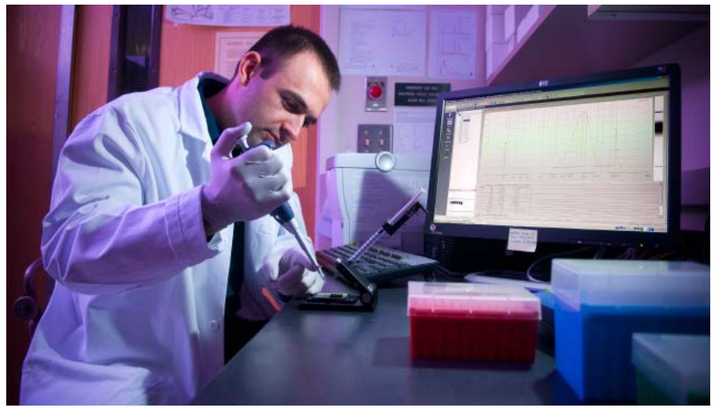
Executive Summary

The IBEST Genomics Resources Core (GRC) provides biomedical researchers at the University of Idaho access to the technology, experience, and expertise in molecular biology methods and bioinformatics needed to acquire, analyze, and visualize data generated from the high throughput technologies used in genomics research. The GRC staffs, operates and maintains over $2 million in state of the art equipment to offer services in nucleic acid sequencing, DNA microarrays, single nucleotide polymorphism genotyping, high throughput sample preparation and quality assurance and performs bioinformatic analysis of resulting data. The GRC fills the gaps in a research lab's expertise for molecular biological methods and bioinformatics expertise in the analysis of genomic data. This allows University of Idaho principle investigators to conduct genome scale research with little or no previous experience. The state of the art genomics facility and the "turnkey" approach to management has contributed to both recruitment and retention of University of Idaho faculty.

In FY2013 the total operating expenses of the GRC were $545,000 while income from all sources was $587,000. This resulted in a $42,000 surplus that was applied to pay down previous debt. Debt for the GRC now stands at $9,000. The GRC financial projection for FY2014 is a 5% growth in expenditures and 10% in service fees. In part this positive projection results from consolidating services and focusing on nucleic acid sequencing and high throughput sample preparation, while at the same time shutting down obsolete equipment and services After FY 2014 we expect GRC projects and service income to grow at a rate of 20% while expenditures grow at 5% in FY 2015 to FY 2018. The increased revenue relative to expenditures will be used to offset reductions in COBRE funding. The Core facility therefor requests support from IBEST to continue at the current level of 15% of operating cost, projected to be $80,000 in FY2014 and increasing by 5% thereafter.

Facility Description

The core facility offers investigators next-generation sequencing with Roche 454 FLX+ long read pyrosequencing technology and shorter read technology with Illumina MiSeq, targeted re-sequencing using the Fluidigm Access Array, and high-throughput sample preparation, quantitation and quality control. The core facility staff has expertise in both molecular biology and bioinformatics, enabling a holistic approach to genomics research that we refer to as the "Interdisciplinary Triangle of Collaboration". Communication between all key persons (principle investigator, molecular scientist, bioinformatician) begins early in the study planning and design, continues through data generation, interpretation, and visualization, and doesn't end until manuscript publication. By doing so the IBEST Genomics Resources Core is able to contribute as full members of productive research partnerships.



Daniel New working in the IBEST Genomics Lab.

From 2002 to 2009, the GRC had roughly $200,000 in capital equipment and no full time employees. But 2009 marked the beginning of significant growth. Since 2009, we have since acquired near $2 million in new capitol equipment, which has led to dramatic expansion of capabilities and services offered. With these new services, we have also added staff including: A Core Director who is also a bioinformatician, two lab technicians, and a bioinformatics scientist. Core facility staffs fill "knowledge gaps" in research groups. Some groups lack expertise in molecular biological methods, while others lack bioinformatics experience in the analysis of genomic data. To seamlessly bridge these gaps, we devised and implemented an innovative approach to Core Facility structure: the *Interdisciplinary Triangle of Collaboration*. This nontraditional and innovative approach to genomics core facility operations allows the GRC to become an extension of an investigator's laboratory, providing specialized technical expertise, experience, and equipment most single investigators do not have nor could afford or sustain on their own.

This approach to Core facility structure produces three significant outcomes: 1. *Research Productivity*: Biomedical investigators with interesting research questions overcome the "barriers to entry" posed by their own lack of expertise in genomics and bioinformatics, enabling them to formulate and pursue research questions as they never could working in isolation. 2. *Intellectual Capacity*: Core staff work in a more intellectually stimulating environment, one in which they share knowledge with and learn from researchers, and their work contributes to projects with meaningful biomedical relevance; and 3. *Core sustainability*: This approach attracts more researchers to use the facility, which increases revenue from service fees. These three outcomes are mutually beneficial and create a positive feedback loop that has fundamentally altered the course of research programs.

Staff

The IBEST Genomics Resources Core facility operates as a "turnkey" facility in which project design, sample preparation, data generation, and data analysis are integrated within a single core. Therefore the GRC has two laboratories, the "wet" lab and the "dry" lab and the GRC Director oversees both. Professionals with molecular biology expertise who analyze the samples provided by investigators staff the "wet" laboratory. The "dry" laboratory is staffed by bioinformatic scientists and is where data generated in the "wet" is analyzed, summarized and interpreted. A significant amount of communication and coordination occurs between the "wet" and "dry" laboratories.

Core Director

Dr. Matthew L Settles received his PhD in Bioinformatics and Computational Biology from the University of Idaho. In addition he has a M.S. in computer science from the University of Idaho and B.S. degree in electrical engineering from the University of Portland. Prior to joining IBEST, Dr. Settles was manager of the Bioinformatics Core facility at Washington State University. His experience and background is focused on the computational manipulation and interpretation of very large datasets, often by innovative uses of and development of new bioinformatics tools.

Data Scientist

Mr. Sam Hunter received a M.S in Statistics form the University of Idaho and a dual B.S. in Computer Science and Biology from the College of Idaho. Mr. Hunter is also currently a Ph.D. Candidate in Bioinformatics and Computational Biology at the University of Idaho with a completion date targeted for Spring 2014. Mr. Hunter is responsible for bioinformatic and analysis of genomics data.

Molecular Biology Scientists

Mr. Daniel New earned a B.S. degree in Microbiology, Molecular Biology and Biochemistry from the University of Idaho. Prior to joining the GRC, Mr. New was a Research Associate at Washington State University in the College of Veterinary Medicine where he gained extensive experience with various molecular biological assays and high throughput technologies.

Ms. Tamara Max earned a M.S degree in Biology at Northern Arizona University and a B.S. degree in Environmental Science from the University of New Mexico. Before joining IBEST she was the laboratory manager for the Center for Environmental Genetics and Genomics at Northern Arizona University. Ms. Max is currently 0.4 FTE in the Core facility and has extensive experience in various molecular biological assays and high throughput technologies.

Infrastructure

The IBEST Genomics Resources Core facility is a state of the art genomics core facility that researchers can use to study biological processes at the genome scale. The GRC has the equipment necessary to generate data through a range of applications including DNA sequencing, DNA microarrays, single nucleotide polymorphism (SNP) genotyping, high throughput sample preparation and quality assurance, and computational resources described below. In addition, there are wet lab benches, biosafety cabinets, thermocyclers, centrifuges, microcentrifuges, freezers, refrigerators, and computational resources. The GRC occupies approximately 1530 sq. feet of laboratory space in Gibb Hall 242, 775 sq. feet of laboratory space in Gibb Hall 116, and approximately 300 sq. feet of office space in Life Sciences South at the University of Idaho main campus in Moscow, Idaho. The Core facility infrastructure is described in more detail below.

- *Roche 454 Genome Sequencer:* The Genome Sequencer FLX+ Instrument, powered by GS FLX Titanium series reagents, features a groundbreaking combination of long reads (up to 800 bp read lengths), exceptional accuracy (consensus accuracy 99.997% at 15x coverage) and throughput (~600 Mb).
- *Illumina MiSeq:* The MiSeq offers capabilities of up to 2x300bp paired-end sequences (600bp total per read) and 14-16Gb per run.

- *Fluidigm Access Array System:* The Access Array System enables the user to enrich multiple unique targets (such as exons) from a large number of samples, all at one time using micro-fluidics and PCR.
- *IntegenX Apollo 324 for NGS Library Preparation:* The Apollo 324 is a bench top system that automates next-generation sequence library preparation workflows (Illumina TruSeq/Nextera libraries and Roche 454 libraries) by using bead technology to execute high-performance isolation and purification.
- *Roche Nimblegen DNA Microarray Instrumentation:* Two 4-Bay Maui Hybridization Systems, a 12-bay Maui Wash Station and a Roche MS200 microarray slide scanner.
- *Illumina BeadXpress:* This system supports the development of both single- and two-color assays, across genotyping, methylation, and protein-based assays. The GoldenGate Genotyping Assay is available in 48-384 (SNPs) multiplex kits for the VeraCode platform, providing a flexible customized solution for mid-level multiplexed assays.
- *High Throughput Sample Preparation and Quality Assurance:* Qiagen QIASymphony SP, Qiagen QIAgility, Qiagen QIACube, Qiagen QIAxcel, Molecular Devices SpectraMax Paradigm with absorbance (ABS) detection and the tunable wavelength (TUNE) detection cartridges, Agilent 2100 Bioanalyzer, Molecular Devices Gemini XPS microplate reader, Turner TBS-380, Diagenode Bioruptor Plus (UCD-300), Boreal Genomics Aurora System, BioRad T100 PCR instrument.

The Genomics Resources Core facility utilizes the IBEST Computational Resources Core facility for nearly all its computational, information technology (IT) and system administration needs.

Services and Strategic Advantages

From the perspective of our most common client type, an academic principle investigator, the GRC service is actually *genomics research management*. The Core facility provides services in three phases of genomic research: project planning and consultation, genomics data generation, and data analysis and bioinformatics.

Project Planning and Consultation

Core facility staff consult with investigators to discuss project aims and expectations, experimental design, appropriate and best use of technology, sample needs and quality issues, and data analysis needs. During consultation a project timeline is typically formed and expected costs are discussed. Having these discussions early in a project provide an opportunity for Core personnel to offer their expertise, advice, and assistance to enhance the proposed project and sidestep potential problems.

Consultation is a service that the Core facility provides free of charge. Providing this service free of charge ensures that researchers come to the GRC to thoroughly plan and flesh out their proposed work early in the process.

Genomics Data Generation

The GRC operates and maintains equipment to offer services that generate genome scale data in the following categories:

- *Nucleic Acid Sequencing*: DNA sequencing has become an indispensible tool for basic biological research, biomedical research, diagnostics and biological systematics. Services using nucleic acid sequencing include whole genome shotgun sequencing, transcriptome sequencing, genome re-sequencing and targeted re-sequencing, single nucleotide polymorphism (SNP) discovery, amplicon sequencing, and many other applications.
- *DNA Microarrays:* A DNA microarray is a collection of microscopic oligonucleotide fragments attached to a solid surface. Services that utilize Microarrays include conducting whole genome gene expression, comparative genomic hybridization (CGH) to test copy number differences between genomes, chromatin immuno-precipitation on chip (ChIP-Chip) for analysis for regulatory protein-DNA interactions, DNA methylation for analysis of aspects of epigenetics and others.
- *Single Nucleotide Polymorphism Genotyping:* Single Nucleotide Polymorphism (SNP) Genotyping measures the genetic variation of single locus in genome between members of a species. SNPs are found to be the etiology of many diseases (particularly human diseases) and are becoming of particular interest in biomedical research. Because SNPs are conserved during evolution, they have been proposed as markers for use in quantitative trait loci (QTL) analysis and in association studies.

- *High Throughput Sample Preparation and Quality Assurance:* Access to equipment for high throughput sample preparation gives investigators abilities for increased speed and reduction of sample-to-sample variability over manual methods without having to hire new technicians. In addition providing high-end equipment for assessment of sample quality enables researchers to perform costly procedures without the additional worry of unknown sample quality. Services offered by the GRC for high throughput sample preparation and quality assurance in include access and training to specialized equipment.

While the GRC operates much of the equipment necessary to perform most of the proposed work of its customers, occasionally genomics projects require technologies not present in the facility. In these cases the GRC does not typically turn the customer away but rather facilitates the use of the needed technology through cooperation and collaboration with other facilities that operate the needed technology. An example is when experiments warrant the extra sequencing capacity from an Illumina HiSeq DNA sequencer. Illumina DNA libraries are prepared in the GRC facility and sent to other core facilities with a HiSeq (such as UC Berkeley, or the University of Oregon) and data is sent back to the GRC. This service offers a seamless experience to the client and expands the range of services and products the GRC can offer.

Data Analysis and Bioinformatics

The GRC offers bioinformatics services to conduct the full range of analysis tasks from quality assurance of data to data interpretation and visualization. Data processing occurs in a cyclical manner, with preliminary analysis being performed, feedback provided by the investigator, and reanalysis or additional analysis, as needed. Feedback continues until the project meets its goals, figures are generated, and summary tables delivered. As needed the GRC staff provides investigators with explanations of the molecular protocols and bioinformatic techniques and methodologies used so they can be included in reports and publications. They also assist in the preparation of figures and tables for publications and poster presentations. As appropriate GRC staff are included as co-authors on publications resulting from significant intellectual contributions to a research project.

Assessment of Capabilities

The GRC has increased its user base (the number of projects conducted per year) at 20% per year since 2010. The users include University of Idaho investigators, academic off-campus investigators and commercial entities. In FY 2013 45% of projects were conducted for University of Idaho investigators, 45% for academic off-campus investigators and 10% for commercial entities. Investigators are most often directed to the GRC by word of mouth from previous clients.

Future Directions

The Genomics Resources Core will be phasing out a number of services and equipment that are being discontinued by their manufacturer in FY2014. These services and corresponding equipment are:

- DNA Microarray services with Roche Nimblegen. Roche discontinued their product line in January 2013. The GRC will explore selling or mothballing all equipment associated with microarrays.
- Single Nucleotide Polymorphism Genotyping with the Illumina BeadXpress. Illumina announced they would no longer be supporting the BeadXpress as of October 2013. The GRC will explore a possible trade in for the Illumina BeadXpress.
- Nucleic Acid Sequencing with the Roche 454 FLX+. Roche announced that the 454 sequencer will no longer be supported after late 2016. This will not cause trouble to the GRC since this instrument is obsolete and last used in March 2013.

Opportunities and Risks

Value Metrics

The GRC gauges its success by its continued and steady growth (~20% per year) and well as the number of users who return to the core for additional and future services.

Identified Risks

The most significant risk to the GRC is the ability to hire new staff and staff retention. The GRC has a critical need to hire a second full time bioinformatician (data scientist), however the current university classification system and pay scale have resulted in one failed search with little hope for a future successful search. Current staff members are

under-compensated by as much as 80% relative to comparable positions nationally, likely resulting in the University of Idaho being a stepping-stone for a more lucrative position elsewhere.

Financial Projections

Financial Overview and Explanatory Narrative

The Genomics Resources Core facility has seen rapid growth in terms of both revenue and number of projects performed over its first three years. The Core facility has four primary expense categories: salaries, service contracts, materials and supplies. The GRC has three sources of funding: GRC user fees, COBRE grant funds and a subsidy from the university. The total operating budget for FY 2013 was $545,000, while sources of income totaled $587,000 showing a surplus of $42,000 that was used to pay down the GRC budget deficit to an estimated $9,000.

Fee Structure

The costs to customers for each service have been established and are published on the GRC website. Service center fees are established from estimates on the combined costs of consumables, maintenance agreements and personnel time associated with each service. Customers who request new method and protocol development receive an estimated cost associated with the projected time and materials needed to complete the proposed work. Costs for bioinformatics services for standard analysis types have also been established and are published on the GRC website. Customers who request custom bioinformatic analysis and/or new method development receive an estimated cost associated the amount of projected time necessary to complete the proposed work.

Financial Projection

Projecting the expenses and revenues for the GRC is, to say the least, is a tricky business because there are so many unknowns. Certainly the landscape of high throughput next-gen DNA sequencing is ever changing. All at once the costs of data generation are decreasing at the same time the amount of data that can be obtained has skyrocketed. These ever-reducing costs of DNA sequencing and sample preparation are good news to investigators, but have practical implications for genomics core facilities. The number of projects done each year must increase in order to maintain the same level of user fee revenues. Said another way, each project becomes smaller in terms of the effort and costs of acquiring data. This is a sea change from even a few years ago when study design was limited by the available funds; they are now limited by imagination, logistics and the ability to usefully analyze the complex datasets that are generated.

We project there will be a significant increase in the number of projects in the coming year, but the total operating costs will only increase by 5%. Revenues are expected to increase at a rate of 20% again in FY2015 through FY2018 due to an increase in projects and bioinformatic billings, while expenditure are expected to increase at a significantly slower rate (anticipated 5%) due to increased efficiencies in the laboratory procedures. The increase in revenue relative to costs will be used to offset reductions in COBRE grant support and to hire new bioinformatics personnel, and decrease user fees. Future growth in GRC use will be determined by many factors, including whether the research programs of newly recruited faculty require genomics, and whether one or more of the large initiatives describe elsewhere in this report are funded.

Salaries for FY2014 are expected to increase by $55,000 to $286,000 while at the same time COBRE support for salaries decreases by 20% each year ($36,000), these monies must be made up either with increased revenue relative to expenses or increased support from other sources such as IBEST support or other grant support. We expect to partly fill this gap by increased efficiencies in the laboratory and increased billings for bioinformatics services. Efficiencies in the laboratory will be realized by purchasing new capitol equipment that will decrease costs associated with processing samples and increase throughput. The proposed new equipment are:

- Advanced Analytical Fragment Analyzer – A parallel LED fluorescence capillary electrophoresis system for rapid DNA fragment analysis, along with RNA quality analysis and RNA quantitation. $45,000
- Covaris S220 Focused ultrasonicator – An adaptive focused acoustics system for DNA, RNA, and chromatin shearing. $75,000

Charging for bioinformatic services has increased steadily over the past 4 years, in FY 2013 the Core charged $10,500 specifically for bioinformatic services. However, bioinformatic services offer the greatest potential for closing current and future gaps between expenditures and revenue. Expected billing for bioinformatics services in FY 2014 already exceeds that of FY 2013.

Funding Request

The Genomics Resources Core facility receives funds from service revenues, COBRE grant support, IBEST and other grant monies. We expect to be able to offset reductions in COBRE grant support over the next five years with increased revenues and laboratory efficiencies, and are requesting continued support from IBEST totaling 15% of projected expenditures that is primarily used for salary support. That request amounts to $80,000 in FY14 and projecting to increase by 5% each year for the next five year.

IBEST OPTICAL IMAGING CORE (OIC)

Executive Summary

The IBEST Optical Imaging Core (OIC) is committed to providing quality imaging and cytometry services to the regional research community. The services at the OIC include expert advice on all stages of imaging and analytical cytometry along with a breadth of shared instrumentation to ensure that researchers can take their science from concept to publication. New and experienced faculty members along with their staff and students, gain insight on fluorescence techniques, access to research-ready instruments and training to efficiently produce quality data that can be used in publications and in grant proposals that will secure funds for their personal and collaborative research programs. The recent increase in users (up 33% this past year) and retirement of service contracts on instruments that are under utilized coupled to success in obtaining funding for new instrumentation suggests we are on the right track to supporting our active research community at the University of Idaho in a fiscally responsible manner.

Facility Description

All of the services of the OIC are located on 4th floor of the Life Sciences South building on the University of Idaho campus. The acquisition instruments, lab prep area and offline analysis computers are located in a 686 sq. ft. suite of rooms, LSS450, and the director's 129 sq. ft. office is located nearby in LSS447B. All microscopes are situated on high quality anti-vibration tables.

Staff

The daily operation of the OIC is the responsibility of the director, Ann Norton. Ann provides all of the direct assistance to the users including consultations on experimental design and instrument choice, scheduling, training and direct assistance during image acquisition and analysis. Ann has a Master's degree in Zoology and has worked in the field of biological imaging for 35 years with experience in electron microscopy, histology, fluorescence and confocal microscopy and, recently, fluorescence-activated cell sorting techniques. Ann performs routine maintenance on most instruments and manufacturer-based service contracts are purchased for the most complex instruments.

As OIC Director, Ann is also in charge of fiscal planning and development of the core, including securing funds and investigating options for new instrumentation to assure a sustainable facility for current and future investigators at the University of Idaho. The IBEST Director, Dr. Larry Forney, is Ann's direct supervisor and the IBEST administrative staff assists with billing, marketing and other administrative duties. Dr. Deb Stenkamp, faculty member in Biological Sciences, is advisor to the OIC and is the principal investigator on recent shared instrument grant proposals. The Department of Biological Sciences and the College of Science provide her time and effort.

Infrastructure

Fluorescent biomarkers are used in many different biological applications to specifically label molecules and organelles in cells and tissue. Scientists require proper preparation techniques and sophisticated tools to locate and quantify those fluorescent labels. Fluorescent and confocal microscopes, flow cytometers and visualization software are necessary to tell the full story of this type of scientific investigation. The IBEST Optical Imaging Core provides these tools along with training and guidance to use them efficiently and produce quality results. Some of the instruments in the OIC are not necessarily unique on our campus, such as the fluorescent stereoscope, the histology microscope or the epifluorescent microscope, yet, the quality of instrument we provide is not often affordable to a new investigator. In the OIC, these tools are well-maintained, accessible and research-ready, allowing young investigators to move forward to achieve their research goals as soon as they arrive on campus.

Confocal microscopes and flow cytometers, especially the more complex fluorescence-activated cell sorters, provide high resolution and sensitivity for counting and imaging samples with fluorescent labels. As shown in Figure 1, the flow cytometer characterizes cells on the basis of size, complexity and presence or absence of fluorescent markers. The power of the flow cytometer is the ability to count many cells and many different fluorescent labels in a short time. Once characterized, cells can be sorted into separate tubes for culturing or DNA and RNA analysis.

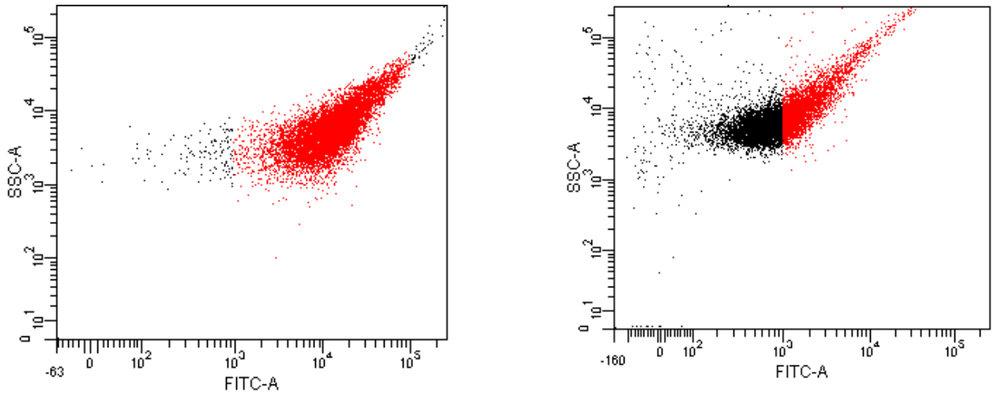


Figure 1. An investigator explores plasmid stability in bacterial species on the flow cytometer. Loss of fluorescence indicates the loss of the plasmid.

Fluorescent labels identify the location and intensity of a particular molecule or organelle within a cell or tissue. Laser scanning confocal microscopes do an excellent job of capturing high resolution images of these labeled molecules in three dimensions. This type of imaging is critical to the work of cell and developmental biologists, as well as pathologists and structural microbiologists. Figure 2 shows images from neurobiologists that detail fine structures within developing neural tissue. One image has been processed using visualization software to better see the connections between cells of the developing retina. This type of imaging and processing would be cost prohibitive to a single investigator. The OIC provides a format for sharing of these complex instruments and is the type of infrastructure expected when applying for funding of new instruments.

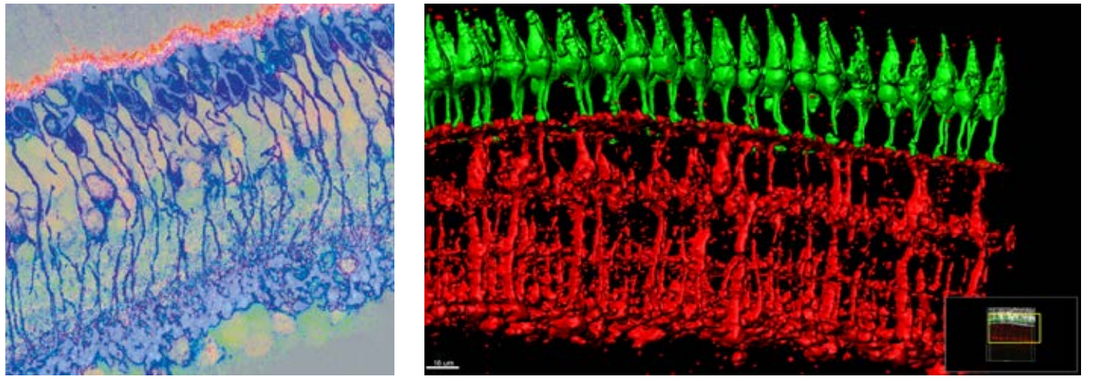


Figure 2. These images show how critical high-resolution imaging is to seeing details of the relationships between cells and how neural tissue structure changes during development and following perturbations. The right image has been further processed with visualization software.

Offline computer stations in the OIC provide investigators with opportunities to analyze and process their images and flow cytometry data in preparation for publication and prior to initiation of new experiments. Separating the analysis and processing activities from the microscope and flow cytometry stations allows other investigators to continue to do their acquisition work, though at the cost of additional software. Again, sharing of the cost among multiple investigators reduces the overall cost of this step for everyone. Additionally, some investigators initiate their use of the OIC at these offline stations. By facilitating their workload at this step, they discover other services in the OIC that may become useful in their future endeavors.

Services and Strategic Advantages

At the IBEST OIC we strive to provide quality, efficiency and choice to our current and potential users. Our attention to fiscal responsibility is a commitment to providing these services at a reasonable rate to current investigators and also to continue these standards and services in the future.

Quality and efficiency are achieved by providing expert advice on experimental design and sample preparation to produce the best results on the specific instruments in the OIC. Our general philosophy is to place an investigator on the simplest instrument that will produce data to answer their specific scientific question. By maintaining the instruments to be research-ready, providing personal training and direct assistance when requested, the investigator's work can be seamless. To maintain these standards, we must at times replace and remove older instruments that are no longer useful or dependable.

The OIC provides different types of service to investigators including a *full service option*, where the OIC director is an integral part of the research project team and is engaged in project planning, protocol development, data acquisition and analysis. This option, at the current cost of $50/hour, provides an opportunity for investigators who simply do not have time or staff to do the work at the quality they need. Often, those investigators who are pursuing a new avenue of research and require some preliminary data for a grant proposal may use this option.

In our efforts to facilitate a variety of investigators, we also provide personal training on each instrument, which allows students, staff and faculty to become independent users. Following consultation about the project goals, instructions on safety and guidance on the appropriate instrument, the director will train users on the chosen instrument, at a cost of $35/hour. Once the OIC Director determines that they are sufficiently prepared to work on their own, they receive access to the facility during all hours and can reserve instruments using our scheduling software. During regular hours, of course, the director is still available for direct assistance to resolve any problems or provide advice in our combined efforts to produce quality results efficiently. An independent user works at a lower hourly rate, which is currently $15/hour on most instruments. This *self-service option* is not available on the fluorescence-activated cell sorter, as it is a complex instrument that requires almost constant attention during acquisition. The full-service option, whereby the director is the operator during this application, is required.

The OIC director also provides analytical services outside of the OIC when time permits. Typically, this involves maintenance, installation or problem solving of microscopes and imaging systems in an investigator's personal research laboratory. This service is currently available at $35/hour.

Our established abilities in facilitating research that involves fluorescent biomarkers, our commitment to quality and our choice of services will continue to create new collaborations for on campus and regional investigators.

Assessment of Capabilities

There are always new cytometry tools and techniques to consider adding to our current services. The decision to move forward to secure funding for new instrumentation will depend on a number of criteria, including at least a benefit to multiple users at UI, a significant opportunity for new avenues of fundable research and new users, and the ability to maintain the instrument. Fortunately, those are similar criteria used by agencies that provide funding for shared instruments, such as confocal microscopes and flow cytometers.

The laser scanning confocal microscope in the OIC provides excellent quality images of static specimens, as shown in Figure 2, yet our capacity to understand living systems cannot be fully realized through conventional static observation. Key cellular and subcellular activities occur on rapid temporal scales. Motions and fates of cells and subcellular components need to be analyzed over developmental time or in response to environmental manipulations. A dynamic imaging system will provide a new service in the OIC and holds great promise for understanding mechanisms underlying developmental processes, rapid evolutionary processes, diseases and treatments.

Toward the goal of providing dynamic imaging, we submitted three instrument grant proposals this year (MJ Murdock Charitable Trust, NSF-MRI, NIH-SIG) and based on the results, we are confident that we will be successful in securing funds for a purchase in FY2015. Our recent funding approval from the MJ Murdock Charitable Trust and our NSF panel recommendation of 'Outstanding' (though funding was declined) suggests that we are on the right track. NSF reviews noted that our proposal investigators are 'highly research active and funded and have demonstrated that there is a high need for this instrumentation to advance their research activities'. At this time, our NIH proposal has received a score of 26, which secures our move to the next level for review.

Integral features of the successful instrument grant proposal included:

- strong rationale for the instrument in the research programs of well-funded investigators
- matching the instrument choice to the scientific questions of the investigators
- presenting preliminary data from similar instruments on investigator samples (as seen below)
- existing qualified personnel and institutional support for the instrument
- clear financial and management plan for maintaining and sharing of the instrument

The director will continue to work with principal investigators to secure outside funds for the current needs of a dynamic imaging system and future needs to replace aging instruments. Cytometry instruments have recently improved greatly in efficiency and integration and will provide our current and future users with new research opportunities as well as attract new investigators to the university (Appendix 10) shows plans for maintenance and replacement of for major instrumentation over the next five years.

Opportunities and Risks

In the past year significant changes were made to provide better services, increase users and create sustainability. The OIC was consolidated into one location, user fees were charged for the first time in November 2012 and service contract expenses were reduced by $15,000. Dr. Deb Stenkamp became our faculty advisor; IBEST and INBRE provided technology grants for many investigators to use the OIC, and the OIC Director presented separate workshops on optical microscopy and flow cytometry. These workshops had 30 attendees and brought in two new projects to the OIC. The core website was updated and data management software (iLab Solutions) was contracted to improve efficiencies in reporting, scheduling, billing and logging. The OIC was featured in two articles about research at the University of Idaho and the director made three presentations on campus about our services.

The OIC provided services to 77 users on our campus, an increase of 33% from the previous year. These hands-on opportunities were experienced by 24 undergraduate students and 23 graduate students, about 60% of our users. When they arrive at the OIC, they have often put in many hours preparing their samples and really enjoy the opportunity to 'see' their results immediately.

Many of our new users came from other universities and federal agencies, including Washington State University, UC-Davis, USDA Rocky Mountain Research Station, US Geological Service and Colville Confederated Tribes. The projects from these groups have typically been short term, though these investigators have been grateful for the professional guidance throughout their project and returned when the project became reactivated.

To continue these collaborations and create new opportunities, we plan to increase our visibility by presenting these successful workshops for the whole campus at least twice a year and to make direct contact with potential faculty hires. The most likely potential for new faculty users are the upcoming searches in the WWAMI Medical Program for an immunologist and an infectious disease scientist.

Some off-campus users discovered our facility by visiting the Regional Research Directory on the website of the Institute of Translational Health Sciences. A link to our website is also available on the Association of Biomolecular Resource Facilities website. We will search for additional regional links, but imaging and flow cytometry are not unique services at research universities and we are not likely to pick up off-campus users from distant locations. The OIC Director, with the help of the IBEST staff, will collect data on the number of submitted/funded grant proposals that plan to use the OIC and the number of publications that have resulted from work in the OIC in an effort to plan for future use and examine our success in producing quality results.

Off-campus contacts are encouraged to visit the facility, preferably with samples, to see if we have something to offer. Our recent experiences have shown that this initial personal interaction along with providing honest advice in a timely manner, quality results and follow up discussions usually creates a collaborative opportunity.

Much of the increased use (and users) this past year was on the flow cytometer. The improved accessibility of the instrument, more dependable results provided by having one operator for all cell sorting techniques and follow-up discussions in preparation for subsequent experiments are likely major reasons for this increased use. Additionally, the Washington State University (WSU) users have expressed gratitude for the exceptional service and interaction we provide throughout the process, though the inconvenience of coming to UI is not insignificant. At this time, WSU does not have quality service or instrumentation for cell sorting on a breadth of sample types and we plan to continue to provide that for them here at UI, yet, it is expected that they will soon purchase new instrumentation and hire new operators which may reduce their use of our services.

The addition of a dynamic imaging system will provide a much-needed service to UI researchers. Once this

system is well established and mastered, we will focus on attracting some non-traditional users, such as engineers who may be fabricating microfluidic devices or biophysicists and chemists who may be developing new fluorescent probes.

New instruments do provide new services, create new users and inspire new research avenues for existing users, yet, it is critical to keep focused on instrumentation that will have multiple users. New instruments can provide increased breadth of services but with only one staff member it is difficult to provide depth and experience in all arenas.

Some researchers depend heavily on the services of the OIC, whereas most users are occasional or short-term. Our concern at the University of Idaho is that the volume of heavy users who are consistently well-funded is too low to provide adequate support to continue the quality and breadth of services we currently offer. In the financial projections, we plan to create a new fee structure that reflects the increased value of the more complex instruments, while balancing the need to continue to make the services affordable. Despite these efforts, the low volume of heavy users at the university will always be a concern.

Financial Projections

Optical imaging at the University of Idaho had been available at no charge to the users for many years with the costs underwritten by various large grants. This approach was not sustainable and a fee-for-service facility was created in November 2012.

For the first year of billing, we established a simple fee structure based on the overall cost of running the OIC and using estimates of hours of anticipated use based on previous years. The result a rate that was unaffordable for most investigators, so a reasonable rate was established and a substantial subsidy was provided by the university. The simple fee structure and reasonable rates have made it easier for investigators to adjust to this expense, though it has reduced the total number of hours of use on some instruments. Some investigators have found it necessary to more carefully choose which staff or student would become a user, as efficiency and experience of the user influence their overall expense. Some investigators were successful in securing funds from the IBEST/INBRE Technology Access Grant program.

Fee Structure

The current fee structure with descriptions of each service can be found on the IBEST website at https://www.ibest.uidaho.edu/cores/optical-imaging-core/oic-rates/. Additional details on these service options were also described in the Services and Strategic Advantages section. The hourly rates are the same for any instrument or application, with the exception of the sorting service on the flow cytometer. All users are required to pay the full-service rate for this service, as the director runs the instrument for this complex application. Users are billed by the hour and in 30-minute increments.

Estimated expenses

The major operating expenses for the OIC are salary of the director and service contracts.

Salary and fringe

This category covers only the expense of the director of the OIC. These estimates include a 2% increase in salary each year though the fringe rate remained stable. In our efforts to make the facility sustainable, we are not proposing any additional staff.

Service contracts

These are purchased only for major instrumentation that has expensive replacement parts, especially lasers, and complicated engineering. We plan to keep the number of service contracts to a minimum, typically two each year, though which instruments will be on contract will change according the table found in Appendix 12. The lower figure in FY2017 reflects the plan of having only one major instrument on a service contract that year, a replacement instrument on warranty and a third instrument will be self-insured (i.e. pay-per-visit).

Maintenance

This includes maintenance done in-house or on a pay-per-service basis by an external vendor. This category includes replacement and upgrade of small parts and computers that are not covered on service contracts. In FY2016 and FY2017, the laser scanning confocal microscope will no longer be on a service contract, which requires a plan for increased pay-per-visit expenses. We have therefore estimated an increase in maintenance expenses, though this choice is likely to save up to $15,000 per year for that instrument. A decision on whether to have it repaired will depend on frequency of use, overall condition and expense of the recommended repair at the time.

Consumables & lab supplies

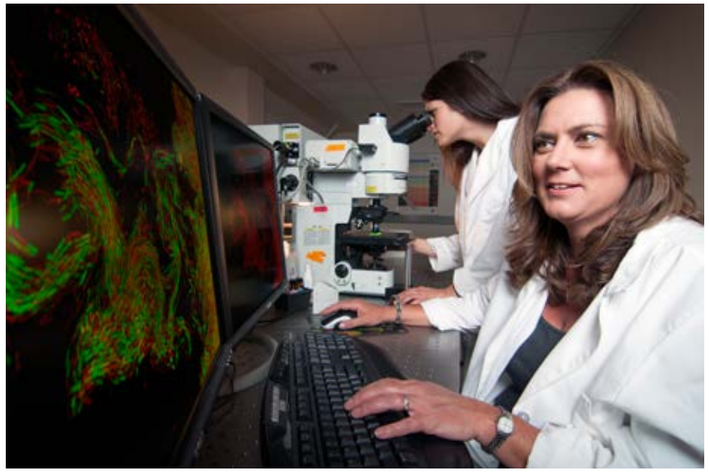
Most of the consumables are required for the flow cytometry services, though, this category also includes microscopy cleaning and safety supplies. The reduction in consumable expense in the later years reflects the efficiency anticipated in the newer replacement flow cytometer.

Professional development

The director attends at least one professional meeting each year (typically Association of Biomolecular Resource Facilities or Microscopy Society of America) and one focused training course every other year. These meetings provide professional connections important for sharing new ideas and marketing our facility, learning about new instrumentation and new applications.

Estimated income

The estimated income and request for support subsidy for fiscal years 2014 through 2018 are shown in Table 3 These projections are based on a number of anticipated changes, including improvements in administration activities. The installation of the iLab Solutions data management system will improve the logging of use and the director plans to improve logging and billing of full-service activities. In this first year of offering the full-service option, the director agreed to work on projects that were not well-designed and took many more hours than originally anticipated. Better communication and more strategic decisions will prevent the need to suffer such an income and time loss in the future.



Dr. Stephanie Smith works at the confocal microscope in the IBEST Optical Imagine Core.

Though some instruments saw reduced use during this first year of billing, the overall usage was up and we anticipate this to continue to gradually rise, as our current customers have expressed satisfaction in their results and complained less about the expense. Requests for the OIC service, where the director visits other laboratories to maintain and repair instruments is expected to continue, though not rise dramatically, as investigators that have used this service often request it again for a different instrument. The self-service category is the one that is expected to rise gradually and continuously as we gain new faculty that will need the existing services and as we add new users and increase the use by existing users with the addition of dynamic imaging. Early investigators are anticipated to become more active users as the funding for their research improves.

These projected incomes show an increase in the percentage of expense that will be covered by user fees from 24% in FY2014 to 43% in FY2018.

Funding Request

The requested subsidy for the OIC will gradually reduce over the next five years because the users will take more responsibility for the expense of the core and the director will continue to seek new users and work to retain existing ones. The director's activities that are focused directly on the users of the core include consultations before and after using the instruments in the core, in-house maintenance, training and direct assistance and amount to approximately 45% of her time. In the last year, approximately 20% of her time went to full-service and OIC services, which are funded completely from extramural funds. Therefore, approximately 35% of her time was spent on professional development, program development (including writing instrumentation grant proposals) and IBEST administrative activities (reports and meetings). As 2/3 of the director's time is focused directly on the users, the user fee rates will move toward covering that expense over the next five years. The other activities are focused on broader goals for IBEST and the university.

The IBEST Optical Imaging Core services are critical for many current investigators at the University of Idaho. Our efforts to maintain quality, pay attention to efficiency and continue to provide choice in instrumentation and type of service for established and initial investigators fulfills the research goals of the university. Maintaining the quality of our services will attract new faculty, help to retain existing active researchers and improve the capability for these investigators to secure extramural funds for the continuation of their research programs. Our attention to fiscal responsibility while still retaining high standards for service and quality results shows our effort to be a team player in the overall research goals of the university research community.

IBEST MASS SPECTROMETRY CORE (MSC)

Executive Summary

The overarching goal of the IBEST Mass Spectrometry Core (MSC) facility is to serve the University of Idaho research community by providing high quality mass spectrometric and other chemical analytical services that meet the needs of researchers. The core staff will work with facility clients to help them increase the effectiveness and efficiency of their research programs. Lastly, the core director will strive to maintain the viability of the core facility by increasing usage.

To maintain its relevance to the UI research community and to increase the number of researchers using core services, the core will pursue opportunities to expand analytical capabilities through method development and instrument acquisitions. It is also expected that the core will contribute to the overall educational mission of the University.

The MSC has available for faculty and student use analytical instruments not available anywhere else on the UI campus. These are state of the art instruments used for various analyses commonly done in chemical, biological, environmental, and pharmaceutical labs. Although the MSC is not currently financially self-supporting, revenue generation is increasing and the core is moving towards self-sufficiency.

Facility Description

The progression of science and technology has required that the tools used by researchers in various disciplines change over time. One example is mass spectrometry, which was previously used by only some chemists and physicists but is now widely used by biologists and scientists in other disciplines. As is common in research universities instruments such as these are commonly housed in a central facility shared by many researchers because a single investigator rarely has the resources or need to acquire and operate high-end, specialized instruments such as these. In these 'shared use' facilities one or a few trained operators will have the responsibility and expertise to run samples, maintain instruments, and train users.

Using research grant funds the University of Idaho (UI) has been able to acquire state-of-the-art, high-end mass spectrometers and this has created an opportunity for UI researchers to exploit the capabilities of mass spectrometry analyses. By doing so the MSC will serve the University of Idaho research community and other regional research programs in academia and the private sector. To insure the continuing availability of these resources we propose to operate the MSC as a revenue-generating service center so that the costs of operating and maintaining the MSC facility can be partially offset by reasonable usage fees charged to investigators.

Personnel

The mass spectrometry core is operated and managed by Dr. Lee Deobald the core director. Dr. Lee Deobald has a BS degree in Chemistry, a PhD in Biochemistry, and more than 20 years experience operating gas chromatographs, liquid chromatographs, and other chemical analytical instruments. The core director has operated and maintained mass spectrometers in the MSC for more than 7 years and is currently the sole staff person in the core. As demand and usage of the core increases it may be necessary to add another full or part time staff to work under the supervision of the core director. The core director is responsible for consulting with users, scheduling analyses, running samples, analyzing raw data, maintaining the instruments, ordering supplies, troubleshooting problems, arranging for instrument service, and training users in sample preparation and instrument operation.

Developing and implementing plans to increase usage of MSC resources and managing relations with MSC clients is also the responsibility of the core director along with maintenance of instruments and other core facility resources. Working in collaboration with the IBEST Business Manager, the director implements billing for service

fees and manages the finances of the MSC. The MSC director also meets with the directors of the other IBEST core resources and other IBEST staff on a monthly basis to discuss information on matters of shared concern.

The core director reports directly to Dr. Larry Forney, the Director of IBEST. The IBEST Director meets regularly with the MSC director to review operations policies, short and long term goals, user fee schedules, and core facility usage. A UI faculty member acts as advisor to the core director and the IBEST director, providing recommendations on the pricing of services, services offered, and other aspects of core facility operations. In the future, one or more faculty members with interest in the MSC may be added as an advisor to the core at the discretion of the IBEST Director. The faculty advisor should be a UI researcher who has a vested interest in the quality and utility of services offered and the financial viability of the core. Dr. Andrzej Paszczynski, Professor in the School of Food Science and former Associate Director of the Environmental Biotechnology Institute, has agreed to serve as faculty advisor.

Physical Location

The IBEST MSC occupies two labs, room 105B and 105C, and an office, room 103B, all located in the Food Research Center building. The lab space is a modern laboratory designed to house analytical instrumentation. This space accommodates sample preparation, instrument operation, and data analysis.

Instrumentation

The mass spectrometers, associated chromatographic instruments, and the Environmental Biotechnology Institute, which ceased operation in July 2011, originally acquired sample preparation resources of the IBEST MSC facility. The instruments within the core (Table I) can be used for the analysis of many different chemical and biochemical analytes. The three mass spectrometers listed in the table have complimentary analytical capabilities and so no major instrument acquisitions by the MSC are anticipated at this time.

Table I. Major Instruments in the Mass Spectrometry Core.

Instrument	Description
Waters Q-Tof Premier mass spectrometer with nanoAcquity Ultra Performance Liquid Chromatograph (UPLC)	Quadrupole-time of flight tandem mass spectrometer for accurate mass determination. Equipped with electrospray ionization (ESI) and MALDI sources.
Waters Xevo TQ mass spectrometer with nanoAcquity UPLC	Triple quadrupole tandem mass spectrometer equipped with ESI sources.
HP (Agilent) GC-MS	6890 gas chromatograph interfaced with a 5973 (single quadrupole) mass selective detector
Waters Acquity Ultra Performance Liquid Chromatograph	Liquid chromatograph equipped with a diode array detector

Services and Strategic Advantages

Mass spectrometers are used to measure the masses of compounds in many different structural classes and are designed to work in a stand-alone mode or as a detector preceded by a chromatographic separation of analytes prior to introduction to the mass spectrometer. Mass spectrometers operate by separating and detecting mixtures of charged analytes in the gas phase under high vacuum. Two of the mass spectrometers in the MSC are tandem mass specs, which further increase the instrument's capabilities. They can be programmed to detect intact charged analytes or they can be programmed to fragment precursor molecules with detection of the resulting analyte-specific product ions. This allows investigators to identify and quantify chemical analytes present in small samples with low limits of detection.

Analysis of various chemicals by mass spectrometry is a common need in nearly every institution doing biological or chemical research. For a researcher requiring such analyses, their choices are to have the analyses done by a resource facility within their organization, send samples to an outside facility, or to find an alternative to mass spec analysis. We intend to attract customers to the MSC by offering high quality services at competitive prices. Core staff is well experienced in mass spectrometric analysis and is willing to work with clients to develop and apply analytical methods to successfully identify or quantify their compounds of interest. We provide clients with advice on sample preparation and assist with method development and data analysis and interpretation. Because the core is located on the UI campus, users can drop off samples and receive results faster. Since shipping is not required, overall cost for an analysis is also lower. Researchers can also participate in the analysis of their own samples by observing the analysis and for some analyses, core users can be trained to analyze their own samples thus lowering the cost of analysis and enhancing the educational experience. The basic services offered by the MSC are briefly described below.

Mass spectrometry

Proteomics

This method acquires MS/MS spectra of peptides that are first purified by liquid chromatography by exploiting the capabilities of the mass spectrometer software to automatically switch from MS to MS/MS mode when a probable peptide elutes. The data analysis software is used to process the raw data and search databases for probable protein matches. This method is ideal for characterizing and identifying an isolated protein or a mixture of proteins in solution. Peptide digests can be prepared by the investigator or by core staff.

Expression Proteomics

This method is used to determine the relative quantity of proteins in complex mixtures and can be used to measure differences between two or more samples. The mass spectrometer is programmed to acquire LC-MS data in a specific way and determine relative differences in concentration.

Small molecule LC-MS

LC-MS analysis of low molecular weight analytes has grown in popularity over the last several years because it is very specific, very sensitive, and does not require complete chromatographic separation of analytes prior to quantification by mass spectrometry. Generally, LC analysis is a desirable separation method used prior to MS because samples can be analyzed directly from aqueous samples without prior extraction or derivatization. The mass spectrometer can be programmed to acquire a simple mass spectrum, or it can acquire data in single reaction monitoring (SRM) or multiple reaction monitoring (MRM) modes.

Large molecule (LC-) MS

One of the remarkable capabilities of the quadrupole-time of flight (Q-TOF) mass spectrometer is the ability to measure the masses of biological macromolecules such as proteins and oligonucleotides. The mass analyzer has a useful mass range up to about 200,000 Da, which is useful for measuring the mass of single charged analytes such as those produced by MALDI. The masses of analytes capable of accommodating multiple charges, such as proteins, can be accurately measured to within a Da by de-convoluting the complex spectra produced by electrospray ionization mass spectrometry. This service would be useful to customers interested in confirming the masses of analytes or who would like to determine if a known protein has been chemically modified. The samples generally would be nearly pure when submitted and would not require LC separation.

GC-MS

Low molecular weight analytes that can be volatilized by heating are best analyzed by GC-MS. These compounds are frequently non-polar and have a neutral charge. High-resolution separations can be achieved by gas chromatography prior to introduction to the mass spectrometer where the compounds are ionized by electron impact ionization and spectra are acquired with a quadrupole mass analyzer. The resulting spectra can be compared to library spectra to identify compounds.

Technical services

Sample Preparation

Some MSC clients may not have the expertise or the resources to prepare samples for analysis in their own labs and so may prefer to have samples prepared for analysis by core staff. It is expected that these will be primarily proteolytic digestion of protein samples prior to LC-MS analysis. Other possible sample preparation services include sample extraction, analyte derivatization, cell lysis, and electrophoretic separations. Core staff will determine what sample preparation methods are needed and the costs for these services. The amount charged will depend upon the difficulty of the protocol, materials used, and the time required. These costs will be added to the base price of the LC-MS analysis.

Instruction

For those researchers who prefer to analyze their own samples on the MSC instruments, instruction will be provided on instrument operation, data analysis, sample preparation, and other tasks. The cost of time spent on instruction will also be added to the cost of sample analysis.

Custom analyses and method development

Customers may require an analysis that is not routinely done by MSC users but is within the capabilities of instruments in the core. The MSC will strive to meets these needs by developing an appropriate analysis method assuming the process is not excessively time consuming or demanding of other resources (e.g., instrument time, operator time). Pricing will be determined on a case-by-case basis depending upon the instrument and operator time invested and the cost of other required resources (e.g., analytical standards, solvents, gases).

Fees for services

To establish pricing for services, a survey of prices at similar facilities will be conducted. This information will be used along with estimates of labor, materials, and instrument service contract expenses to set prices for various services. Users will be able to choose to prepare their own samples or have samples prepared by MSC staff with the cost of sample preparation added. Basic raw data processing using software on the MSC computers will be included in the sample analysis cost but extra charges will be applied for more advanced data analysis.

The services offered by the core will be directed primarily towards UI researchers working in the chemical, biological, and agricultural sciences. Although the core will mainly serve the UI research community, it will also do analyses for off-campus users. This will likely be researchers from other academic institutions, the private sector, collaborators of UI researchers, and investigators that do not have access to instruments with the required capabilities.

Assessment of Capabilities

Future Directions

It is essential to the long-term maintenance of the core that it remains relevant to the research needs of the University. It will do this by looking for new ways in which the core resources can be applied to research problems of interest to UI faculty. Methods described in the scientific literature that make use of resources similar to those of the MSC will be considered for inclusion in the services offered by the core. Consideration of methods for adoption will be based on the demand of those methods by researchers and the expense and difficulty in developing and testing the methods. Some methods being considered for inclusion in the list of available services are bacterial taxonomic identification by MALDI MS, hydrogen deuterium exchange, DNA methylation determination, epitope mapping of antibodies, and LC-MS analysis of glyphosate and its degradation products.

Opportunities and Risks

The University of Idaho has been fortunate to acquire high-end, state of the art analytical instrumentation with extramural funding. This has created the opportunity for UI faculty and others to make use of these instruments in their research. This creates the opportunity for UI faculty to apply these instruments in cutting edge research contributing the success of their research programs and to explore new research possibilities. The core facility has the opportunity to generate high quality research results, easier and faster. The MSC also has the opportunity to help faculty receive new research grants.

Value Metrics

In order to continually attract a sufficient number of customers to keep a service center such as the MSC a viable operation, it has before it the obligation to gauge the satisfaction and the willingness of potential users to have analyses done by the core. This should be done in a quantitative way and should examine satisfaction with services offered, quality of the results produced, and cost of the services. Apart from anecdotal measures like customer comments and the volume of repeat business, the MSC does not currently use a quantitative measure of customer satisfaction. After the UI Service Center Committee approves the MSC an anonymous satisfaction survey will be set up.

Identified Risks

There are a number of risks that can affect the long-term viability of the MSC. Although many of these cannot be controlled, those that can should be mitigated to the extent possible. For example, if researchers who would normally be expected to use core resources are unable to attract research funding or if there were changes in research trends where the services available in the core were not widely utilized, the viability of the core would be threatened. Establishment and operation of other core facilities, which may be subsidized to a greater extent, may offer similar services at lower prices and attract customers away. If instruments in other core facilities have dramatically better performance characteristics than those in the MSC then the core will be at risk of failure. As the instruments in the core age, the potential for an equipment breakdown increases, and if one should occur, repair costs could be prohibitive. In the future it may also be difficult to replace the mass specs with newer, high performing instruments. For these reasons the core should ensure prices are competitive, keep instruments in the best operating conditions possible, keep staff current in analytical methods, and pursue opportunities that arise to add or replace analytical instruments.

Financial Projections

Financial Overview

Although the MSC is not a for profit entity, to sustain the MSC resources to make them available to UI researchers and for the long-term advancement of the core, it is the objective of the MSC to strive to be as financially self sufficient as possible. Accomplishing the three objectives outlined below will permit us to achieve this goal.

The first objective is to devise and implement strategies to increase awareness of the services offered by the MSC core. With the high rate of change of research methodology, researchers don't always recognize how new analytical methods can be applied to their research or the wealth of information that can be acquired using a particular technique. By making the capabilities of mass spectrometry instrumentation known to UI researchers, more are likely to avail themselves of the services and expertise available in the MSC, thus increasing revenues. The availability of core services will be brought to the attention of potential users by creating a web page with descriptions and prices of standard services. A detailed list of services offered and the proposed prices is given in the Appendix 14. Core staff will also contact potential clients by e-mail then meet directly with any that express interest in learning more about applications and methods. Opportunities to present seminars to departments with the objective of highlighting instrument and core capabilities will also be sought out. An open house was also held to make the availability of resources known to potential users. The core director also meets frequently with potential users to discuss instrument capabilities and how they might be applied to achieving the users' research objectives.

The second objective is for core staff to stay abreast of innovations in liquid chromatography and mass spectrometry and develop appropriate new analytical services that can be offered by the core. This is expected to increase the core user base and to increase the relevance and usefulness of the core facility to the UI research community. This will be done by being aware of developments in biological mass spectrometry, by surveying the scientific literature, and by attending scientific conferences. Candidate analytical methods such as bacterial taxonomic identification by MALDI MS, hydrogen deuterium exchange, DNA methylation determination, epitope mapping of antibodies, and LC-MS analysis of glyphosate and its degradation products. Implementation of these will be influenced by the instrument requirements and potential demand from the research community.

The third objective is to seek out research partnerships and research opportunities in which core staff become integral members of a research team. Of course these will be chosen based not only on the likelihood that analyses done using core resources will significantly contribute to a particular research project, but also whether the research can (at least eventually) be supported by extramural grant funding. In these cases, core resources may be used to generate preliminary data at a reduced cost to the principle investigator. To enhance the likelihood that potential core users' grant applications will be funded, core staff will write supporting documentation for grant applications that describe the capabilities of the MSC and how they will contribute to achieving the aims of the proposed research. These opportunities will be identified primarily by potential principal investigators who are expected to initiate a discussion with the director. But it is also planned that director will propose potential research projects, identify funding sources, and contact appropriate researchers that might be potential collaborators.

Fee Structure

Prices of each specific analysis should be set to cover the actual cost of that analysis so that one analysis is not expected to subsidize others. An estimate of resources invested in each sample for a particular analysis can be made and is broken down into operator time required, instrument time required, and other material resources, such as chemical reagents and vials, that are required. Rates used in calculations of prices are $30/hr for both instrument time and operator time. The calculated prices were compared to the prices posted online for numerous other analytical core facilities at other research institutions. Although other cores offer slightly different services carried out on different mass spectrometers, the prices that we have arrived at are similar and should be competitive with other cores. As the Director gains additional experience doing various analyses, prices will be evaluated and adjusted if necessary to ensure that they reflect the actual cost for performing them. A complete price list has been proposed (which is included in Appendix 11) and will be implemented when the Mass Spectrometry Core receives final approval from the UI Service Centers Committee.

Financial Projections

Although the core has some experience as a fee-for-service operation, the numbers of requests for services are quite variable over time. This makes long-term estimation of revenues very speculative. The most likely approach to establish a steady revenue stream would be to establish long-term research collaborations with a few researchers.

The projection of expenses and income for the MSC over the next five years can be broken down into fixed costs and variable costs. The largest expenses are staff salary and the expense for the service contract for two of the mass spectrometers and their associated liquid chromatographs. This service contract accounts for about 40% of the total budget of the MSC.

These expenses should be reasonably predictable from year to year. The revenues, on the other hand, are less predictable. The first year's projection is on target but subsequent year projections, which are shown to increase by 40% each year, is more conjecture. With a coordinated business development strategy in place we believe that this is an attainable goal, but many factors will affect it and there is not enough operating history for the MSC to know how likely it is that this can be achieved.

Since so much of the cost of the MSC is associated with the staff salary and service contract, it is essential to increase the number of samples processed through the core to increase the number of billable staff hours.

A comparison of the revenues from the most recent 12-month period with the previous 12-month period shows that revenues have increased about 50% from $11,202 to $17,030. This demonstrates the potential to grow the user base and increase revenues.

Funding Request

A subsidy will be necessary to keep the MSC operational. The subsidy for year 1 is about 85% of the total cost of operation of the core, eventually dropping to an estimated 55% of the total at year 5. If the marketing is very successful, it is conceivable that the subsidy required is substantially less than 55%.

There is a substantial portion of staff time that is invested in the operation, maintenance, and promotion of the core that cannot be recovered in user fees. For example, it is necessary for core staff to meet with potential clients to describe the capabilities of the core and to discuss possible experiments that might be applied to their research. Some of these people choose not to bring samples for analysis. Other unbillable time includes general instrument and lab maintenance, continuing education, instruction of students, troubleshooting problems, and promotion of the core. It is expected that this time assigned to tasks not associated with sample analysis will require at least 20% of the core director's time.

APPENDIX X

Appendix 1 - Proposals Submitted

PROPOSALS SUBMITTED THROUGH IBEST IN FISCAL YEAR 2012-2013			July 1, 2012 to June 30, 2013
PROPOSALS SUBMITTED TO THE NATIONAL INSTITUTES OF HEALTH			
PI College/Dept.	**Proposal Title**	**Sponsor**	**Total Amount**
Forney, Larry COS/Bio Sci	*The vaginal microbiome in pregnancy: Maternal factors and risk of preterm birth*	National Institutes of Health	$283,647
Forney, Larry COS/Bio Sci	*Center for Human Vaginal Systems Biology*	National Institutes of Health	$425,658
Forney, Larry COS/Bio Sci	*Development of the vaginal microbiome in young black women*	National Institutes of Health	$367,003
Robison, Barrie COS/Bio Sci	*A zebrafish model for early cortisol effects on the brain and behavior*	National Institutes of Health	$1,866,325
Settles, Matthew ORED/IBEST	*Effects of early life nutrition on Xenopus Tropicalis epigenome*	National Institutes of Health	$267,352
DOLLAR AMOUNT OF PROPOSALS SUBMITTED TO THE NATIONAL INSTITUTES OF HEALTH			**$3,209,985**

PROPOSALS SUBMITTED TO THE NATIONAL SCIENCE FOUNDATION			
PI College/Dept.	**Title**	**Sponsor**	**Total Amount**
Foster, James COS/Bio Sci	*INSPIRE: What is Normal Milk? Exploring Sociocultural, Evolutionary, Environmental, and Microbial Aspects of Human Milk Composition*	National Science Foundation	$297,402
Harmon, Luke COS/Bio Sci	*Detecting the signature of species interactions in the tree of life*	National Science Foundation	$630,055
Harmon, Luke COS/Bio Sci	*An Integrative Approach to Studying Natural Selection, Reproductive Isolation, and the Genetics of Adaptation in White Sands Lizards*	National Science Foundation	$18,744
Harmon, Luke COS/Bio Sci	*Preliminary Proposal: Collaborative Research: Detecting the signature of species interactions in the tree of life*	National Science Foundation	N/A
Hohenlohe, Paul COS/Bio Sci	*Emergence, transmission, and evolution of Tasmanian devil facial tumor disease*	National Science Foundation	$470,481
Hohenlohe, Paul COS/Bio Sci	*Collaborative Research: Ecology, genotype, phenotype, and reproductive isolation: elucidating mechanistic pathways of speciation in the wild*	National Science Foundation	$301,230
Hohenlohe, Paul COS/Bio Sci	*Preliminary Proposal: Using experimental evolution to link pattern and process in population genomics*	National Science Foundation	N/A
Settles, Matthew ORED/IBEST	*Genomic divergence in a ring species: molecular processes underlying the evolution of reproductive isolation*	National Science Foundation	$207,166
Settles, Matthew ORED/IBEST	*Collaborative Research: Heterogeneity in viral shedding: does gene expression mediate the effect of food restriction?*	National Science Foundation	$291,435
Sullivan, Jack COS/Bio Sci	*Preliminary Proposal - Collaborative Research: A Comparative Phyogeographic Approach to Predicting Cryptic Diversity*	National Science Foundation	N/A
Sullivan, Jack COS/Bio Sci	*Preliminary Proposal - Phylogenomic-based Estimates of the Role of Sexual Selection in Divergence-with-Gene-Flow in the Chipmunk (Tamias) Radiation.*	National Science Foundation	N/A
DOLLAR AMOUNT OF PROPOSALS SUBMITTED NATIONAL SCIENCE FOUNDATION			**$2,216,512**

Appendix 1 (cont.) - Proposals Submitted

PROPOSALS SUBMITTED THROUGH IBEST IN FISCAL YEAR 2012-2013		July 1, 2012 to June 30, 2013	
PROPOSALS SUBMITTED TO NON-FEDERAL SPONSORS			
PI College/Dept.	**Title**	**Sponsor**	**Total Amount**
Forney, Larry COS/Bio Sci	*Comparison of the vaginal microbiome of pre- and postmenopausal women*	Proctor & Gamble	$76,239
Harmon, Luke COS/Bio Sci	*Predicting predictability: How convergent are traits and genomes across vertebrates?*	John Templeton Foundation	$201,494
Harmon, Luke COS/Bio Sci	*Predicting predictability: Can we predict the "convergent-ness" of traits and genomes across vertebrates?*	John Templeton Foundation	$199,790
Hohenlohe, Paul COS/Bio Sci	*Population Genetics of North American Rift Valley Fever Disease Vectors*	Floragenex, Inc	$25,000
Tank, David CNR/Forestry	*Genomic approaches to weediness and crop domestication: rapid evolution of vernalization and rosette structure in the genus Raphanus (radish)*	Martin Marietta Foundation	$266,499
DOLLAR AMOUNT OF PROPOSALS SUBMITTED FEDERAL SPONSORS			$692,783
DOLLAR AMOUNT OF NEW SUBMISSIONS:			**$6,119,281**
TOTAL # OF NEW SUBMISSIONS:			**21**

Appendix 1 (cont.) - Grants Awarded

IBEST AWARDS RECEIVED IN FISCAL YEAR 2013-2013				July 1, 2012 to June 30, 2013		
Sponsor	PI	PI College/ Department	CO-PI1	CO-PI2	Award Title	Award Amount
National Institutes of Health	Joyce, Paul	COS/ Mathematics	Wichman, Holly	Miller, Craig	Patterns of Adaptive Evolution	$266,408
National Institutes of Health	Forney, Larry	COS/ Biological Sci	None	None	Eco-Pathogenomics	$183,218
National Science Foundation	Tank, David	CNR/Forestry	Marx, Hannah	None	Graduate Research - Marx	$1,500
National Institutes of Health	Forney, Larry	COS/ Biological Science	None	None	Marmoset Project	$103,560
National Institutes of Health	Forney, Larry	COS/ Biological Science	None	None	Marmoset Project	$84,020
National Institutes of Health	Top, Eva	COS/ Biological Science	None	None	Plasmid Host-Range	$312,218
National Institutes of Health	Top, Eva	COS/ Biological Science	None	None	Plasmid Host-Range	$13,876
National Science Foundation	Foster, James	COS/ Biological Science	Foster, James	None	BEACON Administrative Support	$38,224
National Science Foundation	Foster, James	COS/ Biological Science	Foster, James	None	BEACON Administrative Support	$49,759
National Science Foundation	Soule, Terence	COE/ Computer Science	Foster, James	None	MichSU BEACON Yr2-Soule	$17,754
National Science Foundation	Soule, Terence	COE/ Computer Science	Foster, James	None	MichSU BEACON Yr2-Soule	$26,994
National Science Foundation	Harmon, Luke	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Harmon	$727
National Science Foundation	Sullivan, Jack	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Sullivan	$10,472
National Science Foundation	Wichman, Holly	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Wichman	$65,799
National Science Foundation	Rosenblum, Erica	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Rosenblum	$47,834
National Science Foundation	McGowan, Craig	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-McGowan	$43,285
National Science Foundation	McGowan, Craig	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-McGowan	$46,337
National Science Foundation	Hohenlohe, Paul	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Hohenlohe	$18,000
National Science Foundation	Hohenlohe, Paul	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Hohenlohe	$22,575
National Science Foundation	Top, Eva	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Top	$34,735
National Science Foundation	Tank, David	CNR/Forestry	Foster, James	None	MichSU BEACON Yr2-Tank	$40,684
National Science Foundation	Heckendorn, Robert	COE/ Computer Science	Foster, James	None	MichSU BEACON Yr2-Heckendorn	$20,590
National Science Foundation	Foster, James	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Foster	$1,453
National Science Foundation	Foster, James	COS/ Biological Science	Foster, James	None	MichSU BEACON Yr2-Foster	$1,454
Department of Defense	Top, Eva	COS/ Biological Science	Forney, Larry	None	Plasmid Persistance	$997,826
National Science Foundation	Heckendorn, Robert	COS/ Biological Science	Foster, James	None	BEACON Summit to Catalyze Diversity	$2,500
National Science Foundation	Harmon, Luke	COS/ Biological Science	Foster, James	None	BEACON:Symbiotic bacteria in a predator-prey coevolutionary arms race	$17,770
National Science Foundation	Foster, James	COS/ Biological Science	Luke Harmon	Travis Hagey	BEACON - Optimization of the Gecko Adhesive System	$45,313
National Institutes of Health	Forney, Larry	COS/ Biological Science	None	None	COBRE III Center for Research on Processes in Evolution	$434,296
National Institutes of Health	Forney, Larry	COS/ Biological Science	None	None	COBRE III Computational Resources Core	$254,365
National Institutes of Health	Forney, Larry	COS/ Biological Science	None	None	COBRE III Genomics Resources Core	$352,262
# OF AWARDS RECEIVED: 31				**TOTAL AMOUNT OF AWARDS RECEIVED:**		**$3,555,808**

Appendix 1 (cont.) - Grants Expenditures

FY2013 IBEST GRANT EXPENDITURES						
SPONSOR	College/Dept	PI	Award Title	Direct Expenditur	F&A Expenditur	Total Expenditur
NIH	COS/BioScience	Forney Larry	COBRE Proj 5 Yr 5	$141,872	$55,768	$197,640
NSF	COS/BioScience	McGowan Craig	BEACON Yr2-McGowan	$57,881	$26,220	$84,101
NSF	COS/BioScience	Robison Barrie	UBM UI-WSU Math Bio	$10,718	$0	$10,718
NSF	COS/BioScience	Robison Barrie	UBM UI-WSU Par Sup	$34,500	$8,625	$43,125
NIH	COS/BioScience	Forney Larry	U01 Genomic Tools for HVM	$13,995	$6,074	$20,069
NIH	COS/BioScience	Forney Larry	ECO-PATHOGENOMICS IV	$119,388	$50,964	$170,352
Procter & Gamble	COS/BioScience	Forney Larry	Vaginal & Vulvar Microbial Comm	$86,065	$21,516	$107,582
Procter & Gamble	COS/BioScience	Forney Larry	Microbiota	$31,405	$7,851	$39,256
NIH	COS/BioScience	Forney Larry	Marmoset Project	$58,107	$25,219	$83,326
Procter & Gamble	COS/BioScience	Forney Larry	Bacterial Biofilms	$81,268	$19,509	$100,777
NIH	COS/BioScience	Forney Larry	COBRE Admin Core Yr 5	$38,964	$16,910	$55,874
NIH	COS/BioScience	Forney Larry	COBRE Admin Core Yr 5	$210,803	$69,138	$279,942
NIH	COS/BioScience	Forney Larry	COBRE CRC Yr 5	$259,342	$41,350	$300,692
NIH	COS/BioScience	Forney Larry	COBRE Seq GRC Yr 5	$258,058	$46,824	$304,882
NIH	COS/BioScience	Forney Larry	COBRE Seq Pilots Yr 5	$43,223	$18,759	$61,982
NIH	COS/BioScience	Forney Larry	COBRE III Admin Yr 1	$69,817	$31,627	$101,444
NIH	COS/BioScience	Forney Larry	COBRE III CRC Yr 1	$61,767	$27,981	$89,748
NIH	COS/BioScience	Forney Larry	COBRE III GRC Yr 1	$68,883	$31,042	$99,925
NIH	COS/BioScience	Forney Larry	COBRE III Tech Access	$580	$263	$843
NSF	COS/BioScience	Foster James	BEACON Yr 2 Admin	$105,969	$28,030	$133,999
NIH	COS/BioScience	Forney Larry	COBRE Proj 3 Yr 5- Brown	$136,318	$59,162	$195,480
NSF	COS/BioScience	Wichman Holly	Probing Retrotransposon	$2,474	$1,121	$3,594
NIH	COS/BioScience	Forney Larry	Eco-Pathogenomics III	$23,974	$10,186	$34,160
NSF	COS/BioScience	Rosenblum Erica	BEACON Yr 2	$38,306	$16,055	$54,361
NIH	COS/Math	Joyce Paul	Patterns Adaptive Evolution	$211,228	$87,605	$298,833
NSF	COS/BioScience	Harmon Luke	BEACON Yr-2	$13,267	$6,010	$19,276
NSF	COS/BioScience	Harmon Luke	Workflows for the Tree of Life	$470,331	$65,566	$535,897
NSF	COE/Comp Science	Heckendorn Robert	BEACON Yr2 - Heckendorn	$18,081	$5,264	$23,345
NSF	COS/BioScience	Hohenlohe Paul	BEACON Yr2 - Hohenlohe	$15,729	$6,521	$22,249
NIH	COS/BioScience	Forney Larry	Human Microbiome Project 2	$0	$0	$0
NSF	CNR/Forestry	Tank David	Species Delimitation Radiation	$3,015	$1,366	$4,381
NSF	COS/BioScience	Harmon Luke	How Geckos Stick	$14,920	$0	$14,920
NIH	COS/BioScience	Top Eva M.	Plasmid Host-Range	$218,322	$94,384	$312,706
NSF	COS/BioScience	Top Eva M.	BEACON Yr 2 - Top	$246	$111	$357
Dept of Defense	COS/BioScience	Top Eva M.	Plasmid Persistance	$119,137	$53,969	$173,106
NSF	COS/BioSci	Wichman Holly	BEACON Yr 2	$30,151	$13,658	$43,810
NSF	COE/Comp Science	Soule Terence	BEACON Yr 2	$27,060	$10,783	$37,842
NSF	COS/BioScience	Sullivan Jack	BEACON Yr 2	$31,677	$13,747	$45,424
NSF	CNR/Forestry	Tank David	Grad Student Research - Marx	$1,914	$0	$1,914
NSF	CNR/Forestry	Tank David	BEACON Yr 2-Tank	$28,909	$11,271	$40,180
TOTAL EXPENDITURES FOR FY2013:				**$3,157,665**	**$990,446**	**$4,148,111**

Appendix 2 - Research Publications

Acharya, S., Peters, A., Norton, A., Murdoch, G. K., Hill, R. A. Change in Nox4 expression is accompanied by changes in myogenic marker expression in differentiating C2C12 myoblasts. Pflugers Arch. 2013 Aug; 465(8):1181-96. doi:10.1007/s00424-013-1241-0

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Alle HK, Bunge J, Foster JA, Bayles DO, Stanton TB. Estimation of viral species richness from shotgun metagenomes using a frequency count approach. Microbiome. 2013 Feb 4; 1:5. doi:10.1186/2049-2618-1-5

Anderson CJR, Harmon LJ. Ecological and mutation-order speciation in digital organisms. American Naturalist. 2013; doi:10.5061/dryad.b87rp

Aurzada F, Gao F, Kühn T, Li WV, Shao QM. Small deviations for a family of smooth Gaussian processes. J. Theoret. Probab. 2013 Mar 1; 26(1):153–168. doi: 10.1007/s10959-011-0380-5

Baumgardt JA, Goldberg CS, Reese KP, Connelly JW, Musil DD, Garton EO, Waits LP. A method for estimating population sex ratio for sage-grouse using noninvasive genetic samples. Molecular Ecology Resources. 2013 May; 13(3):393-402. doi:10.1111/1755-0998.12069.

Beauileu JM, Tank DC, Donoghue MJ. A Southern Hemisphere origin for campanulid angiosperms and traces of the break-up of Gondwana. BMC Evolutionary Biology. 2013 Apr 8; 13:80. PMC3636071. doi:10.1186/1471-2148-13-80.

Benner MJ, Settles ML, Murdoch GK, Hardy RL, Robison BD. Sex-specific transcriptional responses of the zebrafish (Danio rerio) brain selenoproteome to acute sodium selenite supplementation. Physiological Genomics. 2013 Aug 1; 45(15):653-66. PMC3742966. doi:10.1152/physiolgenomics.00030.2013.

Blanquart F, Kaltz O, Nuismer SL, Gandon S. A practical guide to measuring local adaptation. Ecology Letters. 2013 Jul 15; 16:1195–1205. doi:10.1111/ele.12150

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Brown CJ, Millstein J, Williams CJ, Wichman HA. Selection Affects Genes Involved in Replication during Long-Term Evolution in Experimental Populations of the Bacteriophage ϕX174. PLoS ONE. 2013 Mar; 8(3):e60401. PMC23533679. doi: 10.1371/journal.pone.0060401.

Brown CJ, Sen D, Yano H, Bauer ML, Rogers LM, Van der Auwera GA, Top EM. Diverse broad-host-range plasmids from freshwater carry few accessory genes. Applied and Environmental Microbiology. 2013.

Brown CJ, Stancik AD, Roychoudhury P, Krone SM. Adaptive regulatory substitutions affect multiple stages in the life cycle of the bacteriophage ϕX174. BMC Evolutionary Biology. 2013 Mar 18; 13:66. PMC23506096. doi:10.1186/1471-2148-13-66.

Appendix 2 (cont.) - Research Publications

Carstens BC, Brennan RS, Chua V, Duffie CV, Harvey MG, Koch RA, McMahan CD, Nelsen BJ, Newman CE, Satler JD, Seeholzer G, Prosbic K, Tank DC, Sullivan J. Model selection as a tool for phylohgeographic inference: An example from the willow Salix melanopsis. Molecular Ecology. 2013 Aug; 22(15):4014-28. doi: 10.1111/mec.12347.

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Eastman JM, Harmon LJ, Tank DC. Congruification: support for time-scaling large phylogenetic trees. Methods in Ecology and Evolution. 2013 Apr 29; 4(7):688-691. doi:10.1111/2041-210X.12051

Fant JB, Weinberg-Wolf H, Tank DC, Skogen KA. Microsatellite primers in Castilleja sessiliflora (Orobanchaceae), a perennial forb of the shortgrass prairie. Applications in Plant Sciences. 2013 Jun; 1(6):1200564. doi: http://dx.doi.org/10.3732/apps.1200564

Gao F. A simple proof of the right-hand rule. College Math. J. 2013 May; 44(3):227–229. doi:http://dx.doi.org/10.4169/college.math.j.44.3.227

Gao F. Bracketing entropy of high dimensional distributions. Progress in Probability. 2013; 66(3-17). doi:10.1007/978-3-0348-0490-5_1

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Gao F, Liu Z, Yang X. Comparison for upper tail probabilities of random series. J. Korean Stat. Soc. 2013 Feb. doi:10.1016/j.jkss.2013.01.005

Gao F, Wellner JA. Global rates of convergence of the MLE for multivariate interval censoring. Electron. J. Stat. 2013; 7:364–380. doi:10.1214/13-EJS777

Appendix 2 (cont.) - Research Publications

Gaze WH, Krone SM, LarssonDGJ, Li XZ, Robinson JA, Simonet P, Smalla K, Timinouni M, Topp E, Wellington EM, Wright GD, Zhu YG. Influence of Humans on Evolution and Mobilization of Environmental Antibiotic Resistome. Emerging Infectious Diseases. 2013 Jul; 19(7). PMC23764294. doi:10.3201/eid1907.120871.

Goldberg CS, Sepulveda A, Ray A, Baumgardt J, Waits LP. Environmental DNA as a New Method for Early Detection of New Zealand Mudsnails (Potamopyrgus Antipodarum). Freshwater Science. 2013 Sep; 32(3):792-800. doi:http://dx.doi.org/10.1899/13-046.1

Harmon LJ, Baumes J. Arbor: Comparative Analysis Workflows for the Tree of Life. PLoS Currents. 2013 Jun 21; 1. PMC23811960. doi:10.1371/currents.tol.099161de5eabdee073fd3d21a44518dc.

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Appendix 2 (cont.) - Research Publications

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Appendix 2 (cont.) - Presentations at conferences

Presentations & Seminars

Date	Title	Event	Organization Level	Faculty
Tuesday Jan 15, 2013	Comparative methods for unraveling adaptive radiations	University of Florida, Department seminar	National	Luke Harmon
Friday Jan 25, 2013	Population genomics in evolutionary and conservation biology	department seminar, University of Colorado	National	Paul Hohenlohe
Monday Feb 11, 2013	The human vaginal microbiome: rethinking health and disease	University of Oklahoma. President's Dream Course: The Human Micriobiome.	National	Larry Forney
Thursday Feb 14, 2013	Progressive radiations and polyploidy: investigating evolutionary patterns across scales using plant phylogenies	Department Seminar, Department of Biology, University of Florida	National	David Tank
Tuesday Feb 26, 2013	Comparative methods for unraveling adaptive radiations	American Museum of Natural History Seminar Series	National	Luke Harmon
Wednesday Feb 27, 2013	Size effects rainbow trout (Oncorhynchus mykiss) utilization of dietary carbohydrates and lipid deposition over time	Aquaculture America	National	Matt Powell
Thursday Feb 28, 2013	Comparative methods for unraveling adaptive radiations	U Mass - Boston Department Seminar	National	Luke Harmon
Thursday Feb 28, 2013	Dietary purple corn extract affects plasma antioxidant potential and lipid retention in rainbow trout (Oncorhynchus mykiss)	Aquaculture America Annual Meeting	National	Matt Powell
Thursday Feb 28, 2013	Optimal dietary N-3 fatty acid requirement of rainbow trout fry	Aquaculture America Annual Meeting	National	Matt Powell
Thursday Feb 28, 2013	Progressive radiations and polyploidy: investigating evolutionary patterns across scales using plant phylogenies	Department Seminar, Department of Botany, Smithsonian Institute	National	David Tank
Monday Mar 04, 2013	De novo generation of bound structures for an intrinsically disordered protein using only alpha carbon chemical shifts	Biophysical Society Annual Meeting	National	F Ytreberg
Wednesday Mar 06, 2013	Changes in gene expression in PCB-exposed and reference wild rainbow trout	Society of Toxicology Annual Meeting	National	Matt Powell
Wednesday Mar 13, 2013	Mechanisms underlying microphthalmia in zebrafish embryos exposed to ethanol	Bowles Center for Alcohol Studies Seminar Series, North Carolina Central University	National	Deborah Stenkamp
Monday Mar 18, 2013	Community ecology and the human vaginal microbiome	Institute of Medicine, National Academy of Sciences, Forum on Microbial Threats: Microbial Ecology in States of Health and Disease	National	Larry Forney
Wednesday Mar 20, 2013	Understanging and interpreting the growing tree of life	Gonzaga University - Department Seminar	Regional	Luke Harmon
Tuesday Mar 26, 2013	The dimensionality of reproductive isolation and speciation	ESF Workshop on speciation genetics and genomics, EAWAG, Switzerland	International	Paul Hohenlohe
Wednesday Apr 17, 2013	Role of the early ocular vasculature in regulating retinal neurogenesis	Biology Department Seminar, Gonzaga University	Regional	Deborah Stenkamp
Monday Apr 15, 2013	Community ecology of the human vaginal microbiome	Cornell University. Grand Rounds.	National	Larry Forney

Appendix 2 (cont.) - Presentations at conferences

Date	Title	Event	Organization Level	Faculty
Monday Apr 16, 2013	Reproductive contributions from migratory Oncorhynchus mykiss colonizing a natal stream after barrier removal	Western Division American Fisheries Society Meeting	Regional	Matt Powell
Tuesday Apr 16, 2013	Particle Systems and Reaction-Diffusion Equations: connecting micro and macro models	Mathematical Biosciences Institute: Spatial Models of Micro and Macro Systems	National	Steve Krone
Monday Apr 17, 2013	Colonization of steelhead (Oncorhynchus mykiss) in a natal stream after barrier removal	Western Division American Fisheries Society Meeting	Regional	Matt Powell
Friday Apr 19, 2013	Community ecology of the human vaginal microbiome	University of Arizona	National	Larry Forney
Saturday Apr 20, 2013	Tracking hybridization of red wolves and coyotes	Invited University seminar	National	Lisette Waits
Monday Apr 21, 2013	Evaluation of Ulva clathrata meal supplementation in fish meal vs. plant protein-based diets for rainbow trout Oncorhynchus mykiss	International Seaweed Symposium	International	Matt Powell
Monday Apr 22, 2013	Evolution Short and Long: A Paradox in Reverse	University of Idaho, Coeur d'Alene - Seminar series	Regional	Luke Harmon
Monday Apr 22, 2013	Population genomics for evolutionary and conservation biology in non-model organisms	department seminar, University of Arizona	National	Paul Hohenlohe
Monday Apr 29, 2013	Shifts in the Host Range of Promiscuous Drug Resistance Plasmids	Departmental Seminar, University of Montana	Regional	Eva Top
Tuesday Apr 30, 2013	Understanging and interpreting the growing tree of life	ETH Zurich - Seminar	International	Luke Harmon
Wednesday May 01, 2013	Understanging and interpreting the growing tree of life	University of Lausanne - Department Seminar	International	Luke Harmon
Wednesday May 15, 2013	Coevolution and the architecture of mutualistic networks	Invited Departmental Seminar. University of Illinois	National	Scott Nuismer
Thursday May 16, 2013	The Next Generation of Systematics: (sub)genomic approaches to large scale data collection and phylogenetic analysis of plants	Inland Northwest Genomics Symposium, IBEST, University of Idaho	Regional	David Tank
Monday Jun 10, 2013	Function valued trait analysis of domestication selection	Society for the Study of Evolution	National	Barrie Robison
Saturday Jun 22, 2013	Systematic Biology 20 Years after Evoltuion 1993 and W(h)ither the Species Tree	Presidential Address to the Society of Systematic Biologists	International	John (Jack) Sullivan
Sunday Jun 23, 2013	Arbor: Comparative Analysis Workflows for the Tree of Life	Evolution Meetings (symposium talk)	International	Luke Harmon
Saturday Jul 06, 2013	Tutorial: Designing and Building Powerful, Inexpensive Robots for Evolutionary Research	Genetic and Evolutionary Computation Conference (GECCO)	International	Terence Soule
Sunday Jul 14, 2013	Best practices for eDNA analysis	Symposium - Society for Conservation Biology	International	Lisette Waits
Tuesday Jul 16, 2013	Genomic patterns of differentiation between populations: what do the data actually mean?	Gordon Research Conference: Ecological and Evolutionary Genomics	International	Paul Hohenlohe
Thursday Jul 18, 2013	Structure, Function and Diversity of the Human Vaginal Microbiome.	International Congress of Mucosal Immunology	International	Larry Forney

Appendix 2 (cont.) - Presentations at conferences

Date	Title	Event	Organization Level	Faculty
Tuesday Aug 06, 2013	Gene expression rainbow trout (oncorhynchus mykiss), Nile tilapia (oreochromis niloticus), and white sturgeon (Acipenser transmontanus) erythrocytes under differing glycemic conditions.	Annual meeting of Idaho INBRE program	Regional	Matt Powell
Tuesday Aug 06, 2013	Toward Using Intrinsic Disorder to Manipulate Cell Signaling Networks	Idaho INBRE Annual Conference	Regional	F Ytreberg
Thursday Aug 08, 2013	Detecting the Signature of Species Interactions in the Tree of Life	ESA Meetings - symposium talk	International	Luke Harmon
Wednesday Aug 28, 2013	A Bayesian missing data approach for interval-censored and truncated covariates	The 34th Annual Conference of the International Society for Clinical Biostatistics	International	Michelle Wiest
Saturday Sep 14, 2013	Modeling with Interacting Particle Systems, part II	International Graduate Training Centre in Mathematical Biology Annual Summit	International	Steve Krone
Sunday Sep 15, 2013	Particle Systems, reaction-diffusion equations, and spiral waves	International Graduate Training Centre in Mathematical Biology Annual Summit	International	Steve Krone
Thursday Sep 26, 2013	Stickbreaking: A novel fitness landscape model that harbors epistasis and is consistent with commonly observed patterns of adaptive evolution. Mathematical tools for evolutionary systems biology	Banff International research station for mathematical innovation and discovery	International	Paul Joyce

Appendix 3 - Technology Access Grants awarded

2013 Technology Access Grants Awarded		
Name	**Project**	**Amount**
COMPLETED TECHNOLOGY ACCESS GRANTS		
Fuerst, Peter	To initiate research related to cell signaling within the vertebrate retina.	$8,460.00
Brown, Celeste Karasev, Alexander	To sequence the complete genomes of 196 samples of *Potato Virus Y* collected from a field test site for PVY infection.	$6,266.00
Miura, Tanya Miller, Craig	To use microarray technology to characterize thecellular rsponses to infection by respiratory viruses and determine how these responses are altered during infection by a second, unrealted respiratory virus.	$12,680.00
Fortunato, Lee	To use Nimblegen microarrays to study cell signaling.	$4,400.00
Waits, Lisette	To find single nucleotide polymorphism (SNP) and microsatellite markers. This research seeks to understand the impact of forest fragmentation on the genetic diversity and reproductive ecology of bat-pollinated and bat-dispersed mid canopy tree species in the Caribbean lowlands of Costa Rica.	$15,000.00
RECENTLY AWARDED TECHNOLOGY ACCESS GRANTS		
Balemba, Onesmo	To study high-fat diet-induced enteric neuropathy to accomplish necessary research experiments and generate data that will enhance my competitiveness for external funding.	$4,835.00
Sullivan, Jack	To study the importance of geographics mosaics of coevolution and the phylogeography of a set of tightly interacting plants and insects from southern South America.	$6,200.00

Appendix 4 - Inland Northwest Genomics Resources Symposium

INWGRS Participants

Education	Number of Attendees
Central Washington University	1
Eastern Washington University	1
Gonzaga University	1
Idaho INBRE	1
Idaho State University	5
Lewis-Clark State College	1
North Idaho College	1
Northwest Nazarene University	1
School for Global Animal Health, WSU	1
UI North Idaho	1
Universidad Complutense de Madrid	2
Universita` di Genova, Italy	1
University of Idaho	87
University of Montana	2
UW	1
Walla Walla CC	1
Washington State University	26

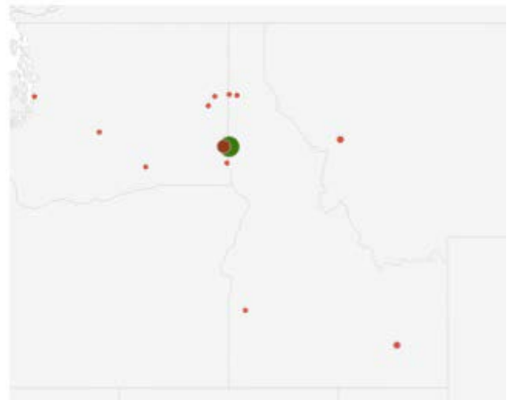
Industry	Number of Attendees
Bio-Rad	1
BioTeam	1
Fluidigm	2
Illumina	2
Institute for Systems Biology	1
Phytelligence	1
PNNL	1
Qiagen Inc.	1
Roche Applied Science	2

Agency	Number of Attendees
USDA-ARS	3

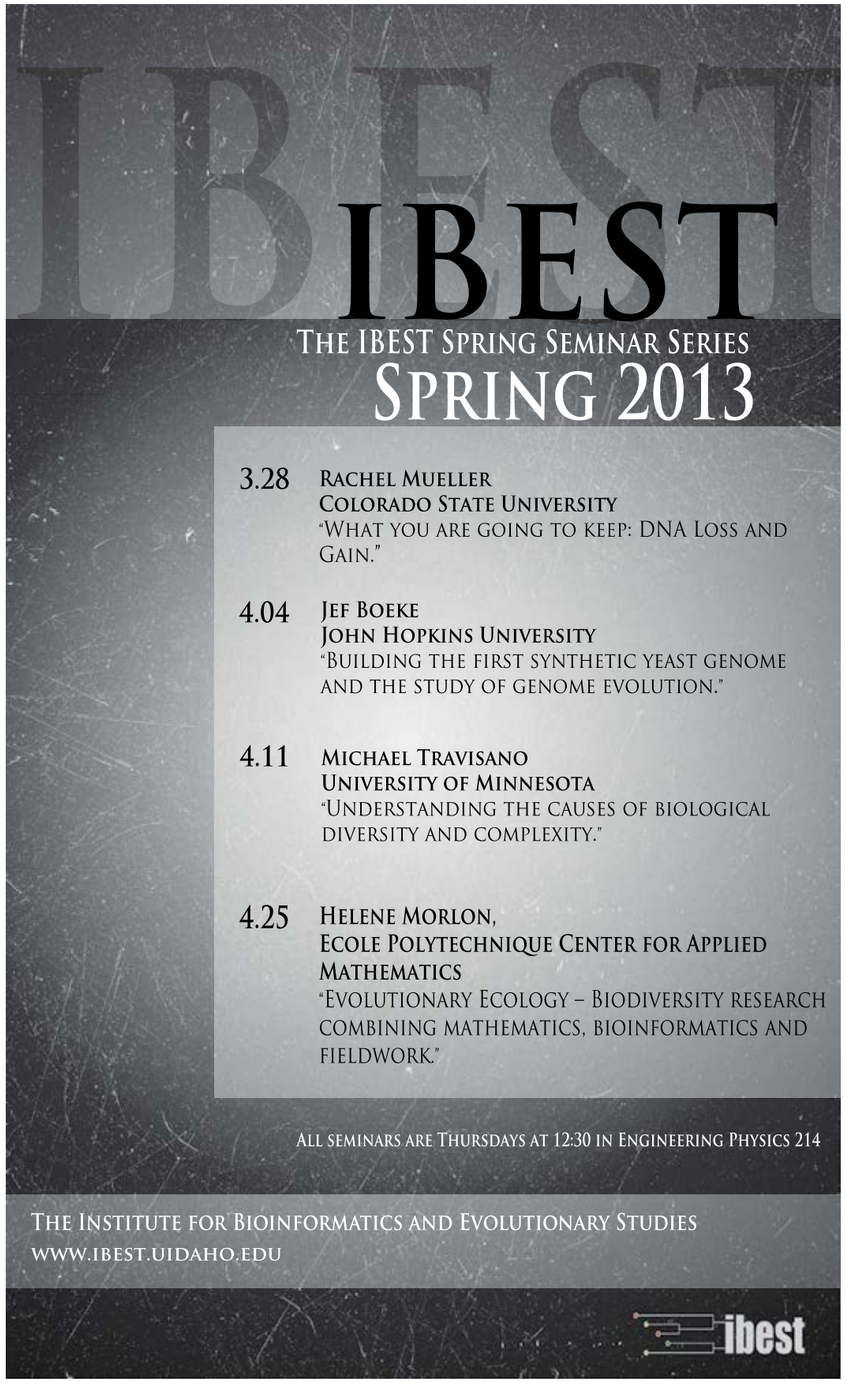
Total	149

INWGRS Participant Dynamics

35	Professors
29	Grad Student
19	Scientists & Geneticists
12	Researchers
12	Students
11	Post doc
8	Directors
6	Grad Research Asst
5	Admin Staff
3	Sales Rep
2	Technician
2	System Admins
2	Sequencer
1	President
1	Dean
1	CEO
149	**TOTAL**



Appendix 5 - IBEST Seminars in Spring 2013



Appendix 5 (cont.) - IBEST Seminars in Fall 2013

Appendix 6 - BEACON funded projects

UI PI	CO PIs (UI members bold)	PROJECT TITLE	AMOUNT
Soule, Terence		Evolutionary Games K - 6	$6,395
Soule, Terence	Getty	Evolution curriculum for elementary classrooms: implementation and assessment of LadyBug and supporting activities	$35,504
Soule,Terence	**Heckendorn**, McKinley, Zhan, Harrison, Espinosa	Distributed, Onboard Evolution in a Robotic Cloud	$53,989
Harmon, Luke	Boughman, Lenski, Williams	Mystery of Mysteries	$3,442
Harmon, Luke	Eisthen, Zakon, Liebeskind	Evolution of mechanisms enabling the use of a neurotoxin as a pheromone	$1,453
Harmon, Luke	Felsenstein	Long-term consequences of evolution in action examined over a phylogeny	$65,306
Sullivan, Jack	Hillis	An integrated approach to testing divergence with gene flow model of speciation; empirical genomics: simulation, and in silico evolution	$117,894
Wichman, Holly	Ellington	Evolution of synthetic genomes	$116,154
Wichman, Holly	**Miura**, Bull	A tractable animal model for experimental viral evolution	$131,598
Harmon, Luke	**Hohenlohe**, Rosenblum, Boughman	The Genetic Architecture of Multidimensional Adaptation and Speciation	$179,244
McGowan, Craig	Gutmann, McKinley, Moore	Why hop? Understanding morphology, mechanics, and natural selection in the evolution of bipedal hopping	$92,674
Hohenlohe, Paul	Williams	An experimental evolution model for genomic islands of speciation	$72,006
Top, Eva	**Forney,** Kerr, Ofria, Pennock, Wilke	Slow and steady wins the race? Adaptation in structured worlds	$69,468
Tank, Dave	**Foster**, Conner	The genetic basis of weediness: rapid evolution of flowering time in wild radish,	$81,368
Heckendorn, Robert	Dworkin, Lenski	Cross-fertilization of techniques for epistasis from evolutionary computation and biology	$41,183
Foster, James	Day, **Soule,** Dozier, Ofria	Teaching evolution through action: the Avida challenge	$23,594
Foster, James	**Soule,** Pennock, Ofria, Graves, Smith,Swalla, Wilke	Avida-ED Infrastructure Maintenance and Development	$3,651
Foster, James	**Soule**, Pennock, Mead, Graves, Kerr, Wilke, Smith, Lark, Johnson	Avida-ED Curriculum Development and Assessment Pilot Study	$2,500
Heckendorn, Robert	Clarke	BEACON Summit to Catalyze Diversity	$5,000
Foster, James	**Harmon,** Eisthen, Vaelli, Theis	The role of symbiotic bacteria in a predator-prey coevolutionary arms race	$35,540
Hagey, Travis	Riley, Soroushian	Optimization of the Gecko Adhesive System	$90,627
Heckendorn, Robert		Sabbatical Support	$73,255
O'Rourke, Michael	Pennock	Developing a virtue-based approach to RCR training	$1,500
Foster, James	**Heckendorn, Soule**, Poulin	Idaho Administrative Budget	$654,183
Foster, James		Idaho Administrative Budget	$240,864
		TOTAL BEACON FUNDING TO DATE:	**$2,198,392**

	Post docs funded:	Martina Ederer, Ann Gutmann, Josef Uyeda, Jonathan Eastman, Travis Hagey, Thibault Stalder
	Grad Students :	Tyler Hether, Josh Rubini, Brice Sarver, Simon Uribe Convers, Max McKinnon, Travis DeVault, Kayla Hardwick, Julie Hughes, Juan Marulanda Arias, Janet Williams
	Undergrads funded:	Katie Slavens, Rebecca McKenzie, Tracy Myron, Justin Anast, Cody Wiench,

Appendix 7 - Strategic Reinvestments

IBEST Strategic reinvestments FY2013		
Description	**Amount**	**Impact**
Distribution of earned F&A		
Earned F&A returned to faculty	$34,266	Principal investigators
Earned F&A returned to departments		
Biological Sciences	$21,851	Biological Sciences
Mathematics	$993	Mathematics
Statistics	$833	Statistics
Total earned F&A returned	$57,943	
New faculty recruitment		
Research start up	$95,437	College of Science-Biological Sciences
Research start up	$50,000	College of Science-Biological Sciences
Research start up	$10,000	College of Science-Biological Sciences
Research start up (FY 2014-2016)	$165,000	College of Science-Biological Sciences
Total new faculty recruitment	$155,437	
Research support		
Technology Access Grants	$43,223	University community
IBEST website development	$11,250	University community
IBEST reporting site development	$25,489	University community
iLab solutions - core facility management	$16,500	University community
Publication charges	$3,310	Biological Sciences
INBRE Summer symposium	$5,000	State of Idaho
MATTLAB Liscense	$1,500	College of Science
IBEST Seminar series	$21,387	University community
Inland Northwest Genomics Research Symposium	$7,500	Inland Northwest
Total research support	$135,159	
Student support		
BCB Gradaute student fellowships	$105,500	College of Science-Biological Sciences
BCB Gradaute student travel grants	$4,500	College of Science-Mathematics
BCB Gradaute student group	$1,000	College of Science-Biological Sciences
BCB Graduate student office supplies	$500	College of Science-Biological Sciences
UBM Summer students	$380	College of Science-Mathematics
BEACON 101 Students	$200	College of Science-Biological Sciences
Graduate student bridge stipend	$12,019	College of Science-Biological Sciences
Graduate student bridge tuition	$9,593	College of Science-Biological Sciences
Sponsor Women in Science seminar series	$2,000	State of Idaho
Computer for Metamorph program	$1,000	College of Science-Mathematics
Total student support	$136,692	
TOTAL IBEST STRATEGIC REINVESTMENTS	**$485,231**	
Sources of investment funds		
IBEST Earned F&A returned to faculty	$219,384	
COBRE grant funds	$154,847	
Other IBEST resources	$111,000	
TOTAL INVESTMENT SOURCES	**$485,231**	

Appendix 8 - Earned F&A

Facilities and Administrative Cost Recoveries Earned by IBEST and allocated by ORED to IBEST Overhead Return budget AB6317						Period Ending June 30, 2012		
FY2012						IBEST INTERNAL DISTRIBUTIONS		
PI Name	**Agency Name**	**FY12 Total Expenditures**	**FY12 Total F&A**	**UI Admin 75% of F&A**	**IBEST 25% of F&A**	**PI 15%**	**Dept 10%**	**IBEST 75%**
FORNEY	NIH COBRE	$1,908,833	$419,745	$314,809	$104,936	$15,740	$10,494	$78,702
FORNEY	OTHER	$523,411	$126,026	$94,520	$31,507	$4,726	$3,151	$23,630
JOYCE	DHHS-NIH	$261,844	$79,445	$59,584	$19,861	$2,979	$1,986	$14,896
ABDO	NIH-UMD	$117,879	$33,309	$24,982	$8,327	*	833	$6,245
								$1,249
TOP	DHHS	$372,354	$112,251	$84,188	$28,063	$4,209	$2,806	$21,047
FOSTER	NSF-BEACON	$551,568	$160,557	$120,418	$40,139	$6,021	$4,014	$30,104
ROBISON	NSF-UBM	$44,750	$8,950	$6,713	$2,238	$336	$224	$1,678
PI Name	**Agency Name**	**FY12 Total Expenditures**	**FY12 Total F&A**	**UI Admin 50% of F&A**	**IBEST 50% of F&A**	**PI 15%**	**Dept 10%**	**IBEST 75%**
HARMON	NSF	$1,151	$359	$180	$180	$27	$18	$135
NUISMER	NSF	$9,737	$3,031	$1,516	$1,516	$227	$152	$1,137
	TOTALS	$3,791,527	$943,673	$706,907	**$236,766**	**$34,266**	**$23,677**	**$178,823**

Appendix 9 - Salary Averages and Cost of Living

	UI First Quartile	National Avg	Regional Avg	of National	of Regional	Diff National	Diff Regional
Linux System Administrator	$44,491.20	$72,000.00	$50,000.00	38.21%	11.02%	$27,508.80	$5,508.80
Senior Linux System Administrator	$44,491.20	$84,000.00	$59,000.00	47.03%	24.59%	$39,508.80	$14,508.80
HPC System Administrator	$44,491.20	$93,000.00	$65,000.00	52.16%	31.55%	$48,508.80	$20,508.80
Computer Science Graduate		$58,000.00	$53,000		23.29%		

Moscow, ID - Cost of Living
5.8% above the Idaho average
3.7% lower than the National average

Moscow, ID - Employment Income
28% lower than the Idaho average
43.6% lower than the national average

Moscow, ID - Average Housing Value
20% above the Idaho average
0.1% lower than the national average

The Moscow statistics only include permanent residents. Data collected from the 2010 census

Average starting salary for a computer science graduate:
$58,547 - *Source: September 2013 Salary Survey, National Association of Colleges and Employers*

Appendix 10 - Maintenance and replacement plans for major OIC instrumentation

Careful consideration is taken on choosing which instruments to provide in the OIC, which maintenance approach to choose for each instrument and when an instrument should be retired or replaced. Though a manufacturer provided service contract is the safest approach, the cost and quality of such contracts should be compared to the option of self-insurance. With self-insurance there is more risk and unpredictable expense, yet, we may anticipate a savings of $10,000-15,000 annually for each instrument that is self-insured. The age and efficiency of an instrument, it's frequency of use and whether a delay in service is acceptable will be taken into consideration when making a choice on a maintenance plan. Table 1 shows the current plans for major instruments in the OIC.

Table 1. Maintenance and replacement plans for major instruments in FY2014 – FY2018

Instrument		FY2014	FY2015	FY2016	FY2017	FY2018
Laser scanning confocal	Active	Yes	Yes	Yes	Yes	Replace
	Maintenance*	Contract	Contract	Self-insure	Self-insure	Warranty
Cell sorter	Active	Yes	Yes	Yes	Replace	Yes
	Maintenance	Contract	Contract	Contract	Warranty	Contract
Spinning disk confocal (new in FY2015)	Active	-	Yes	Yes	Yes	Yes
	Maintenance	-	warranty	contract	contract	contract

*The three maintenance options are: contract, an annual service contract will be purchased; warranty, instrument maintenance will be covered by a vendor warranty; self-insure, instrument maintenance will be paid for on a per-service basis if deemed necessary and prudent

Appendix 11 - MSC Service and fees "Draft" (Not yet officially approved by UI Service Center Committee.

List of IBEST MSC analytical services and fees

Analytical Service	On campus	Off campus	Volume Discount
Q-Tof Premier/nanoAcquity			
Proteomic LC-MS (DDA): LC-MS/MS of trypsin-digested in gel or in solution proteins on Q-ToF Premier mass spec programmed to acquired data in Survey mode (DDA). Includes data analysis with Protein Lynx and Mascot software. Sample preparation is not included.	$120/sample	$132/sample	-10% if ≥ 10, and -20% if ≥ 20
Proteomic LC-MS (MS^e): Shot gun proteomic analysis of trypsin-digested protein mixtures to determine relative quantities of peptides and proteins. This requires multiple LC-MS per sample with data analysis using Protein Lynx Global Server and MS^e software.	$400/sample	$440/sample	
Proteomic sample preparation: reduction, alkylation, and trypsin digestion of in gel or in solution protein samples in preparation for proteomic analysis by LC-MS or maldi. Other proteases are optional.	$20/sample	$20/sample	-25% if ≥ 10
Proteomic data analysis: downloading and searching of custom databases using Protein Lynx or Mascot or other specialized data analysis acitivities.	$35/h	$38.50/h	
Maldi analysis. Acquisition of spectra and accurate mass determination within 5 ppm (run by core staff)	$30/spot	$33/spot	20% if ≥ 20
Maldi analysis (run by user)	$60/h	$66/h	20% if ≥ 20
ESI-MS-- (by infusion)	$30/sample	$33/sample	20% if ≥ 20
Xevo TQ MS/nanoAcquity			
LC-MS with quantitation by MRM or SRM	$40/sample	$44/sample	
additional injections of a sample	$5/injection	$5/injection	
LC-MS (user run)	$45/h	$50/h	20% if ≥ 20
ESI-MS (by infusion on Xevo)	$30/sample	$33/sample	
6890 GC/5973 MSD			
GC-MS (per injection)	$30/sample	$33/sample	20% if ≥ 20
Acquity LC, HP GC			
LC-UV-Vis, LC with fluorescence or other detection	$30/sample	$33/sample	20% if ≥ 20
GC-FID or GC-ECD	$20/sample	$22/sample	20% if ≥ 20
Custom assays	$35/h + cost of materials and instrument time	$38.50/h + cost of materials and instrument time	