Annual Report for Period: 02/2005 - 02/2006 **Submitted on:** 12/11/2005

Principal Investigator: Boomer, Sarah M. **Award ID:** 0237167

Organization: Western Oregon University

Title:

RUI-Microbial Observatories: A Longitudinal Molecular Diversity and Chemical Survey of Red Layer Microbial Communities in Yellowstone National Park

Project Participants

Senior Personnel

Name: Boomer, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

In addition to continuing to facilitate previously-described research-based undergraduate course lab experiences in General Microbiology and Molecular Biology, I have facilitated the following projects (with some revisions) based on specific goals in the renewed grant (to be described in more detail in other sections): (1) revised and ran 2 summer GERMS (Geochemistry and Ecology of Red Mat Systems) programs in Yellowstone - one specifically for teachers, the other for undergraduates; (2) developed and implemented 5 microbial diversity/biotechnology weekend workshops (2 of which were new) for secondary science teachers; (3) managed and advised ongoing pre-college outreach activities in microbial diversity and biotechnology (Kelly Shipley served as the primary instructor, coordinator, and assessor) for Saturday Academy, GEAR-UP, and the new WAMS program (see next item); (4) continue to co-direct campus-based pre-college outreach program WAMS, Western Adventures in Math and Science (with Kelly Shipley and 3 other Science/Math Faculty); (5) contributed to the authorship of 1 Oregon Science Teacher Association (OSTA) regional meeting poster (curriculum- and outreach-based); (6) co-authored 3 manuscripts about computational biology and photosynthesis/pigment curriculum for ASM and OSTA; and (7) and am in the process of advising an undergraduate Honors Research/Thesis projects (Jennifer Esparza).

Name: Shipley, Kelly

Worked for more than 160 Hours: Yes

Contribution to Project:

Kelly began full-time at the end of August 2004, effectively spear-heading the successful development and advertising of our new campus-based pre-college science and math outreach program, WAMS (see Activities/Findings for more information). In addition to recruiting for and facilitating WAMS (both RLMO-based and Division-wide programs), she has provided pre-college outreach modules for Saturday Academy and the GEAR-UP program (described fully in the Activities/Findings section of this report), as well as in-school activities, after-school activities and on-campus fieldtrip opportunities for local high school teachers and students. Of particular significance, Kelly created a new sustained weekend program targeted specifically for GEAR-UP students from 2 local high schools: Students Learning Interesting Microbiology Experiments (S.L.I.M.E.). She has taken an active role in co-leading undergraduate labs for Microbiology and Molecular Biology, and developed/facilitated a new DNA lab for our freshman, majors-level Principles of Biology course this fall. She also co-led both GERMS programs this summer. In total, Kelly has provided over 160 hours of educational programs, serving over 400 students (both pre-college and undergraduate). In addition to facilitating educational activities, Kelly has become an active membership of the Oregon Science Teacher Association (OSTA), providing an RLMO-informational booth and presenting a poster at the annual regional conference in October 2005, and making herself available for advising science teachers about in-class projects and outreach programs available. Kelly co-authored three curriculum-based publications (see Publications section). Kelly has been a tremendous asset, not only for RLMO-driven outreach û but also to the entire Division of Natural Science and Math. Finally, she heavily assisted Jennifer Esparza's sequencing efforts throughout the summer and will be a major research contributor to the major manuscript that develops from this work.

Name: Dutton, Bryan

Worked for more than 160 Hours: No

Contribution to Project:

Bryan, as described in the Final Report for our last MO grant, has been an outstanding colleague and collaborator, assisting with curriculum assessment and revision, manuscript development, phylogenetics, and database design. Bryan serves as one of the WAMS Co-Directors and has continued to provide a regular series of pre-college outreach modules for this program (all gratis). Bryan co-authored 1 computational biology manuscript this year for ASM.

Post-doc

Graduate Student

Undergraduate Student

Name: Students, Microbiology

Worked for more than 160 Hours: No

Contribution to Project:

A total of 32 undergraduates participated in revised Microbiology curriculum in Spring and Fall 2005. As proposed and outlined in this grant and described previously, students mastered five weeks of traditional culture-based environmental enrichment and phenotype-based identification testing followed by five weeks of culture-independent molecular methods using the RLMO project: including plasmid isolation, DNA fingerprinting, DNA sequence analysis, phylogenetics, and pigment analysis/fluorescence microscopy-based detection methods.

Name: Drury, Will

Worked for more than 160 Hours: No

Contribution to Project:

Will Drury, supported as a summer research student in 2003, has continued to assist with RLMO database modifications - funded as needed by 'Computer Services' funds. Specific upgrades Will developed for the database this year include cosemetic changes, basic maintenance during server migration, and some new query systems. Will graduated in spring 2005 and was hired by the Bend Tribune doing database and web design.

Name: Manning, Terry

Worked for more than 160 Hours: No

Contribution to Project:

In the past year, Terry finally completed his Honors Thesis, having had to take off spring term for financial reasons. Terry helped with database entry and field leadership during both summer GERMS programs and returned to school this fall to finish missed coursework from the spring. He has decided to join the Peace Corps, with the intention of pursuing either medicine or education thereafter.

Name: Esparza, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project:

As a result of participating in GERMS 2004, Jenn began work with me on her Honors Thesis. After applying in winter 2005, Jenn was awarded an ASM Undergraduate Research Fellowship (the same award Terry Manning received 2 years ago). Jenn completed extensive research over the summer 2005 (described in Activities/Findings section of this report) and is currently writing her thesis (which will be submitted for review in January 2006). She will also be preparing and delivering a research poster about this work at the ASM General Meeting in May 2006. Jenn will graduate in June, 2006 and hopes to attend medical school following graduation.

Name: Howell, Nathan

Worked for more than 160 Hours: No

Contribution to Project:

Nathan, a GERMS participant from 2004, was accepted to join GERMS again in 2005 - our only repeat offender. For participation in the 2005 GERMS program (See Activities and Findings), he received two undergraduate credits, a $250 stipend and travel support funding (total trip $2000 for 7 total people) Students spent a week at Yellowstone National Park surveying target RLMO sites and collecting water and mat samples. After field work, they spent 10 hours in the lab at WOU performing pigment analysis, chemical analyses, and completing web templates of their work. Nate will graduate in spring 2006 and is in the process of applying to dental school at this time (having changed his mind about medical school over the last year).

Name: Students, Molecular

Worked for more than 160 Hours: No

Contribution to Project:

A total of 3 biology majors participated in RLMO-based Molecular Biology lab curriculum this spring, 2005. As proposed and outlined in this grant, students isolated total genomic DNA from RLMO samples collected in 2004, amplified and cloned 16S

rRNA genes, and continued new methods in 16S-based hybridization and DGGE-based population analysis. They used lab-dedicated computers to assemble web pages about their projects, incorporating all new digital technology in the lab (digital cameras, Photodyne gel imaging system, upgraded DNA sequencer).

Name: Hanson, Nana

Worked for more than 160 Hours: No

Contribution to Project:

Nana Hanson, a visiting African student from Ghana, is a third year undergraduate at WOU. For participation in the 2005 GERMS program (See Activities and Findings), she received two undergraduate credits, a $250 stipend and travel support funding (total trip $2000 for 7 total people) Students spent a week at Yellowstone National Park surveying target RLMO sites and collecting water and mat samples. After field work, they spent 10 hours in the lab at WOU performing pigment analysis, chemical analyses, and completing web templates of their work. Nana hopes to attend medical school after completing her undergraduate degree.

Name: Huffstetter, Morgan

Worked for more than 160 Hours: No

Contribution to Project:

Morgan Huffstetter, originally from Oregon, is a third year undergraduate at WOU. For participation in the 2005 GERMS program (See Activities and Findings), she received two undergraduate credits, a $250 stipend and travel support funding (total trip $2000 for 7 total people) Students spent a week at Yellowstone National Park surveying target RLMO sites and collecting water and mat samples. After field work, they spent 10 hours in the lab at WOU performing pigment analysis, chemical analyses, and completing web templates of their work. Morgan hopes to attend medical school after completing her undergraduate degree.

Name: Students, Biology

Worked for more than 160 Hours: No

Contribution to Project:

Approximately 115 undergraduate freshmen participated in a new central dogma lab designed and facilitated in the fall of 2005 by Kelly Shipley and Sarah Boomer. Although not a stated specific goal in our grant, I (Boomer) - as a co-instructor of our important freshman-level Principles of Biology series (Biology 211) - have long felt that a DNA lab would benefit our often central-dogma-deficient freshmen. Thus, Kelly and I designed both active (DNA isolation/gel electrophoresis methods) and manipulative-driven exercises (replication, transcription, and translation modeling using lots of paper and post-it notes).

Technician, Programmer

Name: Kernan, William

Worked for more than 160 Hours: No

Contribution to Project:

As Director of Campus Computing Services, Bill continues to oversee computer service projects as carried out by students like Will (who receive the only direct support).

Other Participant

Research Experience for Undergraduates

Organizational Partners

American Society For Microbiology

ASM provided Jennifer Esparza (research student June 2004-present) with one of 25 national undergraduate summer research fellowships. Jennifer received most of this stipend for thesis-related research over summer 2005; and in May 2006, she is funded to travel to Orlando where she will present her research at the ASM General Meeting. She is currently completing her Honors Thesis.

Saturday Academy, Oregon University

Saturday Academy is a national non-profit program that provides fee-based college-level enrichment experiences for pre-college students (grades 7-12). The only local Saturday Academy program is hosted by Oregon State University. Fees, all of which go to OSU/Saturday Academy, facilitate advertising, recruitment, and registration.

Western Adventures in Math and Science

In February 2004, colleagues and I began developing and defining this new non-profit, on-campus program: Western Adventures in Math and Science (WAMS). WAMS aims to be a self-sustaining long-term program, offering low-cost science and math activities. Since the formal beginning of WAMS activities (March 2004), 15 of 30 Natural Science and Math faculty have enthusiastically devoted time (all gratis) to offering WAMS activities, providing 3-5 hour, mostly weekend workshops in biology, earth science/geology, forensics, and math. In total, 26 WAMS workshops have served 216 students.

GEAR-UP

In November 2004, we began partnering with GEAR-UP (Gaining Early Awareness and Readiness for Undergraduate Programs). GEAR-UP, which is partially funded through the Department of Education, serves 19 high schools and 22 middle schools in Oregon, including Monmouth's own Central High School. GEAR-UP's primary goal is to ensure that Oregon's low-income middle and high school students are prepared for, pursue, and succeed in postsecondary education. In the past year, Kelly Shipley served approximately 150 freshman students at Central High School in Monmouth, providing activities in DNA isolation and analysis. Kelly also developed a new cohort program with GEAR-UP called Students Learning Interesting Microbiology Experiments (SLIME). This sustained weekend program is offered to local GEAR-UP school district students as a way to enhance their knowledge of microbiology and biotechnology in a cohort format. Two cohort sessions have run during 2005, serving a total of 13 students for 9-12 hours each. Future cohort sessions are planned for Winter and Spring of 2006. Western Oregon University and Oregon GEAR-UP also jointly offered an intense one-week, on campus program for eligible high school students to learn about the Human Genome Project. During this week, 16 students spent 9 hours in our lab learning about DNA structure, DNA Isolation, DNA Fingerprinting, Biotechnology and Computational Biology using NCBI. Our partnership with GEAR-UP has grown dramatically over the last year, giving us more opportunities for outreach within the community.

Microbial Life - Educational Resources

We have contributed RLMO information, data, images, and curriculum resources/links to the Microbial Life Educational Resources (MLER), a web-based database designed at TBI (Thermal Biology Institute, Bozeman MT) and supported, in part, via an NSF-supported National Science Digital Library (NSDL) grant.

Other Collaborators or Contacts

Bev Pierson (U. Puget Sound, Tacoma, WA)- research advice
Tim McDermott (TBI/MSU, Bozeman, MT) research/culturing advice
Bill Inskeep (TBI/MSU, Bozeman, MT) - RCN grant
Mark Young (TBI/MSU, Bozeman, MT)- MO Workshop organization/grant
Maria Fung (WOU Math, Monmouth, OR) - WAMS Co-Director
Phil Wade (WOU Earth Science, Monmouth, OR) - WAMS Co-Director\
George Rice (TBI/MSU, Bozeman, MT) - MLER primary author

Activities and Findings

Research and Education Activities:

As described extensively throughout this report, this project serves undergraduate research and provides research-driven lab curricula and workshops that provide research-driven experiences for undergraduate biology and/or education majors, secondary science teachers seeking professional development or masters degrees (in education), and pre-college students. Some specific revisions relative to last year's annual report:

Owing to significant interest in the Yellowstone-based GERMS program last year (which, in 2004, served 6 undergraduates for 5 weeks), we decided to run 2 mini-GERMS field programs in 2005 plus 3 GERMS-based workshops in DNA methods. For each of the 2.5 week field courses (8 days in Yellowstone, 1 week of follow-up work in lab), we focused only on field-based survey data, including digital site documentation, water/mat collection and chemical analysis, pigment extraction/analysis, and light/fluorescence microscopy. For the first GERMS mini-field program (July 2005), we specifically targeted secondary teachers, generating immediate interest and a significant waitlist. Unfortunately, 1 of the finalists dropped out 12 hours before departure for a summer job offer û which was disappointing as we could not get an alternate to step in that late. For the second GERMS mini-field program (September 2005), we specifically targeted undergraduates at WOU. As with the teachers, 1 of the finalists dropped out 12 hours before departure because of illness. Long-term undergraduate research students

(both ASM-supported, either previously or currently), Terry Manning and Jennifer Esparza joined both trips. Given that the mini-GERMS field programs did not include specific DNA methods, we designed 3 10-hour on-campus summer workshops (Genomic Isolation/PCR, Fingerprinting/DGGE, and Sequence Analysis) that were designed to serve and target both teachers and non-majors. We provided free credits and transportation costs to 6 students and filled all spots quickly. In the end, we served 3 secondary science teachers and 3 forensic chemistry majors from WOU. Although we felt this program was successful in that it served more û and more diverse - students and teachers, we plan to return to the old format next year for 2 key reasons: (1) we did not feel we were able to present as much depth or connection between site/mat data and DNA data (and presenting or completing database entry with 2 separate groups was next to impossible); and (2) September trips to Yellowstone are very dicey in terms of weather and bison issues, particularly when dealing with field-inexperienced groups of students.

Findings:

Major research findings include two areas of progress: (1) the collection of site and community information from four long-term monitoring sites in Yellowstone (the basis for both GERMS experiences); (2) mat formation studies, the thesis work of Jennifer Esparza.

Summer monitoring activities involve several methods and findings we have described previously (site/community characterization, water/mat chemical analysis, water/mat microscopic evaluations, pigment assessment, and fluorescence microscopy). Owing to geochemical data presented at the 'Geothermal Biology and Geochemistry in Yellowstone National Park' meeting (organized by TBI/MSU, October 2003), we have continued to monitor RLMO sites at 2 timepoints: early July (teacher GERMS cohort) and mid-September (undergraduate GERMS cohort). Ongoing site and water/community assessment continues to show site-specific chemical profiles. In comparing early vs. late water chemical data, we have continued to note concentration differences that reflect data presented at the aforementioned meeting. Given this body of data, we will be mining our chemical and pigment database, and presenting long-term trends about this work for a requested/invited Yellowstone Science Journal manuscript later this spring. DNA-based monitoring, however, was not as successful this year because we attempted to teach these methods via three special GERMS workshops for teachers and non-majors/forensics students, none of whom had significant lab experience. Consequently, we plan to return to a more intensive field/DNA GERMS program next summer.

After a pilot study in 2003, we began a formal study in May 2004 to study whether layered photosynthetic mat systems with red layers could be effectively 'grown' in situ using sterile glass rods that were partially submerged in thermal run-off channels of known RLMO sites. Given that Yellowstone was extremely reluctant to approve this study because we asked to leave materials in the field for 1 year, the only study site for this experiment was Fairy Spring, owing to its distant, off-trail status. During the 2004 GERMS program, Jennifer Esparza was so taken with the rod experiment (then in progress for 1 month) when we collected the first set of new replicates that she immediately asked to work on this project for her Honors Thesis. Last fall, she formulated an appropriate hypotheses to test: that Cyanobacteria will be the most abundant phototroph in early rod biofilm communities because GNS/Chloroflexi are known to perform photosynthesis better under low light and oxygen; only after Cyanobacteria have formed a shielding layer will anoxygenic phototrophs accumulate visible layers. In the past year, Jenn and/or members of our lab collected 4 rod replicates at 4 timepoints: at 1, 2, 3.5 and 12 months. One-year rod growth was so prolific that Jenn had to dissect the sample into visible green and red layers û the only sample timepoint for which macroscopic layering was apparent. Over the summer 2005 (with support from this grant and her own ASM Undergraduate Research Fellowship), Jenn performed several analyses on each of the 5 samples (1, 2, 3.5, 12/Green, 12/Red). Before beginning, I encouraged Jenn to make all her analyses as quantitative as possible by assessing the mass of each total sample biofilm at each timepoint. After careful weighing and averaging rod contents, Jenn suspended samples and prepared equivalent-sized aliquots û used for all of the following: (1) pigment analysis (extraction of pigments from equal-sized samples from each timepoint); (2) microscopic analysis of phototrophic community members (i.e. Jenn counted equivalent sample/fields of view û assessing filaments under light, and then all fluorescing cells using 2 filters û one for chlorophyll-containing Cyanobacteria and one for bacteriochlorophyll-containing anoxygenic phototrophs); (3) 16S analysis (i.e. Jenn extracted total genomic DNA from equivalent-sized samples representing each timepoint and characterized 2 libraries of clones û all Bacteria and GNS/Chloroflexi-specific); (4) and, finally, limited culture-based studies using simple, well-described media (Nutrient, MacConkey, Starch and Casein). The latter studies were performed with equivalents sample aliquots and were meant solely to get a relative picture of media-selectable chemotroph diversity.

Jenn's data are currently being written up for her Honors Thesis and ASM General Meeting poster (to be presented in May 2005). Some trends from Jenn's representative 16S data (20 clones analyzed per Bacterial library and 10 analyzed per GNS/Chloroflexi library): after one month of biofilm growth, Jenn observed 55% chemotroph-like 16S sequences, 40% Cyanobacterial 16S sequences, and 5% GNS/Chloroflexi sequences using Bacterial primers. When she further analyzed this sample using GNS/Chloroflexi primers only, all isolates were green Chloroflexus. After two months, a similar distribution was observed, although Cyanobacteria had increased: 33% chemotroph-like, 62% Cyanobacteria, 5% GNS/Chloroflexi using Bacterial primers (all confirmed Chloroflexus using GNS/Chloroflexi primers). This trend continued after 3.5 months: 24% chemotroph-like, 67% Cyanobacteria, 9% GNS/Chloroflexi (all confirmed green Chloroflexus using GNS/Chloroflexi primers). After 1 year, Jenn's outer green layer contained 71% chemotroph-like, 14% Cyanobacteria, and 5% Chloroflexus, and 1% Roseiflexus using Bacterial primers. The application of GNS/Chloroflexi primers to this layer showed 50% green Chloroflexus and 50% red Roseiflexus. The inner red layer contained 100% Chloroflexi using Bacterial primers (91% green Chloroflexus-like and 9% red Roseiflexus-like). 16S-based observations were well-supported by companion pigment and microscopic data and, interestingly, even Jenn's

media-based survey correlated well with retrieved chemotroph-like sequences (i.e. supporting DNA-based sightings of Thermus- and Geobacillus-like microbes). In general, Jenn's hypotheses has been well-supported by her data, although we all remain intrigued by her chemotroph data û particularly the trends observed with respect to their high initial colonization. Given how difficult GNS/Chloroflexi are to isolate in culture (and knowing they typically use photoheterotrophy û not photoautotrophy), we wonder whether the initial establishment by chemotrophs is advantageous û if not necessary - to provide some key carbon compound. I should finally mention that, although Jenn attempted some DGGE rod studies using Danny's preliminary 2003 samples last summer û we ran into 2 problems this summer when defining her final summer thesis workload schedule: (1) our mat-based DGGE control set was too limited for her water/rod samples (i.e. didn't represent some of the diversity we were seeing in the water/rods); and (2) our DGGE apparatus broke in late spring after Molecular Biology class use û which was very disappointing given that, in over 8 years, our sequencer (which receives far more use) has never failed.

Kelly and I are, at this time, preparing final companion libraries of Fairy Spring water filter samples so that better correlations between timepoint-matched water microbial content data can be made for what we anticipate will be a very good full manuscript for AEM, to be submitted over the summer of 2006. Although former NSF summer student Peter Williams generated a lot of preliminary data along these lines from Fairy and other RLMO sites, we felt repeating his studies alongside Jenn's collections and using Jenn's precise DNA methods (e.g. using a bead-beater, something Peter did not have access to) was necessary to fully develop this important manuscript detailing our model of layered mat formation in situ.

Training and Development:

Course-Based Undergraduate Training: 36 undergraduates were involved in course-based lab curriculum modules using RLMO data and materials. These included the following: (1) 4 weeks/24 in-lab hours of molecular microbiology laboratory methods (16S rRNA library analysis, DNA sequencing, fluorescence microscopy, and introductory computational biology), serving 32 biology majors in General Microbiology. Students developed web-based portfolio presentations of this project (available on-line at my RLMO website). Some of these curricula and their assessment provided the basis for our 2 ASM curriculum manuscripts (in publication at this time). (2) 10 weeks/40 in-lab hours of molecular biology methods (genomic and plasmid DNA isolation, PCR, cloning, sequencing methods, fluorescent probe studies, and DGGE), serving 3 biology majors. (3) 1 week/3 in-lab hours of introductory molecular biology methods and central dogma, serving approximately 115 undergraduate freshmen. Although not a stated specific goal in our grant, this new DNA isolation/gel electrophoresis lab and manipulative-driven exercise (replication, transcription, and translation modeling using lots of paper and post-it notes) was designed to meet observed deficiencies in our typical class of entering freshmen.

Independent Research Credit/Thesis Training: 5 undergraduates were involved in independent research credit/thesis training. Of these 3 were participants in our GERMS program (September 2005), a 2.5 week/60 hour research experience that included RLMO site analysis (water chemistry and collection/filtration, site/mat assessment and sample preparation), pigment assessment, and microscopy (light and UV/fluorescence). Two additional undergraduates, both WOU Honors Students, completed and/or are completing senior thesis projects over the past year: Terry Manning completed his work describing the application of site-specific designer media to retrieve red layer filaments. After receiving an ASM Undergraduate Research Fellowship (the same award Terry Manning received 2 years ago), Jennifer completed extensive work over the summer 2005 (described in Activities/Findings section of this report) and is currently writing her thesis. She will also be preparing and delivering a research poster about this work at the ASM General Meeting in May 2006.

Graduate/Secondary Educator Training: 22 secondary science educators, all seeking credits toward education masters degree options, have worked with us via formally WOU-credited workshops and GERMS-related programs. In the past year, I have provided 5 one-credit/10 hour weekend workshops covering biotechnology, microbial diversity, and computational biology. In total, these served 19 teachers. In June 2005, 3 additional secondary teachers participated in our revised summer field GERMS program, a 2.5 week/60 hour research experience that included RLMO site analysis (water chemistry and collection/filtration, site/mat assessment and sample preparation), pigment assessment, and microscopy (light and UV/fluorescence).

Outreach Activities:

With the ongoing contributions of Kelly Shipley, a Biology and MAT-trained science coordinator, our outreach has continued to expand significantly. In addition to maintaining ongoing outreach projects with Saturday Academy, GEAR-UP, and WAMS, Kelly has begun a major new outreach initiative with elementary, middle and high school teachers involving in-school, after-school and fieldtrip opportunities (described below).

Saturday Academy, officially hosted by Oregon State University, is a non-profit program that provides fee-based college-level enrichment experiences for pre-college students (grades 7-12). In partnership with Saturday Academy, Kelly provided three four-hour classes, serving 31 local high school students. These activities provided microbial diversity and/or biotechnology instruction; including students working with RLMO-derived clones, performing plasmid isolation and RFLP fingerprinting analysis. There was a notably long waiting list of students

interested in all these classes. Consequently, we will be offering several more DNA technique classes for Saturday Academy in 2006.

GEAR-UP (Gaining Early Awareness and Readiness for Undergraduate Programs) is a partially funded grant program through the Department of Education, serving 19 high schools and 22 middle schools in Oregon, including Monmouth's own Central High School. GEAR-UP's primary goal is to ensure that Oregon's low-income middle and high school students are prepared for, pursue, and succeed in postsecondary education. Our partnership with GEAR-UP over 2005 has grown exponentially. Not only did Kelly continue providing on-site activities during the normal school day in February 2005 (a continuation of 2004 activities, reaching approximately 150 students), she has gone on to develop a sustained cohort program with specific input from and interest in GEAR-UP teachers and students: Students Learning Interesting Microbiology Experiments (SLIME). In contrast with on-site GEAR-UP high school activities, the SLIME program brings interested groups of GEAR-UP students to campus for several weekend of 'over time' experiences, covering basic microbial diversity and biotechnology lab methods. Two cohorts were run in 2005, serving 13 students 9-12 hours each. We have set up 2 additional cohorts for 2006, one specifically designed for middle school students, the other focusing on biotechnology and computational biology for high school students. Other GEAR-UP partnership activities will support of an after-school science club, bringing interested high school students to WOU for first-hand experience in our lab with our RLMO research project, and providing professional development for secondary science teachers so they can adapt microbiology and biotechnology curriculum beyond our presence in the classroom.

WAMS (Western Adventures in Math and Science) is our on-campus non-profit program that provides fee-based enrichment experiences for pre-college students (grades 1-12). With ongoing support from WOU's Division of Extended Programs, WAMS has become self-sustained in terms of generating participant interest, advertising/supply revenue, and need-based discounts. In the past year, WAMS provided 15 workshops, serving 137 elementary, middle and high school aged students. Of these, Kelly ran 4 microbial diversity/biotechnology driven activities, serving 28 students. Remaining workshops were run by 15 faculty from the division (out of 30) û all of whom have provided free time and effort to develop and facilitate these workshops.

As each of our previously described partnerships has grown and become more self-sustaining, Kelly has moved her outreach efforts into two different areas: (1) hosting local science teachers and their classes in our lab at WOU; and (2) bringing microbiology and biotechnology curriculum to local schools for in-class or after-school sessions. In an effort to facilitate these efforts, Kelly has become an active membership of the Oregon Science Teacher Association (OSTA), providing an informational booth and presenting a poster at the annual regional conference in October 2005, and making herself available for advising science teachers about in-class projects and outreach programs available.

Journal Publications

S.M. Boomer and K.L. Shipley, "An Exercise in Computational Biology.

", The Oregon Science Teacher, p. , vol. , ( ). Accepted

S.M. Boomer and K.L. Shipley, "A Laboratory Class Exploring and Classifying Anoxygenic Phototrophic Bacteria Using Culture-Based Approaches, Microscopy, and Pigment Analysis.", ASM MicrobeLibrary Curriculum Resources., p. , vol. , ( ). Accepted

S.M. Boomer, K.L. Shipley, B.E. Dutton, D.P. Lodge, "A Laboratory Class Exploring Microbial Diversity and Evolution Using On-Line Databases, the Biology Workbench, and Phylogenetics Software", ASM MicrobeLibrary Curriculum Resources.
, p. , vol. , ( ). Accepted

Books or Other One-time Publications

Sarah M. Boomer, Will M. Drury, Bryan E. Dutton, Daniel P. Lodge, Melissa S. Boschee, and William M. Kernan, "The Red Layer Microbial Observatory Database: A Model for the Integration and Dissemination of Biological and Geochemical Data via the World Wide Web", (2005).
Book, Published
Editor(s): Thermal Biology Institute, Montana State University
Collection: Proceedings from the First Annual Geothermal Biology and Geochemistry in Yellowstone Meeting
Bibliography: Meetings Proceedings Chapter

Terrance F. Manning, "Attempts to Cultivate Roseiflexus-like Bacteria Using Site-Specific Water and Chemistry Data From Hillside Springs, Yellowstone National Park", (2005). Thesis, Accepted
Collection: WOU Honors Thesis
Bibliography: Western Oregon University Honors Department

Jennifer L. Esparza, "Population Dynamics During Mat Formation in situ", (2006). Thesis, Submitted
Collection: WOU Honors Thesis
Bibliography: Western Oregon University Honors Department

Web/Internet Site

URL(s):

www.wou.edu/~boomers/research/allresearch.html

Description:

This is our comprehensive RLMO website. It contains RLMO-generated educational course curriculum, outreach projects and assessment,project methodology, and links to our Oracle-based RLMO Database.

Other Specific Products

Product Type:

Data or databases

Product Description:

The RLMO Database Project is a web-accessible Oracle database that integrates physical, chemical, and molecular data from RLMO sites. This application, in its second year of development, was written using PL/SQL, HTML, and Javascript. Each research site in this study is assigned a unique identifier that is linked to the following tables: Geochemical Data (pH, 15 common salts and metals); DNA Sequence Data (16S clone name, GenBank-linked accession number, BLAST-inferred identity); Macroscopic and Microscopic Image Data; and Student Collection Team Information. Using the administrative URL, all data can be entered and edited through restricted web-access. Using the public URL, users can view and query all data. Site Query results can be formatted to display any combination of geochemical parameters across one or more years and/or sites. Sequence Query results can be formatted to display inferred identity and GenBank-linked accession numbers across one or more sites. The RLMO Database, in its current form, is designed to accommodate physical, chemical, and molecular information as part of a five-year longitudinal study.

- Excerpted from TBI/Yellowstone meeting abstract (October, 2003)

In 2004, Will Drury expanded DNA Sequence data entry/archive screens, allowing us to enter information about DNA extraction procedures and PCR methods/primers utilized to generate each clone. Concomitantly, Will added appropriate sequence query boxes for searching and downloading this information. Secondly, Will added DGGE entry fields and we have begun archiving population genetics studies from long-term RLMO sites.

Sharing Information:

The RLMO database is provided on-line, as described above. Users can
browse the public portion of this database in a non-restricted
manner. A book chapter about this work, "The Red Layer Microbial Observatory Database: A Model for the Integration and Dissemination of Biological and Geochemical Data via the World Wide Web" is currently in press at the Thermal Institute of Biology, Montana State University.

Product Type:

Data or databases

Product Description:

http://serc.carleton.edu/microbelife/microbservatories/redlayer/index.html

Sharing Information:

We have contributed RLMO information, data, images, and curriculum resources/links to the Microbial Life Educational Resources (MLER), a web-based database designed at TBI (Thermal Biology Institute, Bozeman MT) and supported, in part, via an NSF-supported National Science Digital Library (NSDL) grant.

Contributions

Contributions within Discipline:

In terms of molecular microbial population studies and systematics, the RLMO project continues to improve our understanding of GNS/Chloroflexi diversity. Ongoing studies suggest that temporally variable geochemical mechanisms drive site-specific selection, providing a model for bacterial evolution and selection. This year, we have confirmed that it is possible to grow red layers in situ û which could provide an alternative and less-impacting way to propagate this interesting organism given that culture methods still prove intractable. Unfortunately, Yellowstone National Park research administrators still needs to be convinced that long-term field set-ups like this are valuable in this regard. The RLMO database, formally described in a now-published book chapter, continues to provide a model database for other PIs involved in long-term environmental monitoring studies to archive and analyze environmental and molecular data. In addition to helping us identify appropriate controls for population genetics/identification, we are finding it immensely useful for assessing and comparing long-term data. In February 2006, we will be presenting an overview of the RLMO database to the Yellowstone RCN Meeting/Workshop and discussing specific ways to solicit data input and sharing with other Yellowstone researchers.

In terms of undergraduate education, RLMO-based curricula continue to provide exemplary models for comparable undergraduate courses and now pre-college outreach. We successfully developed 3 accepted manuscripts û 2 for ASM about college-level curriculum and 1 for The Oregon Science Teacher about pre-college curriculum û that are in press at this time. Kelly will be presenting a more comprehensive poster about her outreach activities at the ASM General Meeting in May 2006. Meanwhile, I will be submitting 2-3 more lab curricula manuscripts about to ASM this year û a computational exercise about genomic analysis, a hands-on enrichment about nitrogen cycling, and a hands-on enrichment about river proteobacteria û with an emphasis on Pseudomonas and bioremediation.

Contributions to Other Disciplines:

This project has continued to impact other disciplines in the form of valuable scientific data, adaptable curriculum models, and enhanced outreach/dissemination capabilities. In terms of scientific data, our geochemical monitoring and databasing efforts are providing non-molecular data that is of value, minimally, to ongoing thermal inventory studies by geologists in Yellowstone National Park. As stated last year, most microbiologists who perform research in Yellowstone were highly interested in enhancing monitoring studies after sharing data with geologists via the 'Geothermal Biology and Geochemistry in Yellowstone National Park' Meeting (October 2003). In February 2006, we will be presenting an overview of the RLMO database to the Yellowstone RCN Meeting/Workshop and discussing specific ways to solicit data input and sharing with other Yellowstone researchers.

In terms of curriculum, our computational exercises provide highly adaptable models that can be tailored to many non-microbial systems (e.g. instead of a bacterial 16S project, use any number of eukaryotic markers to study evolution, diseases, development, etc.). That 2 of our 3 accepted curriculum manuscripts were about computational exercisesû including 1 to the general science/teacher-oriented Oregon Science Teacher journal û supports this contention.

In terms of enhanced outreach/dissemination capabilities, this project had facilitated the continued success of WAMS (described extensively throughout this report). This program has provided an unprecedented number of new pre-college outreach venues for colleagues in Botany, Forensic Science, Anatomy/Physiology, Probability/Statistics, Marine Biology, and Geology.

Contributions to Human Resource Development:

In terms of providing opportunities for research and teaching in science and engineering areas, these topics have been extensively covered in the Participants and Activities sections.

In terms of improving access to and retention of underrepresented groups, we have been involved with the following: For our summer GERMS program, we served 1 male and 2 female secondary teachers for our July program; 1 male and 2 female undergraduates from WOU (1 female was and 2-year African visiting student from Ghana) for the September program. Jennifer Esparza, our ongoing Honors Thesis student (and ASM Undergraduate Research Fellowsthip recipient) is also Hispanic.

In terms of outreach, we have continued to facilitate the low-cost WAMS pre-college outreach program (see Participants and Activities) and are developing a need-based assistance scholarship program to actively recruit low-income and underrepresented groups from the area. Finally, we have partnered with GEAR-UP which serves 41 Oregon middle and high schools with low income demographics (see Participants and Activities).

Contributions to Resources for Research and Education:

These topics have been covered and summarized extensively in this report.

Contributions Beyond Science and Engineering:

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Unobligated funds: less than 20 percent of current funds
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Contributions: To Any Beyond Science and Engineering