MONTANA NSF EPSCoR

Experimental Program to Stimulate Competitive Research

Undergraduate Research Issue

Clinton Shepard and Caleb Marceau of Salish Kootenai College working in a lab at The University of Montana

Support provided by Montana NSF EPSCoR for undergraduate research has a large impact on science infrastructure in Montana and beyond. Over the past six years, 972 undergraduates have been exposed to the idea of research as a career path, to necessary experience for acceptance into graduate programs, and to knowledge required for graduate-level and professional research. There is so much to report about this program, the students and the professors who have mentored that it is the primary focus of this issue of the Montana NSF EPSCoR newsletter.

Brigid Crowley of MSU - Bozeman was one of 4 Montana NSF EPSCoR undergraduate researchers who won the prestigious Goldwater Scholarship in the last 2 years

Michalee Moen of Montana Tech - Butte Read more about her research and the Undergraduate Research Program on P. 5

Michael O'Brien of UM studies bison in Yellowstone National Park. In 2006 he was one of 10 nationwide to win the All Nations Louis Stokes Alliance for Minority Participation Student Research Award

Montana NSF EPSCoR Undergraduate Research Milestones:

- **4 Goldwater Scholars in last 2 years**
- **972 supported since 2001**
- **At MSU, participants pursue post-baccalaureate study at twice the rate of students who are not involved in the Undergraduate Scholars Program**
- **At UM, 88% of undergraduate research projects contribute to their faculty mentor's research focus**

Manufacturing Montana's Electronic Future

Cell phones, flash drives, computers, etc., the manufacture of the transistors making up the integrated circuits that drive these everyday devices are associated with top electronic companies – Intel, Texas Instruments, and Toshiba to name a few. But in one corner of Cobleigh Hall at MSU, a group of students designed, fabricated, and tested these metal oxide semiconductor transistors (CMOS) as part of an undergraduate, senior-level course in Electrical Engineering. According to Professor Todd Kaiser of the Department of Electrical and Computer Engineering, these were the first such devices manufactured in Montana.

During the semester-long course, the 13 enrolled students learned about, and applied the series of steps required to fabricate the transistors. Starting with a template, or "mask", the manufacture involves chemical and photographic processing, which gradually creates the circuit on the transistors. The masks were developed as part of an undergraduate research project by student Stilson Applin, who has since graduated and is now working as a production engineer for Micron. As with any lab work, the manufacture requires attention to detail, knowledge of safety protocols, and theoretical understanding of the process and product. Modeled after similar laboratory courses at engineering powerhouses, Georgia Tech and Virginia Tech, students worked in a clean room with microfabrication tools to create the CMOS transistors. The laboratory component of the course reinforced the theoretical concepts learned in the classroom and gave these future engineers knowledge and skills that will be invaluable as they move beyond their undergraduate training.

The fabrication of these transistors involves highly specialized equipment and the use of a clean room. A clean room is an environment that has a low level of environmental pollutants, such as dust and other particles, that could contaminate the manufacture of devices. Such a facility exists at MSU as part of the Montana Microfabrication Facility, funded in part by Montana NSF EPSCoR. Since clean rooms are a common feature of engineering manufacture, and microfabrication is the cornerstone of so many modern research and industry areas, "All of these skills will be marketable to future employers and graduate schools," Kaiser said. The opportunity for undergraduates to enhance their classroom learning with this experience was important to Dr. Kaiser, who also received funding from the National Science Foundation to develop and offer this course.

The course is being offered again this spring and Dr. Kaiser hopes to adapt the course for middle and high school students and teachers, teaching them not only about the fabrication of electrical components, but the engineering approach to applied problem solving.

Circus of Science

Static electricity filled the air, flaming sparks flew, blocks were used to create seven-foot-tall towers and over 670 people of all ages had fun while making scientific discoveries at the UM University Center Ballroom on December 10, 2006. Sponsored by Montana NSF EPSCoR, the "three ring" *Circus of Science* featured science exhibits, numerous activities and entertainment from Native American singers, jugglers and G Wiz (aka UM chemistry professor, Garon Smith), who conjured "wizard magic" using science. Simultaneously educating and amusing visitors, G Wiz was joined by the *Super Science Squad*, the team of educators from Montana NSF EPSCoR's summer Outreach Program, the *Science Learning Tent*. Activities focused on a variety of science concepts such as gravity and conductivity, while exhibits included a Van de Graaff generator, which produces static electricity. This event was another precursor to the permanent interactive science outreach and education center opening this fall on the UM campus.

Murphy's Law

Why did the chicken cross the road? The data is inconclusive.

Two undergraduate researchers, who had hoped to learn whether the non-native, invasive species cheatgrass displaces or negatively impacts the State Grass of Montana, bluebunch wheatgrass, instead learned valuable lessons about research itself. They said, "…nothing is as easy or as quick as it appears to be," and Murphy's Law, the popular phrase that originated with research at Edwards Air Force Base in 1948, "Whatever can go wrong, will go wrong", has become their mantra.

Brian Kelly and Melissa Maggio built 28 planting boxes, each with a Plexiglas side, to observe biomass (root growth and interaction) of cheatgrass and bluebunch wheatgrass when grown together under similar conditions but with varying states of competition. After two weeks building the boxes and repairing the many leaks where sand was escaping, which weakened the overall integrity of each box, they added an inch of topsoil to aid in germination, then planted the seeds. That's when the real problems began.

First, Melissa went to Cancun over Spring Break and got very ill from a bad fish taco. Numerous bathroom stops and dehydration caused her to miss her plane and how she finally got back to Montana is a very long story. Near the same time, Brian was enjoying an evening downtown with friends and found himself in a jello wrestling match. Luckily, Brian was not seriously hurt, but he did lose his lab keys somewhere in the jello. After several days of neglect, the plants did recover slightly. However, shortly after Spring Break, the school paper reported that the lab had been broken into by residents of the nearby dorm. They smoked all the young plants believing them to be of a very different genus.

The outcome of any serious research can only be to make two questions grow where only one grew before.
- Thorstein Veblen

Well....that's one story. Another (accurate, but far less interesting) goes like this: while most of the cheatgrass germinated, several different treatments were tried but not enough of the bluebunch wheatgrass germinated in the lab conditions to produce any conclusive results. And, they just ran out of time to finish their study.

Whichever story you believe, despite their disappointment, Brian and Melissa are still interested in pursuing graduate studies, adding, "…this past semester working on this project has been frustrating, tiring, enlightening, and the best experience we have had in the biology department."

Forays into research for undergraduates are oftentimes eye-opening and frustrating undertakings. However, gaining valuable real-world experience, and making a few mistakes along the way, makes for better researchers. Montana NSF EPSCoR is proud to support this educational program for undergraduates.

Will Fletcher was one of several high school students featured in our Spring 2006 issue. Participating in the Advanced Problems in Science Program, Will traveled to attend the INTEL International Science & Engineering Fair in Indianapolis with support from Montana NSF EPSCoR. There, he won a full-ride scholarship to Drexel University with his research project "Quantitative Analysis of Music in MP3", which made mathematical comparisons between classical and modern music. Will recently turned that scholarship down after successfully applying for the Questbridge College Match, winning a scholarship to Pomona College, his first-choice school, worth nearly $200,000.

Mining for Knowledge

Butte, Montana was once one of the most prosperous cities in the world. It is estimated that Butte supplied close to one-third of the copper for the United States in the late 1800s and early 1900s, then seeing a large economic boom during World War I when copper was needed for bullets.

Times have changed, and, these days, it could be said that the source of Butte's true wealth lies not beneath the ground, but in the bright minds of its researchers and engineers. Montana Tech, with its first-class faculty, is producing talented, well-educated undergraduates, many of whom go on to graduate school or high-level research careers. Supported in part by Montana NSF EPSCoR, the Undergraduate Research Program (URP) is a key factor in the success ratio at Montana Tech. URP provides the authors of approved proposals with $1,000 stipends and additional travel awards intended for presentation of these research projects at various conferences. Joseph F. Figueira, PhD, Associate Vice Chancellor of Research, Graduate Studies and International Affairs, expresses the value this program plays in a student's education:

> *Montana Tech's Undergraduate Research Program has served to introduce our undergraduate students to the world of research – one filled with both the excitement of the unknown and the frustrations of dealing with real life situations. The application process mimics the federal funding process and requires the students to go through the steps of proposal preparation, review, response to comments, and final approval. The research process quickly moves the student from the logical and predictable classroom environment to reality – equipment that doesn't work, experimental methods that must be invented on the fly, calculations that yield strange results, but in the end provides them with the opportunity to work with dynamic and creative faculty and peers.*

A recently adopted new tag line to emphasize a philosophy that has always been present at the institution, "Get Into It" represents the entire school's desire to inspire educational enthusiasm in students and engagement in instruction for faculty. Montana Tech encourages active participation

for its students through community involvement, undergraduate research, design teams, internships, student government, and clubs. This overall attitude towards education is a major contributing factor towards the successful influence the URP has on its undergraduate researchers. With a student to instructor ratio of 16:1 and ample lab space, the size of Montana Tech supports an ideal environment for collaborative and independent research where faculty mentors tend to establish strong scientific relationships working with students.

Tracking student participants after graduation can often prove difficult in this age of mobility and e-mail. These close relationships, formed early in the undergraduates' education, tip the scales towards students staying in better contact over time. URP students tend to check in with their mentors, allowing the program to compile evidence that the difference the URP provides is paying off. Since the unfolding of this program in 1996, approximately 40% of the 300 former participants have gone on to earn a Master's degree, with 5% earning a Ph.D. Thirty research projects have resulted in published manuscripts in scientific journals and two patents are pending. All participating science and engineering students are working in their elected fields – a very significant fact for Montana Tech and Montana NSF EPSCoR.

Some of the Gems....

One former URP participant who has kept in touch is Aaron Hieb. He has obtained his Ph.D. in chemistry from University of Colorado-Boulder and moved to Heidelberg, Germany to pursue research at the German Cancer Research Institute. He now utilizes nanotechnology to help understand how biomolecules influence cancer and other diseases. He sent this endorsement of his undergraduate research experience:


Aaron Hieb

Working on an undergraduate research project helped me tremendously in reaching my goals and directed me to where I am now. I began my undergraduate research with Doug Cameron during my junior year of college and up until then had no idea what I would do with my undergraduate chemistry degree....Besides teaching me how to independently research, I believe that having had undergraduate research experience helped me when applying to graduate schools. I found that most schools had a prerequisite of research experience before they would accept someone....I think undergraduates who have research experience before graduating have a great advantage over those who don't. They know how to apply their knowledge, think for themselves, and have valuable experience with laboratory equipment and skills....I feel very fortunate for the opportunity I have had and have no idea where I would be now without it.

Cleat Zeiler reports from the University of Texas–El Paso, where he is pursuing a doctorate in seismology. At the time he began his first URP research project, he was working towards a bachelor's degree (and, later, earned his M.S.) in geophysical engineering. Both research projects he and Scott Hess, a fellow student, worked on were mentored in part by Mike Stickney, Earthquake Studies Office Director and Senior Research Geologist at the Montana Bureau of Mines and Geology. According to Cleat, the most important thing he learned from his two undergraduate research experiences was that he really wanted to become a research seismologist. Now, he is close to achieving that goal in part because he has been awarded a SMART scholarship (Science, Mathematics and Research for Transformation) by the American Society for Engineering Education. This financial support will help him finish his doctorate. Once he earns his degree, he will begin repaying the award by working for the Air Force Research Labs where he is much needed to assist with research towards accurate identification and differentiation in seismic readings. Mining activity and nuclear explosions can be detected using seismic equipment and the government wishes for Cleat to help them learn how to distinguish each from earthquakes and natural seismic events.


Cleat Zeiler

Recently, three URP students in the Metallurgical & Materials Engineering Department at Montana Tech have been recognized internationally. Kelly Murphey received one of four $10,000 Copper Club Scholarships awarded in the U.S. each year. Nick Gow, a fifth-year Master's candidate, received a $10,000 one-year scholarship from Lucille and Charles Wert Scholarship fund. Eric Streich, who is now a graduate student in the department, received a $10,000 grant from another international competition, the Henry De Witt Smith Trust Scholarship. Streich earned this recognition largely due to his graduate thesis work and the potential benefit it may have. He has been researching the possibility of using residue slags from past mining operations to clean the water in the Berkeley Pit, a large open-pit mine in Butte, which is now a Superfund site. Due to its closure in 1982, contaminated groundwater has been filling the Pit since the pumps were turned off. Streich's research could lead to a breakthrough with both environmental and economical benefits because mining waste piles could potentially be used to remediate the Berkeley Pit.


Meredith Lafond

Contributing to the research of Montana Tech biochemistry professor Andrea Stierle, another recent URP research project focused on the waters of Berkeley Pit. Meredith LaFond and Michalee Moen researched microbes, code named BP 2-0-3C, that have adapted to the harsh environment. Besides their amazing ability to thrive in conditions that are toxic to most organisms, they have exhibited traits that might be useful in developing cancer drugs.

Meredith and Michalee applied for, and were awarded, a trip to the Sigma Xi Annual Meeting & Student Research Conference in Detroit, MI, November 2006, where they received a ribbon for quality research and poster presentation. When Meredith was asked how undergraduate research experience influenced her education, she responded, "It kept me in school!" She said that the opportunity to actually do the hands-on research opened her eyes to the possibilities of where a degree in biochemistry could take her. Having lived most of her life in Butte, she also said she takes great pride in telling people that she is attempting to find a cure for cancer in the polluted waters of the Berkeley Pit, therefore, making something positive from what everyone believes to be a very negative result of the mining there.

Another milestone for the Montana Tech URP is simply the record 65 students who are currently conducting research projects under 30 faculty mentors. Diversity among research topics is another achievement – they do not all involve beakers, microscopes, Petri dishes and high-tech equipment. In addition to laboratory or field research more typically associated with science or engineering disciplines, URP research may also include investigations of a cultural or historical question, documentary or production arts.

Sally Carey and Sarah Thielen are currently studying, "The Effects of Yoga on Heart Rate and Blood Pressure". Haley Doleshal is researching the efficacy of Montana Tech's learning facilities in her project, "A Study to Determine the Effectiveness and Usefulness of the Montana Tech Learning Center". Gregg Feddes may get rich with his "NCAA Division I Basketball Tournament Predictor" (hopefully he and the world's bookies will share some of the wealth with his mentor, mathematics professor and department head, Richard J. Rossi).

All current URP participants will present their research at the Eleventh Annual Undergraduate Research Fair on Saturday, April 28, 2007. This fair is held at Montana Tech to recognize undergraduate research and provide an opportunity for students to share their studies with the community and their peers.

What else is on the horizon for URP? When asked about future plans, Courtney Young, Chair of the Montana Tech Undergraduate Research Program had this to say:

When URP began, the stipends offered were only $500 per year. We had 18 students the first year and 30 the following year. In the third year we were able to offer $1000 scholarships and the number of participants jumped to 50. We are now at a record 65 students and would like to see the program grow to 100 undergraduate researchers, which would be roughly 5% of the students enrolled at our campus. An increased level of funding would not only help us accomplish this goal, but also help us to improve upon our outstanding faculty involvement through better compensation for mentors and their efforts. Employers love hiring Montana Tech graduates because of their extra hands-on experience and work ethic. I would seek to maintain that reputation for our students and ensure that the URP is available to enhance the quality education they are getting.

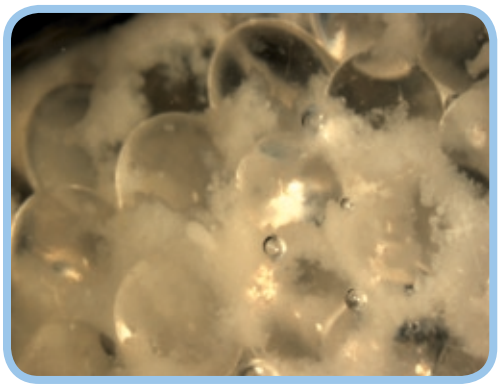
Terra: The Nature of Our World has become one of the world's premiere science websites. The website features science films that are available to anyone through webcasting. Currently averaging 3.5M downloads of programming (after only its first year), Terra is getting ready to launch TerraPod, a fully interactive science website for children between the ages of ten and fifteen. TerraPod is very different in its conception and design than Terra, because it involves kids with science through filmmaking. As an online social community based around science, TerraPod hopes to use free choice learning as a basis for encouraging children to get involved with both art and science. TerraPod is not going to be an entirely virtual community either; the producers have plans to have on-the-ground activities as well, including a summer science film camp. With support from Montana NSF EPSCoR, TerraPod is currently conducting a pilot project with 4H of Montana.

www.lifeonterra.com

Good Slime vs. Bad


Brent Peyton, Ph.D.

Drs. Brent Peyton and Robin Gerlach of the Department of Chemical and Biological Engineering, the Center for Biofilm Engineering and Thermal Biology Institute at MSU are interested in microbes and complex groups of bacteria known as "biofilms" living in underground waste disposal sites and how they may play a role in preventing heavy metals, such as chromium, and radionuclides, such as uranium, from contaminating clean groundwater nearby. There are other ways to slow or stop this dispersion, but they involve pumping the contaminants to the surface or the introduction of other toxic chemicals. By harnessing naturally existing microbes, Peyton and Gerlach hope to provide the basis for a less invasive, yet effective bioremediation strategy.


Above: biofilm formed in a 2mm glass bead pack. Credit: Adrienne Phillips, Center for Biofilm Engineering

Microbial biofilms are communities of bacteria attached to a surface in an aqueous environment. These bacteria secrete a gel-like substance that "glues" them together. These biofilms can degrade toxins or become a thin reactive coating on underground soil particles that can act as a physical and chemical barrier to prevent seepage. As noxious waste is carried by groundwater into this "biofilm", the bacteria changes the chemistry to a less toxic and mobile form, trapping pollutants in place and protecting clean groundwater nearby. Peyton and Gerlach have successfully shown that bacteria already naturally present in the sediment of Department of Energy waste sites can do this. The bacteria can be grown in the lab by simply feeding them sugar water or even vinegar. Unfortunately, understanding the complex interactions of bacteria and contaminants deep underground is much more difficult. While using natural bacteria to clean up environmental hazards, such as gasoline and oil spills, is much more common than it was 15 years ago, usage for remediation of heavy metals and radionuclides is still relatively new. With continued support from the Department of Energy, Peyton and Gerlach, who were both hired with Montana NSF EPSCoR support, plan to pursue their research further before trying this on a large scale.


Robin Gerlach, Ph.D.

This publication promotes the development of Montana science and technology resources through partnerships involving Montana universities, industry and state research and development enterprises. EPSCoR operates on the principle that aiding researchers and institutions in securing federal funding will develop Montana's research infrastructure and advance economic growth. EPSCoR's goal is to maximize the potential inherent in Montana's science and technology resources and use those resources as a foundation for economic growth.

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David Steppler, one of the undergraduate researchers supported by Montana NSF EPSCoR, was one of 75 students selected nationwide by the Council on Undergraduate Research to present his work last spring in Washington, DC to legislators and federal agency directors. He previously worked with Dr. Robin Gerlach, whose research you can read more about on page 7.

Learn more at www.mtnsfepscor.org