RESEARCH WYOMING

Wyoming Business Report
February 2016

UW UNIVERSITY OF WYOMING


Supercritical Fluids LLC
Softray
Analogic Engineering, Inc.
Centennial Woods
Catering Calculator
Western Water Consultants
AirLoom Energy
GlycoBac LLC
BridgeTech, Inc.
TigerTree, Inc.
ENWYO LLC
WRI
Medicine Bow Technologies
Z4Energy
Planktomics
Thermosolv, LLC
Bridge Sense
Envision Financials
Blue Sky Group
Pronghorn Technologies
Autodesk (formerly Firehole Composites)
Arkniteck
Alpenglow
Metrohm (Snowy Range Instruments SnRi)
Happy Jack Software
WellDog
Kid Routine
Logimesh, LLC
Wyoming Analytical Labs
InterTech Environmental
SciAps (formerly Delta Nu)
Falcon Technologies
Language Dynamics Group
Coffee Engineering and Surveying
Western Ecosystems Technology, Inc.
Pollution Control Technologies
ArtistaTek
BHP Social
Sigma Aldrich (formerly RTC)
Doctors Collaborative
UL (formerly iDES)
NutriWyo
OTRATech
Oil Spreading Control LLC
Medicine Bow Pharmaceuticals
Bright Agrotech

UNIVERSITY OF WYOMING

LARAMIE **TECHNOLOGY** BUSINESS SECTOR

AS OF **2015**

AirLoom Energy
Alpenglow
Analogic Engineering, Inc.
Arakniteck
ArtistaTek
Autodesk (formerly Firehole Composites)
BHP Social
Blue Sky Group
Bridge Sense
BridgeTech, Inc.
Bright Agrotech
Catering Calculator
Centennial Woods
Coffey Engineering and Surveying
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Thermosolv, LLC
TigerTree, Inc.
UL (formerly iDES)
WellDog
Western Ecosystems Technology, Inc.
Western Water Consultants
Wyoming Analytical Labs
Z4Energy
WRI

ALL CONNECTED TO UW

STATEWIDE TECHNOLOGY BUSINESS SECTOR IMPACT

GENE WATSON'S ARRIVAL IN WYOMING HELPED SPUR GROWTH OF STATE'S TECHNOLOGY SECTOR

Technology start-ups throughout state benefited from Silicon Valley expertise

By Patrick Wolfinbarger
wyonews@wyomingbusinessreport.com

It's more than coincidence that Wyoming's push to expand technological entrepreneurship opportunities started about 20 years ago. That's when Gene Watson arrived in the Cowboy State.

Watson was involved with technology enterprises in the area south of the San Francisco Bay nearly 50 years ago, before it became known as Silicon Valley. He co-founded seven high-tech start-up ventures, including Spectra-Physics, the first commercial laser manufacturer, and Coherent, which now has more than 2,000 employees and annual sales exceeding $500 million. Three of his companies eventually became publicly traded on the NYSE and NASDAQ exchanges.

"After I retired from working in California, I wanted to move west, so I moved to Wyoming," said Watson, now 88, of his desire to live in the Real West.

After arriving in Laramie in 1994, he and two University of Wyoming professors co-founded DeltaNu, a company that made handheld Raman analyzers (which was purchased by SciAps in 2013). He also connected with Bill Gern, UW Vice President for Research and Economic Development.

See Watson on page 6

Benefits of THE WYOMING TECHNOLOGY BUSINESS CENTER

- 22 client companies representing 9 different industries
- 3 incubation centers in Laramie, Casper and Sheridan
- 6 incubator graduate companies: Falcon Technologies, Firehole Technologies, Happy Jack Software, Medicine Bow Technologies, TigerTree and Bright Agrotech
- Four e2e (entrepreneur to entrepreneur) chapters in Casper, Laramie and Sheridan
- More than 5K attendees at e2e networking events (2008-2014)

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WYOMING BUSINESS REPORT

[FROM THE PUBLISHER]

UW: Business booster

BELINDA NELSON
PUBLISHER

Wyoming's only four-year university has won accolades for the quality education it offers, and for the minimal student debt its graduates have. Giving its graduates a solid start in the business world is just the tip of the iceberg when it comes to the impact UW has on the Wyoming economy.

With the energy sector suffering serious setbacks this year, there is a greater cry for diversification of the state's economy. High-technology businesses are one way to diversify our economy and to keep our brightest graduates here in the Cowboy State with challenging, high-paying jobs. UW graduates are in very high demand in one of the highest tech regions in the country, see the chart on pages 36 and 37

The number of high-tech businesses as a percentage of all business start ups in Wyoming ranks high in the first quartile nationally. This has been particularly true in the past decade or so. Before 1994, there were just nine tech companies in Laramie, three of which had a UW connection. As of September 2015, there were 67 tech companies in Laramie, 48 of which have a UW connection. For a list of active companies with a UW connection, see page 22.

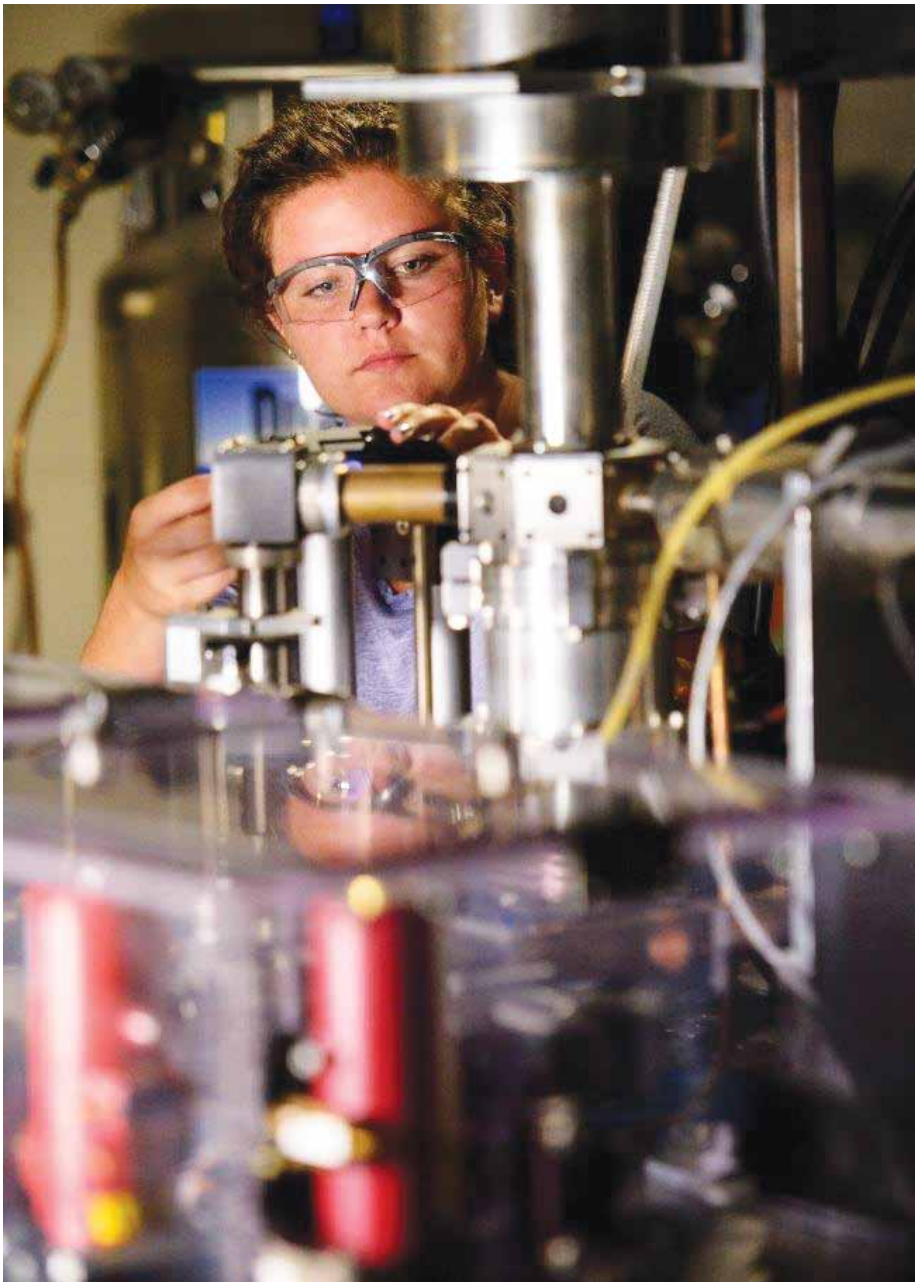
One way to measure the amount of economic potential produced by a university is to measure the numbers of patents awarded per 1,000 sciences and engineering Ph.Ds. In this measure too, Wyoming ranks in the first quartile. Only nine states have a higher percentage of patent awards.

The long-term economic impact of this much innovation can't be overestimated and should be celebrated. This fourth issue of Research Wyoming is one way to do that.

This publication was made possible by the
University of Wyoming Office of Research and Economic Development.

[IN THIS ISSUE]

UW research is key to student education, economic diversity



CHEMICAL MASTERY - UW graduate student Morgan Balabanoff of Denver works in Professor Dave Anderson's chemistry lab. UNIVERSITY OF WYOMING PHOTO

Students involved in discoveries, new business creation.

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

It starts with an idea. An idea of how to apply a new way of using a laser to identify the chemical makeup of a mineral. Or a way robots can adapt to their environment the way living organisms do. Or an improved method of teaching to enhance science, technology, engineering and mathematics or STEM education.

Whether it's enhancing renewable energy, making more efficient use of fossil fuels, developing new technology to recover oil and natural gas, introducing Wyoming's K-12 students to high-performance computing and even peering into the far reaches of space, the University of Wyoming conducts important research that impacts the state, the nation and the world.

"At UW it is about learning" said William Gern, Vice President for Research and Economic Development. "This is accomplished in laboratories, the field and special facilities. It involves students, faculty and staff in such a robust and interactive way that it becomes nearly impossible to determine who is whom. Oftentimes one sees the missions of teaching and research at a university as almost teaching versus research. At UW this

"As faculty do their research and share it with an industry ...

it really becomes a robust part of Wyoming's economy."

-incoming UW President
Laurie Nichols, Ph.D.

has transformed to a different discussion, all focused on learning, from classical situations, to modern concepts of active learning, to the one-on-one interaction of research faculty and students."

Gern referred to data from a survey of UW graduates who were students eight years before. "It was determined that those graduates had such individualized attention as undergraduates, that they considered it as the most important event in their college career." That is what you get at UW, where cutting edge research involves students.

UW has a critical role in Wyoming, especially being the state's only university, in how it applies and takes its research out to the state, Dr. Laurie Nichols recently observed. Nichols, currently the provost at South Dakota State University, will be assuming the post of UW president on May 16.

"It becomes so much a part of the economic engine," Nichols said. "As faculty do their research and share it with an industry, or flip some of the new technology they're discovering into the market through start-ups, it really becomes a robust part of the Wyoming's economy."

Wyoming's richest resource doesn't reside underground, but rests in the minds of faculty, staff and students expanding their knowledge and returning the investment in them back to the people of the state in new jobs, new businesses and new prospects for the following generations.

AGGREGATE SKILL - UW student Kristen Debler of Patterson, CA, works in a UW laboratory with civil engineering Professor Khaled Ksaibati to test aggregate from a gravel road in Teton County. UNIVERSITY OF WYOMING PHOTO

OFF TO CLASS - A typical autumn afternoon on campus in Laramie.
UNIVERSITY OF WYOMING PHOTO

WATSON FROM, 1 >>

In Gern, Watson said he founded a kindred spirit who also believed in the technology and manufacturing opportunities that research at UW offered the state. He became a consultant for UW, including directing the Wyoming SBIR/STTR Initiative (WSSI) until he retired from the post in 2015. The WSSI is supported by the Wyoming Business Council (WBC), and assists businesses and individuals in accessing the funding opportunities provided by the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs administered by UW.

"We've been so fortunate to have someone of Gene Watson's stature to really help us in developing our technology business areas, especially SBIR," Gern said. "He could be considered one of the founders of the Silicon Valley. Gene really does understand technology business development because he's done it several times. He has dedicated a big part of his life to helping Wyoming add a technology component to its economy. All through SBIR, any company that may present an opportunity to grow a technology, he's worked with in Wyoming. We are a lot further along now than we would have been without Gene's input."

Gern, Watson and Chris Bush, a U.S. West representative interested in increasing the number of businesses needing telecom services in the state, approached the newly formed WBC in 1999 about increasing opportunities to access billions of dollars in federal SBIR funds for start-ups. A new program, Phase 0, was created to award funds to applicants needing to develop a competitive proposal that could get them considered for Phase I feasibility study and Phase II research and development grants.

Watson's expertise with start-ups allowed Wyoming "to step up in its weight class" in competition with much more populous states through implementation of the Phase 0 program, Gern said.

The Phase 0 program was an important step in Wyoming's efforts to diversify the economy, Watson said.

"There are a lot of people with money who come to Wyoming," Watson said, "but they don't move here to start a business."

From 1987-1998, the state had received $5,562,360 in SBIR funds for 26 Phase I and 8 Phase II recipients. There were a couple years when no awards were made. Since the start of WSSI in 1999 through 2014, the state has received $47,808,909 in SBIR funds for 121 Phase I and 57 Phase II recipients. During that time period, 419 Phase 0 awards were made, stimulating interest in technology start-ups.

GENE WATSON. UNIVERSITY OF WYOMING PHOTO

UW partnerships with the WBC and other agencies, the establishment of the Wyoming Technology Business Center (WBTC) at UW and its expansion into Casper and Sheridan, and increased infrastructure support by the legislature and governor have all helped to contribute to the growth of the state's technology sector, Watson said.

In Laramie alone, the technology sector grew from seven companies in 1994 to more than 60 companies today, many of which are connected to UW through the WSSI, the WBTC and other programs. Watson was involved with many of those businesses in some way, providing insight that only someone who created several successful startups over the decades could.

Keith Carron was a UW chemistry professor when he first met Watson in 1994. It was the start of a 21-year-old friendship and successful businesses for Carron and Wyoming.

"Over my lifetime I have met hundreds of people: students, scientists of all caliber, businessmen ranging from small business to corporate leaders," Carron said. "Of those hundreds, most had no influence on me at all, a few were not nice, most were enjoyable, but very, very few were really as influential as Gene was for me."

Carron had attended Northwestern University and studied laser spectroscopy in one of the best equipped labs in the United States. The cornerstones of the research were big lasers made by Spectra Physics, Coherent, and Quanta Ray, he said.

"I had pictured a huge industrial complex in California that produced these expensive pieces of equipment," Carron said. "What I found out was that Gene had founded two of these companies, Coherent and Quanta Ray. I also found out that they were small to medium companies that had grown to have a big effect

SEE WATSON, 40 >>

Patently Productive

Since the early 1980's, colleges and universities have been viewed as engines of economic growth. The role of academic research and development in creating new products, processes and services has become more prominent in university towns across the nation, as well as in Laramie where multiple businesses have sprung up as a direct result of research.

Findings

- Throughout the United States, the number of new patents assigned to academic institutions increased 28% from 2001 to 2010; the number of academic S&E doctorate holders rose by 20% during the same period.
- In 2010, states varied widely on this indicator, with values ranging from 0 to 25.5 patents per 1,000 S&E doctorate holders employed in academia.
- California showed the highest level of both academic patenting and venture capital investment.
- The value of this indicator fluctuates over time and across states.

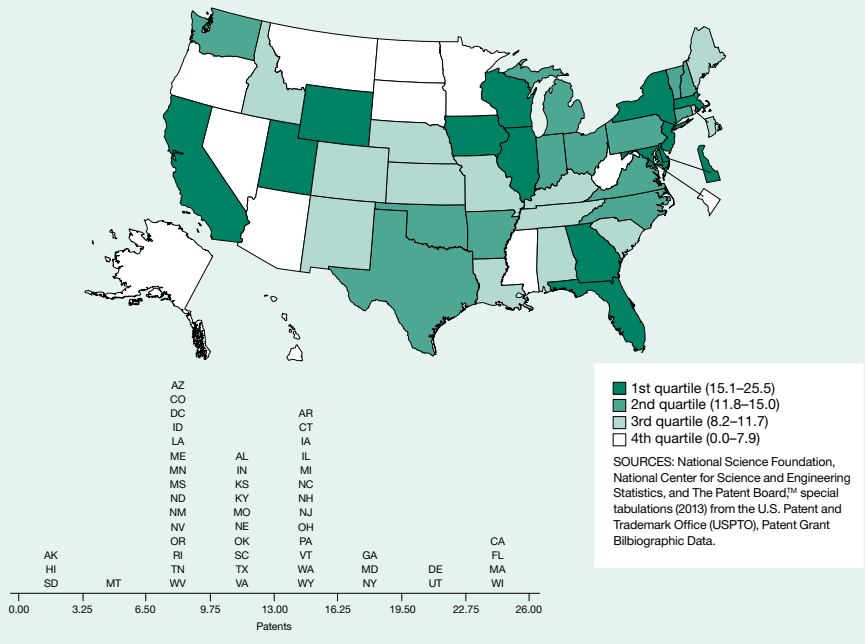
One indicator of the impact of research on the economy is the number of academic patents awarded. Academic patenting partly reflects the resources devoted to institutional patenting offices.

The graph on this page relates the number of academic-owned utility patents to the size of the doctoral science and engineering workforce in academia and is one approximate measure of the degree to which results with perceived economic value are generated by the academic workforce.

Utility patents, commonly known as patents for inventions, include any new, useful, or improved method, process, machine, device, manufactured item, or chemical compound and represent a key measure of intellectual property.

Academic Patents Awarded per 1,000 Science and Engineering Doctorate Holders in Academia

Figure 8-51
Academic patents awarded per 1,000 science and engineering doctorate holders in academia: 2010



SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board,™ special tabulations (2013) from the U.S. Patent and Trademark Office (USPTO), Patent Grant Bilbiographic Data.

Academic Patents /1,000 S&E Ph. D. holders

	2001	2006	2010
United States Total	14.7	13.1	15.6
Alabama	14.3	9.4	10.3
Alaska	0.0	0.0	2.9
Arkansas	18.8	14.2	13.5
Delaware	6.3	6.3	22.2
Hawaii	5.3	6.3	3.1
Idaho	6.7	7.9	9.2
Kansas	8.6	2.3	10.0
Kentucky	7.2	8.3	11.7
Louisiana	14.8	8.5	9.7
Maine	1.8	4.2	9.1
Mississippi	7.5	7.0	7.9
Missouri	11.6	8.6	9.8
Montana	6.3	5.0	5.4
Nebraska	11.1	11.7	10.5
Nevada	3.1	3.1	7.1
New Hampshire	9.2	16.7	13.1
New Mexico	7.9	5.2	9.1
North Dakota	5.7	4.0	7.3
Oklahoma	8.2	9.6	12.1
Rhode Island	17.6	7.0	9.4
South Carolina	5.2	6.6	11.7
South Dakota	1.7	0.0	0.0
Vermont	5.0	5.0	13.3
West Virginia	5.5	1.5	6.9
Wyoming	**5.0**	**8.0**	**16.0**

WYSTEM connects Wyo students to STEM learning

Exposure to the sciences helps guide careers

SUMMER FUN – Participants in Sheridan's Science water systems and geology. Science Kids has been

BY KIM PHAGAN-HANSEL
News@WyomingBusinessReport.com

When Sarah Fanning heard about the Summer Research Apprentice Program (SRAP), she thought it sounding like an exciting opportunity. A senior in high school and interested in geology, Fanning thought the University of Wyoming program funded by Wyoming NSF EPSCoR through the National Science Foundation grant would give her a chance to explore the field a little more. Accepted into the program during the summer of 2014, Fanning ended up studying in the botany department for the six-week summer program and fell in love with the field.

"I was able to help with both lab and field work," Fanning said. "It really showed me I loved being outdoors. It showed me what it would be like having a career as a botanist."

Now a freshman at the University of Wyoming, Fanning said her experience with SRAP not only helped her find a major, but also a career path. Neither of Fanning's parents had attended college, so SRAP helped to guide her way, giving her the opportunity to experience campus life and the college atmosphere.

"It was really cool to have insight into what college would be like," Fanning said. "I loved being in such an immersive environment. It really helped me figure out what I want to be."

For almost 30 years, SRAP has been bringing underrepresented, first generation students, women and minorities for a six-week summer STEM enrichment program. The program has grown from just four students the first year to 24 positions this year, in which students work directly with professors on a variety of STEM-related research and other programming.

"Our goal is to help them understand research," said Lisa Abeyta, student research program coordinator for SRAP. "We also want them to know that college is an attainable goal. The majority of first generation students don't see people in their family having a degree."

"Our goal is to help them understand research."

-Lisa Abeyta, student research program coordinator for SRAP

Through the years, SRAP has successfully encouraged students to continue their education by attending college. Not only has SRAP been instrumental in getting high school students to college, but the program has also helped enhance students' interests in STEM careers.

Finding the right STEM program

While a variety of STEM-based programs

Kids spent time at play in the foothills of the Big Horn mountains, learning about science, wildlife, offered since 2009. SCIENCE KIDS PHOTOS.

exist across the state, the challenge has always been spreading the word about the program to teachers and students. Today there's a new avenue for STEM program opportunities to be shared around the state -- the new WYSTEM website: http://www.uwyo.edu/wystem

During a 2012 STEM education summit, a number of people voiced a desire to have a centralized location for STEM education information. In 2013, the WYSTEM website was created by the University of Wyoming to help provide that service to the state and today is continuing to grow in the information, as well as statewide program development.

"It grew out of a need to connect," Shawna McBride, the coordinator for the WYSTEM program said. "We've tried to make it a statewide online resource."

The site includes information about WYSTEM itself, education and professional development opportunities around the state, STEM competitions like Lego Robotics and the Wyoming State Science Fair. WYSTEM is also partnering with a number of organizations like Boy Scouts, Boys and Girls Clubs and Big Brothers Big Sisters to provide STEM programming.

One of the newest programs for WYSTEM is STEM Saturday, which will include a full day of science and engineering workshops on college campuses. The first STEM Saturday took place Jan. 23 in Laramie and allowed children and their parents a day filled with science-based activities.

"We hope to do several around the state as well," McBride said. "We want to get students excited about science and engineering. It's important to show them what a scientist or engineer looks like. We have a lot of science and engineering careers in the state."

The centralized location for all of the information makes it easier for parents to learn about programs in their area. It also assists teachers in collaboration with other educators.

"It's a resource for them [teachers] to use and hopefully get their students more involved," McBride said.

"It showed me what it would be like having a career as a botanist. "

-Sarah Fanning, SRAP alumna, current UW student

The site includes listings for summer STEM programs like SRAP and Sheridan-based Science Kids, which was started in 2009. The six-week program for elementary-aged kids allows students to explore various environments and science-related experiences.

"Overall it's fostering a love of nature and science," said Sarah Mentock, founder of Science Kids. "Our main goal is to get kids outside and away from their devices. We spark that curiosity."

NSF grants enhance STEM in Wyoming schools

Innovative programs aimed at K-8 and undergraduate education majors

Jacqueline Leonard, director of the University of Wyoming Science and Mathematics Teaching Center (SMTC)
UNIVERSITY OF WYOMING PHOTO

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

Science, technology, engineering and math (STEM) education in schools is being enhanced through research and teaching programs at the University of Wyoming.

Jacqueline Leonard, director of the UW Science and Mathematics Teaching Center (SMTC), and her colleagues are examining innovative ways to improve how STEM-related subjects are taught and learned.

In 2013, Leonard received a $1.2 million National Science Foundation grant for "Visualization Basics: Using Gaming to Enhance Computational Thinking" and a $1.5 million NSF Robert Noyce Teacher Scholarship grant in 2014 for "Wyoming Interns to Teachers (WITS)." The Visualization Basics program is part of the NSF Innovative Technology Experiences for Students and Teachers (ITEST) effort.

Leonard said the gaming program targets elementary and middle school students.

"The students in grades 4-8 are engaged in robotics and game design to learn spatial reasoning and computational thinking (CT)," Leonard said. "Computational thinking is defined as algorithm thinking to solve a problem. In both gaming and robotics, students are also learning to debug and apply the problem-solving process of trial and error until they find a solution. These skills are absolutely important in the workplace."

> **'One fifth-grade girl in Burns told me that she planned to major in computer science when she graduates from high school."**
>
> -Jacqueline Leonard, director of the UW Science and Mathematics Teaching Center (SMTC)

Children have scored higher in 21st century related skills, which require working well with others to solve problems, she said. Their self-efficacy in computer gaming and computer use has also been positively impacted by the robotics and gaming study.

"One fifth-grade girl in Burns told me that she planned to major in computer science when she graduates from high school," Leonard said. "Others, through surveys, have expressed positive interests in engineering."

ROCK HOUND - WITS summer intern Christopher

Hamm, a senior from Morehouse College in Atlanta, GA, enjoys rock climbing at the Teton Science School. PHOTO COURTESY JACQUELINE LEONARD

The Visualization Basics program has influenced more than 500 students in its first two years and will reach more than 1,000 students at the end of the third year in 2016 when the program concludes, Leonard said. The program has served students in Albany County, Campbell County, Fremont County 38, Laramie County 1 and 2, Natrona County, Park County, Platte County 1, Sweetwater 1 and 2, Washakie 1, and Uinta County 1 school districts.

Leonard said the undergraduate student program, WITS, trains teachers with a strong STEM background. WITS has recruited eight students at UW who are double majoring in STEM and elementary education. Noyce scholarships in the amount of $12,000 per year are provided for in-state students and $14,000 per year for out-of-state students, who also have a reduced tuition rate.

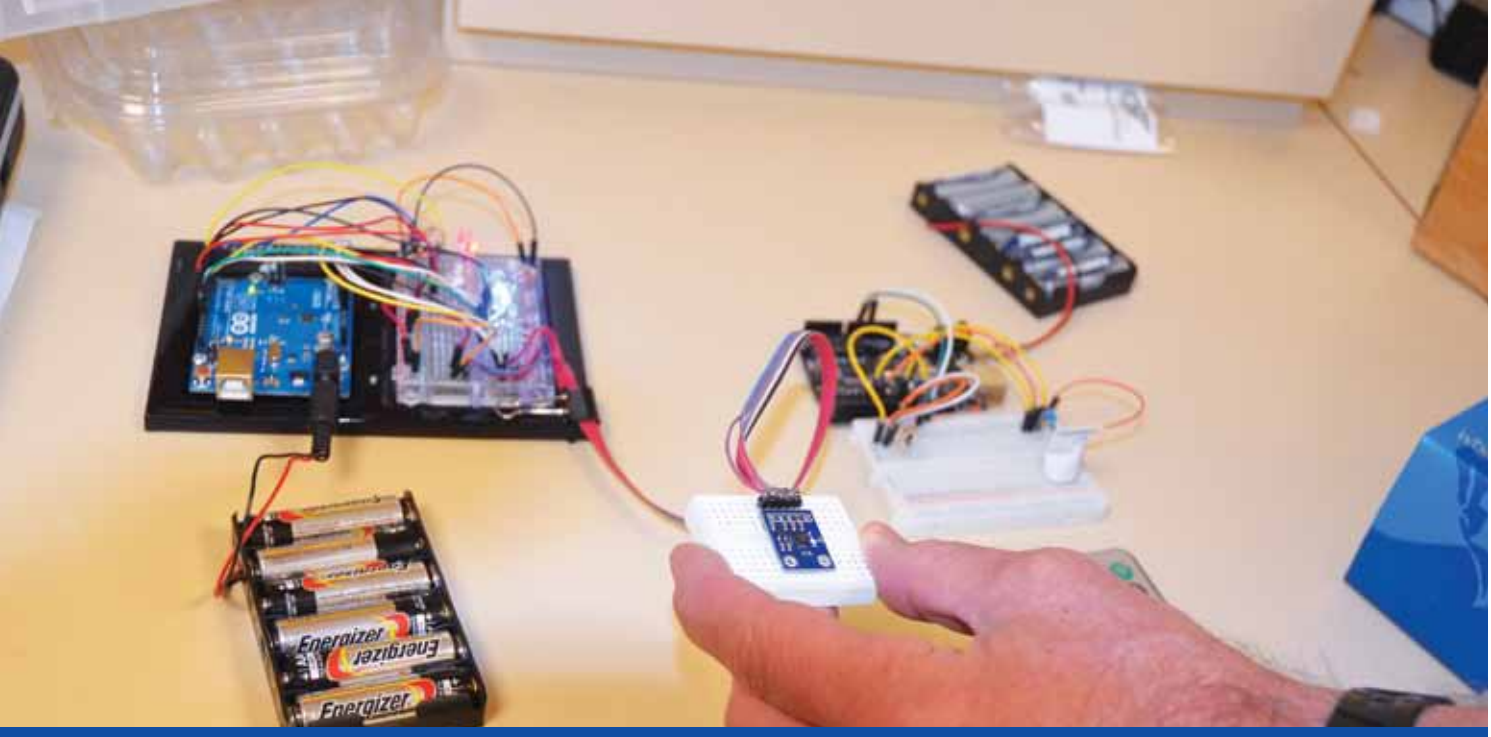
"These teacher candidates have specialties in mathematics, botany, civil engineering, geology, information technology and psychology," Leonard said. "While they may teach in any state once the program is completed, several have expressed interest in teaching in Wyoming."

The program also provides summer interns to work in pre-established summer programs, she said. In 2015, five Noyce interns worked in several programs; Energy Summer Institute (UW, Laramie); Lights on Afterschool (Lander); Teton Science Schools (Kelly); Starbase (Cheyenne); and Sinks Canyon (Wind River).

"Undergraduate students were enthralled with these experiences," Leonard said.

Noyce interns were from Morehouse Col-

SEE NSF, 39 >>



'Not just for the nerdy nerds'

Profs find ways to mainstream computer science

BY MARK WILCOX
MWilcox@WyomingBusinessReport.com

University outreach by its very nature requires a unique point of view and creative mindset. At the University of Wyoming, some programs are stepping forward to embrace those mentalities that could ultimately change the landscape of computer science at Wyoming's only land-grant university. Among directives trying to show that computer science isn't just for nerds are courses designed to let pre-college students loose with "in essence the fastest supercomputer of the early 90s" to make things like "parent detectors." Others institute advanced placement classes to solve societal problems using technology

Where's the filling?

The latter program harnesses "Raspberry Pis" to get the job done. The only filling in Raspberry Pi is essentially smartphone guts that give users a functional computer on a single board the size of a smartphone. This allows for diverse uses, including outreach.

In the summer of 2015, UW hosted teachers from high schools in Green River and Wheatland and the middle school in Burlington during an Engineering Summer Camp. The Department of Electrical and Computer Engineering hosted the camp.

"Our goal is to have high schools use it to teach high-performance computing," said Suresh Muknallipatna, a UW professor in the department.

The Raspberry Pi movement began in the United Kingdom in 2011, when a group created the series of credit-card sized computers to enhance education for computer science, especially in developing countries. The Linux powered computer comes as a bare circuit board that costs under $40. Its small size and inexpensive nature have led to unique applications and modes of thinking for projects.

In 2012, PC Magazine wrote that the "tiny and brilliantly inexpensive proto-computer" brings back the tinkering and pioneering left behind as computers have developed toward mainstream visual interfaces that are comparatively foolproof.

"The Raspberry Pi … demands your active participation and intellectual engagement," Matthew Murray wrote in the article. "But be forewarned: You cannot be a passive user. From the instant you pull it out of its box, you're fully committed, and if you don't know what you're doing, you're going to have to learn quickly."

The magazine at the time gave the device a 4-star, excellent rating. Since then, the diminutive devices have only gotten more powerful, and a range of manufacturers sell cases to make them more bulletproof. But many community colleges already have 3-D printers that can print out a case using open source designs.

"With $50 you can get a fully functional computer chip that has the ability to read and write from memory, do visuals and audio and do accelerometers – it's an incredible device," said Bryan Shader, a UW math professor who doubles as an assistant in the office of Research and Economic Development. In the latter role, he oversees computing efforts for UW research – like Raspberry Pis.

He said the $40 foundation can be built upon, and linking together eight of them not only acquaints students with parallel computing used by supercomputers like the

one at NCAR Wyoming, but also produces the equivalent of the fastest supercomputer of the early 1990s.

For $400.

"We're really trying to get students at the middle school and high school level excited about computing and excited about the design aspect of computers, the innovation aspect of computers," Shader said. So the university is leveraging the devices in conjunction with clubs or classes, like the class the university hosted for high school and middle school teachers.

Some students are tasked with creating a home security system using several Raspberry Pis and some cameras that can autocall police and send an appropriate message. Field data loggers love them because, for example, in an agricultural setting they can be used to track humidity, precipitation, wind speed, etc.

"You can do air quality and even avalanche detection," Shader said. "You can have them spread out throughout a basin and use them to detect movements of snow."

Some students try to make "parent detectors" to let them know when their parents set foot in the house again. Some use them to power binoculars and record their output. In other words, the learning potential is great.

"We're teaching engineering and computer science in stealth," Shader said. "These kids get jazzed about it and they'll do so many things without realizing they're learning coding or design.

The hard thing, he said, is not to get students interested in the devices, it's to get them to slow down.

"They far surpass what you expect as an instructor; they're fearless," Shader said. "The hard thing is for old fuddy duddies like me is that they can learn a lot that way without me going through a strict lesson plan. How do you let it be driven by a project?"

The result is something that could steer younger students toward computer science and is much more powerful than standardized testing.

"We hope it's kind of addictive," said Robert Kubichek, a UW associate professor of electrical and computer engineering.

SURESH MUKNAHALLIPATNA PHOTOS

Tech for a broader world

Other outreach in the computer science arena has taken a more traditional track. Three math and computer science professors, Lynne Ipina, Dan Stanescu and Ruben Gamboa, was awarded a $588,000 NSF grant to design an advanced placement computer science principles class based on a course developed at the University of California Berkley. With the grant funding, the trio will be able to train 20-30 teachers in Wyoming each summer for three years to be able to teach the course.

The three hope to get at least one teacher in each school district in Wyoming capable of teaching the AP course.

"[The class] is different in that it's much broader and it … spends a fair amount of time on the pros and cons of technology," Shader said. "How has it shaped our world for the good and the bad?"

With that foundation, teachers can introduce careers in high-tech paths that aren't strictly computer science. It frames many problems in the context of how they may be solved using technology.

The result, Shader said, is a class that's "not just for the nerdy nerd students." Instead, it exposes students to innovation, alternative technology applications and offers students an opportunity to make a difference in the world via technology.

Shader said coding when he learned it was a dry introduction to lines upon lines of statements that a computer could process. It was like learning Latin. It has its uses but it's a dead language. But framed differently, the code can be impactful to others' lives, and that's what the grant awardees hope to accomplish by introducing this course in Wyoming. In other words, they hope to teach the coding equivalent of Spanish. A living language with growing uses in modern society.

Coding itself has evolved into the sibling of Legos rather than Latin anyway, Shader said, as students can take blocks of code that build on each other to change parameters.

"One of the things that still gets communicated incorrectly about STEM or computer science is that it's very narrow," Shader said. "The point is that we live in a world where we all deal with technology to some extent, even occupationally."

And exploring those relationships could potentially open the floodgates of students that STEM and computer science professors have been hoping to tap.

The grant kicked in starting in January 2015 and will run through December 2017.

Berry Center fuses science, art, beauty, culture, entertainment

From living roof to living it up in class

BY JOSH COOLEY
News@WyomingBusinessReport.com

Examining and explaining biological diversity and the importance of diversity for the maintenance of ecological structure and processes is the mission of the University of Wyoming's world class Berry Biodiversity Conservation Center (BBCC).

Designed and constructed in 2011 using local materials and integrating myriad regional plants, the 40,000 square foot building houses multiple facilities, students, faculty members and programs with a focus on the study of biodiversity.

The center fuses science, arts, beauty, culture, and entertainment.

The popular Green Roof features a wide diversity of native plants, several flower and pollinator gardens, and a deck that is often used for outside functions, lectures, and concerts. Several bronze sculptures of iconic Wyoming animals adorn the grounds.

Every floor has scientific exhibits, displays, and depictions of biodiversity in Wyoming and beyond including mammal, lichen, bacteria and fungi displays; dozens of photographs of living creatures native to Wyoming; and 62 species of prairie plants native to the Laramie area.

The BBCC is a focal point on the UW campus for UW undergraduate and graduate students, faculty and staff for education and research in the fields of Ecology, Zoology, Botany, Wildlife and Fisheries Management, Microbiology, and a variety of non-science-based disciplines such as philosophy and art.

"The Center provides a site where faculty and students from all these disciplines come together to interact and collaborate," said Carlos Martinez del Rio, Director, Biodiversity Institute and Professor of Zoology and Physiology

"In addition, the Center has become an important place where the sciences, the arts, and the humanities meet."

The BBCC was made possible through a $10 million gift from the Wolf Creek Charitable Foundation managed by local conservationists Robert and Carol Berry. The donation by the Berrys was doubled through the Wyoming state matching program.

"Through research, education, and good science, the Center will increase our ability to balance human progress with the natural world that sustains us," said Bob Berry. "The Center will make Wyoming a better place to live and work."

In addition to their conservation efforts, the Berrys are known for their efforts on the behalf of falcons, especially the neotropical orange-breasted falcon. In 1978 the Berrys moved their family to a small ranch outside of Sheridan, where their two school-aged children attended Sheridan High School.

"We owe the Berrys and the State of Wyoming a building at UW that fosters creativity and research in an area that is pivotal for Wyoming," said Martinez del Rio.

Nothing quite like the center exits anywhere else in the nation, according to Martinez del Rio.

"I think that many universities would love to have something like the Berry Biodiversity Conservation Center and the Biodiversity Institute," he said. "To my knowledge, few (if any) have anything like it."

The facility includes display areas, a 114-seat lecture hall, a 36-seat teaching laboratory, public meeting areas, seminar rooms, a "dirty" laboratory for the processing of field biological collections, offices for visiting researchers and office space for 22 graduate students.

UW's Biodiversity Institute (BI) is an academic unit housed at the Berry Biodiversity Conservation Center.

"In addition to managing the building, the mission of the BI is to foster the understanding, appreciation, and conservation of biological diversity (think of the living component of creation) through cutting edge research, education, and public engagement," said Martinez del Rio.

"Many universities would love to have something like the Berry Biodiversity Conservation Center and the Biodiversity Institute."

-Carlos Martinez del Rio, Director, Biodiversity Institute and Professor of Zoology and Physiology

The Ecology Processing Lab (or "EcoLab") is a multi-functional space for a variety of ecology-oriented students, faculty and staff that work directly in the field.

"The Ecolab is a facility shared by all researchers in the University that require space to handle and process samples gathered in the field," said Martinez del Rio. "It has all the state of the art equipment needed for field biologists and ecologists to prepare samples for analyses."

That equipment includes a drying room with three drying ovens, shaker table and furnace; fume hood room with two fume hoods, vacuum desiccator cabinet, vacuum pump, solvent storage cabinet, sink and beakers, and storage/prep room for short-term temporary storage of samples and field gear while using the EcoLab.

Additionally, contained within the center are UW's Vertebrate Zoology Collection, the Program in Ecology (PiE) administrative offices, the Wyoming Natural Diversity Database (WYNND), and three core research facilities-the Stable Isotope Facility (SIF), the Nucleic Acid Exploration facility (NAEF), and

"The Center has become an important place where the sciences, the arts, and the humanities meet."

-Carlos Martinez del Rio, Director, Biodiversity Institute and Professor of Zoology and Physiology

the Macromolecular Core Equipment Facility (MCEF).

The building, designed by architectural firm Malone, Belton and Abel, is LEED GOLD certified (Leadership in Energy and Environment Design).

This means it was constructed "adopting state of the art building practices with local materials and by paying attention to energy efficiency, but that it was designed to have a positive impact on the well-being and health of its occupants," said Martinez del Rio.

To achieve LEED GOLD certification, the center was rebuilt on an already existing site (an old log building used to be in the place the Berry Center now sits). Materials from the former building were reused. The building utilizes energy-efficient lighting programs and heating and cooling systems with natural air ventilation. Numerous windows maximize daylight in the building to reduce the need for lights; all laboratories have large windows so that visitors can witness science as it happens.

With the exception of the Director of the Biodiversity Institute's salary, the Center and the programs of the Biodiversity Institute are funded exclusively by private donations. The Berry Center welcomes visitors at any time. Tours are provided for large groups.

"The BBCC has become a place where science and the amazing richness and natural beauty of the state where we live are celebrated," said Martinez del Rio. "The BI is possible (but it is also necessary) because the University of Wyoming is a remarkable institution that serves the citizens of a magnificent state."

Artists and humanists interested in the natural world are also able to showcase their work at the BBCC, and the center is known for hosting numerous concerts, dance performances and exhibits.

ABOVE IT ALL - Members of the University of Wyoming Department of Theatre and Dance's "Vertical Dance" troupe perform before an appreciative crowd in the Berry Biodiversity Conservation Center atrium. Art programs are part of the UW's Biodiversity Institute's outreach efforts.

UNIVERSITY OF WYOMING PHOTO

Fetal nutrition key to health of livestock, income of producers

IMPROVING THE HERD - Research by Stephen Ford of UW Center for the Study of Fetal Programming demonstrates that inadequate nutrition during a cow's first half of gestation can result in generational health problems for its offspring that could cost producers income. UNIVERSITY OF WYOMING PHOTO

UW research shows good nutrition early in gestation essential

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

Improper fetal nutrition of livestock fetuses can have generational consequences for cattle and sheep that not only affect the health of offspring but the income of producers.

Stephen Ford, the University of Wyoming's Rochelle Endowed Chair in the Department of Animal Science and director of the Center for the Study of Fetal Programming, has a simple message for livestock producers: change the approach to early gestation nutrition of their livestock.

Ford and his colleagues at the UW Center for the Study of Fetal Programming are researching the impact of underfed and overfed cows and dams, demonstrating the consequences of improper fetal nutrition. In the West, with its cycles of drought, it's important to understand the impact of the shortage of quality pasture and range land, he said.

In cattle, producers generally focus on supplementing a cow's nutrition near the end of gestation, he said. By then, it's too late.

"Early gestation is where the problem is," Ford said of fetal development issues. "Producers think a tiny fetus doesn't need much nutrition. It's compounded by the fact that they have been told that late gestation is when to supplement nutrition. The first half of pregnancy is a hundred times more important than the second half."

The gestation period for cattle fetuses is about 280 days. The first 150 days of gestation is when vital organs, bones and tissues develop. If those organs, bones and muscle aren't properly developed, providing nutrition in later stages of gestation won't keep health problems in a calf from showing up later, or in a case of a breeding female, in its offspring.

Ford said when an offspring of a malnourished cow is young and fed a normal diet, alterations in its metabolism and health don't show up.

> **"The first half of pregnancy is a hundred times more important than the second half. "**
>
> -Stephen Ford, director of the UW Center for the Study of Fetal Programming

"It's only when they're stressed," Ford said of notable metabolic changes. "The two most stressful times is when you stick a male in a feedlot and give him all he can eat, and a female getting pregnant. That's referred to in scientific papers as a double hit – the first hit is when they are affected in utero and the second hit is when they actually go through the alterations in metabolism that result in them not responding normally when fed."

The effects on the offspring are the same, whether their mother was overfed or underfed, Ford said.

"You are going to see an animal that doesn't respond well," he said. "If you take an offspring from a malnourished female, raise it up to adulthood, then subject it to ad libitum [latin for 'at one's pleasure' or in

this case, all you can eat'] feeding, you'll see the offspring will eat more, they will put on more fat and be less lean so their carcass is significantly altered, develop insulin resistance, have hyperleptinemia (a resistance to the leptin hormone the body creates to inhibit hunger) so the animal continues to eat and get fat, have cardiovascular problems and hypertension. They don't die, but you can see effects in the carcass."

There is an economic impact to producers for offspring of undernourished cows, Ford said.

"Animals in a feedlot, where you have ad libitum feeding, end up having a poorer quality carcass," Ford said. The cattle add weight, but it's fat.

"It's an economic disadvantage to feedlot owner too," Ford said. "When they start tagging these animals, they'll be able to trace them back to the producer and start docking them for poorer quality animals."

There are generational effects as well, he said. Research shows that the female offspring of an undernourished mother, when fed normally during pregnancy then compared to a control group, had more insulin and glucose in their systems (they are insulin resistant), and so effected the fetus. When that offspring was born, grew and became pregnant, it also showed the same phenotype.

"A cow can produce through the teens, so that same cow is producing several offspring," Ford said of the first mother.

And it's not just female offspring of undernourished mothers that can pass on unhealthy traits. Ford said it's been shown that the sperm of male offspring can be phenotypically changed.

Getting heifers into a nurturing environment can help break the cycle, he said.

"Often cows, once they've had their first calves, are thrown in a pasture with older, bossy cows, who are beating them to best feed," Ford said. "Second pregnancy cows need to be somewhere where they are not competing with older cows."

Convincing producers to change their practices is a challenge, he said, but it's something that can make their livestock more valuable.

"You have to sell to the producer that this is a real phenomenon," Ford said. "And we're pretty convinced it is. The problem is producers don't really look at the condition of their cows until mid-gestation onward."

He said producers check on their cows to make sure everything is okay, "but they're really not looking at the body condition scores."

"I've gone out on a couple of ranches and I could pick out the cows that were second-calf heifers because their body condition scores are maybe a whole point or two points below the others," Ford said. "If I could get producers to realize that in early pregnancy, when they see second calf heifers with a body score visibly less than the other older cows in mid to late pregnancy, it's too late. You can start feeding them more, and they just get fatter."

He said that may be one reason why bad producers go out of business.

"It's not just because their animals die, but because the quality of their offspring go down and down," Ford said.

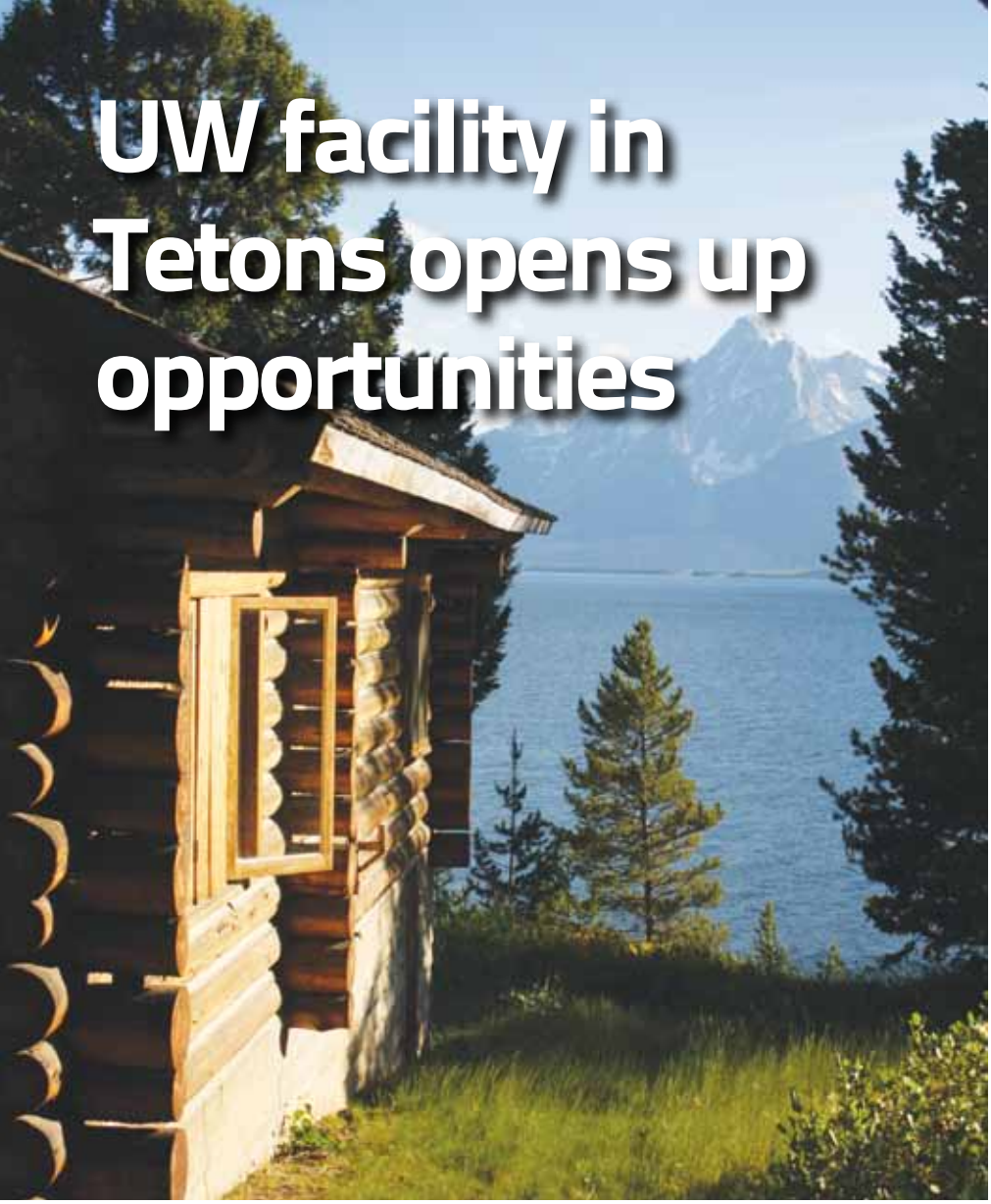
When Ford arrived at UW he found that about 30 years before, a UW flock had been separated into two flocks of sheep, by selling about half of them to a producer near Baggs, WY., in the Red Desert area, and keeping the rest at UW facilities in Archer, WY.

"They were cafeteria sheep," Ford said of the UW flock. "They got too much food and too little exercise. The ones that went to Baggs never received supplements and if they produced lambs, they were kept. If they didn't they were removed. The genetics of both flocks were similar."

Ford purchased some of the Baggs ewes and UW ewes and then undernourished both groups by 50 percent in the first half of pregnancy. He found that the UW ewes lost weight, and their fetuses were 30 percent lighter at mid-gestation and there were alterations in important organs and tissues. He then refed these ewes a normal diet from mid-gestation to bring the weights of the fetuses up to normal by lambing. Those lambs went on to develop insulin resistance, obesity, hypertension and poor carcass quality (high fat to lean ratio) as young adults. However,

SEE IMPROVING HERD, 19 >>

SHEEP TOO - University of Wyoming graduate student Adel Ghnenis, from Libya, and Post-Doctoral Research Associate John F. Odhiambo, from Homabay, Kenya, collect blood samples from a sheep at UW's Laramie Research and Extension Center. The work is part of a research program headed by Peter Nathanielsz, Distinguished Research Professor of Life Course Studies, and co-director of The Center for the Study of Fetal Programming, who is studying the effects of obesity during pregnancy. UNIVERSITY OF WYOMING PHOTO



UW facility in Tetons opens up opportunities

Outreach, research and partnerships served at facility

BY MARK WILCOX
MWilcox@WyomingBusinessReport.com

When you've got it, you flaunt it.

"It" in this case refers to resources in Grand Teton National Park that people want to access from all over the world. The University of Wyoming has what can be described as rich research panoramas at its UW-National Park Service Research Center.

The surprisingly long and narrow road leading to the former AMK Ranch winds through forest dense with wild huckleberry bushes and other native vegetation. As the road peters out at a handful of dorm-like cabins and a main cabin where UW hosts events, a terrific panoramic view of the Tetons opens up across the shimmering waters of Jackson Lake.

The length and remote location of the road have made it difficult for some to find it, including seminar speakers who sometimes show up late to their own gig. And while it may be difficult for some to get to, UW makes it as accessible as possible, knowing the kind of world-class resource that it is sharing.

"It's one of the most beautiful spots in North America if not the world," Director Harold Bergman said in a phone interview. Bergman is a professor of zoology and physiology, and has run the AMK Ranch for the past two years since Hank Harlow vacated the position after holding onto it for more than 20 years. It's that difficult to leave.

But it welcomes people that come and leave consistently, hosting up to 58 researchers at once. The researchers come from all over. In 2015 alone, the ranch fielded 37 research teams consisting of nearly 130 researchers from places as diverse as Harvard, University of California Los Angeles, Iowa State University and, of course, UW. In total, 17 colleges and universities used the research station besides UW and six federal and state agencies also visited. Altogether, they logged nearly 2,000 research days, which shows a lot of interest and outreach capability for the university.

Research topics are as diverse as those coming to the facility. Iowa State University researched the link between butterflies and climate change. Idaho State University studied the cultural history of Snake River rafting. Harvard looked into avian biomechanics. The University of New Mexico examined bushy tailed wood rats. Others mapped the Teton Fault, learned about lake trout egg collections, performed archeological surveys in the area and even checked out spider ecology and biogeography.

Beside the pure research, the facility also hosts interns and visiting scholars, workshops and other meetings, classes and field research courses and a series of weekly seminars coupled with an old-fashioned barbecue that can draw hundreds to the pseudo campus. The seminars drew an average of 120 people in 2015.

All told, the outreach center for the university through the summer of 2015 hosted more than a collective 10 years' worth of hundreds of individuals' lives.

The mission of the center is "to provide opportunities for both management-oriented and basic research on the Greater Yellowstone Ecosystem, especially Grand Teton National Park." The mission seems to be in good functional order since research there over the past three decades has resulted in nearly 1,000 peer-reviewed publications.

Beyond the core mission, the basic outreach mission of UW has been served well as about 1,200 people came to the lecture-barbecues over the summer months.

"It's an important venue to call attention to the work that's being done in the park and the ways in which this kind of information is useful in managing Yellowstone and

Grand Teton National Park specifically," Bergman said.

The former director of the ranch, Hank Harlow, called the summer lecture series one of his brightest achievements while running the facility.

"It's a way to reach out and show how science directly affects people. It puts science in the hands of the public," Harlow said. "And, if you have an informed public, by gosh, you'll have financial support to do more research."

Attendees cite various reasons for attending the lectures, but any lecture has the potential to explode beyond the facility's capacity, especially if something like the Yellowstone super volcano is being discussed. Bergman said that the super volcano pulls in 200 every time it is discussed.

Moran resident and former biology teacher Anne Lippold said she has been attending the lecture series as often as possible for years.

"I love being here. I learn a lot," Lippold said. "It's very stimulating. Plus, I like the ambiance. It's such a beautiful setting."

In all, the ranch is made up of 14 buildings spread over 30 acres within Grand Teton National Park. The area draws millions of visitors a year, and Bergman noted that since tourism is Wyoming's No. 2 economy, anything the university can do to understand the natural resources that draw tourists aids the state economy.

SEE TETON, 38 >>

IMPROVING HERD, FROM 17

"It's not just because their animals die, but because the quality of their offspring go down and down."

-Stephen Ford, director of the UW Center for the Study of Fetal Programming

when the Baggs sheep were undernourished from early to midgestation, the mothers also lost some weight, but the fetuses were normal weight at mid-gestation. When the lambs were born, they showed no phenotypic effects from their mothers being undernourished.

Ford said the placenta of sheep become more efficient as pregnancy goes on, but that this efficiency change normally occurs only in late gestation when the fetal mass enlarged significantly. Because the Baggs sheep had already been living in a diminished food environment, when Ford undernourished them, "they immediately reverted to that more efficient placental type and the fetuses sucked in more maternal nutrients, thereby maintaining a normal growth rate and phenotype."

Livestock can adapt to different environments over a few generation, he said. However, whether an animal is undernourished or overnourished in utero, it will develop an increased appetite and become leptin resistant.

"You eat more before your body says that's enough," Ford said.

The Center for the Study of Fetal Programming in 2013 received funding from the National Institutes of Health to research the effects of maternal sheep obesity. Ford and center co-director Peter Nathanielsz are examining how obesity issues in sheep are similar to those found in humans. Lambs born to obese ewes develop the same metabolic diseases exhibited by human babies, Ford said.

INBRE boosts biomedical research and education

LAB SKILLS - Kelsea Zukauckas, left, an INBRE Transition Fellow from Cheyenne, and Amy Navratil, an assistant professor in the University of Wyoming Department of Zoology and Physiology, perform tissue culture of gonadotrope cells to study the cell signaling pathways involved in the regulation of fertility. The research is among many INBRE-supported projects at UW.

UNIVERSITY OF WYOMING PHOTO

Broad range of health-related studies at UW

BY PATRICK WOLFINBARGER

News@WyomingBusinessReport.com

When Wind River Reservation residents harvest a garden in the "Growing Resilience" food health program developed by University of Wyoming health sciences researcher Christine M. Porter, that is Wyoming INBRE at work.

When UW molecular biologist Mark Gomelsky explores the use of infra-red light to manage disease in mammal cells, that is Wyoming INBRE at work.

When students in Central Wyoming College biology professor Steve McAllister's laboratory uncover the epidemiology of the West Nile Virus, that is Wyoming INBRE at work.

And when Andrea Sanchez Walk from Western Wyoming College in Rock Springs joins eight other community college students who earned transition fellowships to study, receive training and conduct research in UW laboratories, that's also Wyoming INBRE at work.

Since it was first developed in 2001, the Wyoming IDeA Networks of Biomedical Research Excellence (INBRE) program has been enhancing a broad range of health-related research and education opportunities for faculty and students at UW and all of the state's community colleges.

"INBRE was created by the National Institute of Health (NIH) to help support biomedical research in states that were underserved by NIH funding," said Scott Seville, Wyoming INBRE program coordinator/principal investigator and associate dean in the UW Outreach School.

Wyoming INBRE contributes to efforts to enhance STEM (Science, Technology, Engineering and Math) programs such as the UW Science Initiative and Wyoming EPSCoR (Experimental Program to Stimulate Competitive Research), Seville said.

The program helps provide support for: junior faculty members to develop competitive programs that will attract major outside funding support; departments and colleges in new faculty recruitment with startup and development packages in areas relevant to INBRE; graduate research assistantships; collaboration between UW and community college faculty members; undergraduate research opportunities at UW and community colleges; and introducing students to the professional intricacies of a career in science.

Porter, an assistant professor and Wyoming Excellence Chair in Community and Public Health in the UW Division of Kinesiology and Health, said the "Growing Resilience" program wouldn't have been possible without initial Wyoming INBRE support. The program, developed in collaboration with Wind River partner organizations, will

"Once a faculty member gets a foot in the door, it just increases the possibilities for another award, and another award, and another award"

-Scott Seville, Wyoming INBRE program coordinator/principal investigator and associate dean in the UW Outreach School.

evaluate the health impacts of food gardens with 100 Eastern Shoshone and Northern Arapaho families who would like to try home gardening.

INBRE funded initial design of the project, planning with Wind River partners and the pilot data "essential" for a successful application that led to a five-year, $2.5 million NIH grant, Porter said.

An additional Wyoming INBRE "Phase II" grant is supporting work by Tarissa Spoonhunter, Central Wyoming College American Indian Studies professor, in a mentoring program for young adults in furthering their health and biomedical education options. The grant also supports redeveloping a gardening study in Laramie which Porter hopes will secure future NIH funding.

Porter said the mentoring and support by Seville and the UW Research and Economic Development Office has been essential to the program's progress.

"I couldn't be more grateful," she said. "Through INBRE and otherwise, I think the UW research office has proved to be the most intentionally supportive and flexible such office I have yet to hear of to date. The colleagues I meet at national conferences are envious."

Porter's program is an example of what Wyoming INBRE aims to achieve, Seville said.

"Once a faculty member gets a foot in the door, it just increases the possibilities for another award, and another award, and another award," Seville said.

"Wyoming INBRE is creating opportunities across the state for young people to learn about and move in the career track for the biomedical area," Seville said. "This gets them that exposure and knowledge base that they need early."

He added that hundreds of Wyoming students have accessed these opportunities and are progressing through their undergraduate, graduate and professional degree programs, with many already in the biomedical workforce as college researchers, working in the private sector, and as allied health and medical practitioners.

In 2015, nine community college students received Wyoming INBRE Transition Fellowships to study and conduct research at UW. They join 19 other recipients who have or are attending UW.

Wyoming INBRE's biomedical research and education efforts will continue another five years due to a $17.4 million NIH grant awarded in 2015. Wyoming, with UW as the lead institution, is one of 23 states and Puerto Rico funded by the NIH INBRE program. UW received its first INBRE award, totaling $13 million, in 2004. The university received a $16.9 million award to fund INBRE 2 in 2009. The total of the three INBRE awards to UW is more than $47 million which has supported more than 50 UW faculty projects and numerous studies throughout the state in participation with the community colleges.

The funding will allow Wyoming INBRE to continue to support projects that focus on health issues important to rural residents, with an emphasis on cardiometabolic diseases and technology for chronic disease research and therapeutics, Seville said.

For the next five years, Wyoming INBRE 3 aims to:

-- Continue to build on the established multidisciplinary research network with scientific foci that will build and strengthen biomedical research expertise and infrastructure at UW and its partner institutions (Wyoming community colleges and UW-Casper).

-- Build and increase the research base and capacity of the university and its partner institutions by providing research support to faculty, postdoctoral fellows and graduate students.

-- Provide research opportunities for undergraduate students that will create a pipeline for them to continue in health research careers within Institutional Development Award (IDeA)

-- Enhance the science and technology knowledge of the state's workforce.

-- Expand Wyoming research opportunities across the Western IDeA Region.

To accomplish these goals, Wyoming INBRE will support some existing programs and develop new initiatives. The NIH award will continue to fund programs at UW -- including the Wyoming INBRE Thematic Research Project and the Pilot Research Project grants -- to help faculty develop biomedical-related research projects. During the INBRE 2 funding cycle, 14 thematic research projects and 10 pilot projects were supported. Additionally, 10 project investigators -- seven junior faculty members and three postdoctoral researchers -- obtained significant external grant awards for the work originally supported by Wyoming INBRE.

Additionally, the funding will continue to have an economic impact in Wyoming.

According to a 2013 report, titled "Evaluating the Impact of INBRE Funding on Wyoming's Economy" by UW economist Anne Alexander, "INBRE has advanced and will continue to enhance Wyoming's human capital in two ways. The educational and outreach components of the funding mean that more Wyoming workers will be educated and better skilled in higher-level analysis and scientific literacy. Whether those who take advantage of the outreach and education end up as life scientists or biomedical engineers, or whether they simply learn more about biosciences, they will have higher quality human capital. As such, INBRE has directly increased the economic development potential of Wyoming."

The report also notes, "INBRE also has enhanced human capital indirectly in Wyoming by means of those who will ultimately pursue bioscience careers. Those people, depending on their exact career path, will likely be able to enhance the health -- and thus human capital -- of Wyoming citizens by treating, diagnosing and preventing ailments, and by creating ideas and knowledge that will improve health and quality of life."

For more information about Wyoming's INBRE program, visit www.uwyo.edu/wyominginbre.

BUSINESS REPORT **LIST**

Companies That Grew Out Of Work Done At The University Of Wyoming

ranked by number of Wyoming employees

RANK	Company Address Phone Web site	EMPLOYEES 2015	Year of Spinoff	Tech Developed Current status	Founder
1	WESTERN ECOSYSTEMS TECHNOLOGY (WEST, INC.) 415 W. 17th St., Suite 200 Cheyenne, Wyo. 82001 307 634-1756 www.west-inc.com	235	1990	Combining statistics and ecology to address natural resource challenges faced by government and industry. Opening offices throughout the U.S.	Dale Strickland Lyman McDonald
2	BLUE SKY GROUP INC. 1482 Commerce Drive, Suite A Laramie, Wyo. 82070 307 742-6707 www.theblueskygroup.com	85	1998	Fuel cells, oil and gas technical services, reclaimed Wyoming snowfence wood, historic steakhouse, rechargeable battery cathodes Parent company for WellDog, NDC Power, Centennial Woods and the Cavalryman Steakhouse.	John Pope
3	MEDICINE BOW TECHNOLOGIES 3821 Beech St. Laramie, Wyo. 82072 307 721-4050 medbowtech.com	30	2006	IT solutions and products for clinics, healthcare practices, hospitals, law firms, banks, school districts. Services available in Laramie, Casper, Cheyenne and Grand Junction, CO	Luke Schneider
4	BRIGHT AGROTECH LLC 1461 Commerce Drive Laramie, Wyo. 82070 307-288-1188 brightagrotech.com	21	2010	Hydroponic and aquaponic agriculture systems specializing in high yield, space saving designs. Installed largest vertical farm at World Fiar in Milan in 2015	Nate Storey Paul Bennick
5	UL PROSPECTOR (UNDERWRITERS LABORATORIES) 1604 E. Grand Avenue Laramie, Wyo. 82070 307-742-9227 www2.ulprospector.com	17	1986	Began as IL IDES, UL Prospector is a search engine database as well as information technology support center for Underwriters Laboratories. Acquired by UL in 2012	Mike Kmetz
6	DELTA NU ① 5452 Aerospace Dr Laramie, Wyo. 82070 307 745-3245 www.deltanu.com	17	2000	Portable and bench top spectrometers, powerful, modular Roman microscopy systems, and advanced, high sensitivity, low-light imaging cameras. Now a subsidiary of Intevac Inc. of Santa Clara, Calif.	Keith Carron Bob Corcoran Eugene Watson
7	FIREHOLE COMPOSITES 203 S. 2nd Street #A Laramie, Wyo. 82070 307-460-4763 www.autodesk.com	16	2000 ②	Commercial composites analysis expertise and software. Acquired by Autodesk in 2013	Jerad Stack
8	SNOWY RANGE INSTRUMENTS - SNRI 407 S. 2nd Street Laramie, Wyo. 82070 307-460-2089 www.wysri.com	15	2009	Designs and manufactures spectroscopic instrumentation for novel applications Strategic alliance with metrohm for exclusive distribution	Keith Carron
9	HAPPY JACK SOFTWARE 1525 Industry Drive Laramie, Wyo. 82070 307 721-3810 happyjacksoftware.com	10	2004	Custom software development including medical software for long-term care and assisted living facilities. recent products include Kalendi, MedRight and EZ Faculty Search software	Mona Gamboa
10	FALCON TECHNOLOGY SYSTEMS LTD. 210 S. 3rd Street Laramie, Wyo. 82070 307-460-7001 http://falcontradingsystems.com	10	2004	High-performance computers for day traders. Five-year growth rate of over 400%	L. Scott Tafel
11	TIGERTREE LAND MANAGEMENT 209 S. 1st Street Laramie, Wyo. 82073 307-460-4767 www.tigertreeinc.com	8	2007	Wildfire hazard mitigation and tree spraying and removal due to mountain pine beetle epidemic Caring for trees in WY, CO, MT, NE, SD, UT and ID	Jeffrey Smith Emily Parsons
12	PLANKTOMICS BIOSERVICES 1938 Harney Laramie, Wyo. 82072 970-236-6629 www.planktomics.com	6	2013	5 patents to either control unwanted algae or allow low-cost biological harvesting of algal biomass Offering genetic engeneering and phenotyping	Stephen Herbert Levi Lowder
13	BRIDGETECH INC. 302 S. 2nd St., Suite 201 Laramie, Wyo. 82070 307-721-5070 www.bridgetech-laramie.com	6	1988	Innovative software solutions in bridge designs. Working on a number of projects with the Wyoming Department of Transportation	Jay Puckett
14	PRONGHORN TECHNOLOGIES, LLC 1938 Harney St. Laramie, Wyo. 82072 307-766-9511 www.prongtech.com	6	2006	Automated water disinfection technology. Production prototypes being evaluated by the US Navy on the USS Anchorage	Weston Welch
15	LOGIMESH, INC. 1938 Harney Street Laramie, Wyo. 82072 303-376-3780 www.logimesh.com	3	2013	patented technology SMART FUEL SYSTEM, a field deployable diesel fuel treatment and monitoring system Logimesh maintains a research office at the WTBC in Laramie	Bill Gillette
16	ALPENGLOW INSTRUMENTS LLC 1938 Harney Street Laramie, Wyo. 82072 307 760-0954 www.aplenglowinstruments.com	3	2013	Developed a lidar to detect and measure particles in the air using light instead of radio waves Active	Nick Mahon Perry Wechsler Zhien Wang
17	Z4 ENERGY SYSTEMS LLC 25 Dizzy Horse Rd. Buford, Wyo. 82052 307 766-5044 z4energy.com	3	2004	Residential-scale renewable energy products Phase II development rotar blade and wind-powered water-well pumping projects	Steven Turner Georgia Gayle
18	NUTRIWYO, LLC 1938 Harney Laramie , Wyo. N/A 307-703-2214 www.nutriwyo.com	2	N/A	Contract research services to validate safety and efficacy of nutraceuticals. Conducting clinical trial on whether a spice helps reduce the risk of diabetes	Rama Nair Sreejayan Nair
19	ANALOGIC ENGINEERING INC. 25 Dizzy Horse Road Buford, Wyo. 82052 307 766-5044 analogicengineering.com	2	1993	Development of ultrasonic nondestructive test instrumentation used to find cracks in metal structures. DevelopWorld's first ElectroMagnetic Acoustic Transducer (EMAT) patent.	Georgia Gayle Steven Turner
20	SOFTRAY INC. DBA LIGHTSPEED BIODETECTION 519 South 5th St. Laramie, Wyo. 82070	2	2002	Developed Fountain Flow, a system for rapid detection of pathogenic bacteria and fungi in blood and blood products. Active	Paul Johnson

Frog eggs may be key to possible cancer treatment

American Cancer Society awards $792,000 grant to continue research

University of Wyoming molecular biologist Dan Levy uses frog eggs to study cell regulation and its cancer implications.
UNIVERSITY OF WYOMING PHOTO

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

Some people look at frogs and see slippery, croaking amphibians who inhabit lily-covered ponds. When University of Wyoming researcher Dan Levy looks at frogs, he sees an opportunity to expand the understanding of how the nucleus in animal cells becomes corrupted. And when the American Cancer Society looks at Levy's research, it sees an avenue to creating a possible cure for a menacing disease.

Levy, a UW College of Agriculture and Natural Resources Department of Molecular Biology assistant professor, is a recipient of a $792,000 grant from the American Cancer Society. He is examining the DNA in cell nuclei and what triggers the nucleus to enlarge, something that is recognized in diagnosing cancer.

Levy said he's had a longtime interest in cancer-related research.

"On the one hand, I am fascinated by the basic cell biology that underlies the formation of cancer," Levy said. "I am really motivated by the challenge of trying to figure out what is going wrong in a cell so that it starts to divide inappropriately to form a tumor and trying to learn why some of those tumor cells become capable of spreading throughout the body."

> "Reducing the size of the nucleus in a cancer cell might be a new way to treat cancer."
>
> Dan Levy, University of Wyoming molecular biologist

While the work is fascinating, it means more to Levy than just scientific inquisitiveness.

"On a more personal level, several of my family members and friends have been affected by cancer, as I am sure is true for most people," he said. "It is important to me to be contributing in some way to improving our understanding of cancer with the hope that this may lead to new treatments and ways to prevent cancer."

It's not just a whim that Levy's laboratory features a poster of a grinning Kermit the Frog, seemingly giving approval to the work by he and his colleagues. Inducing frogs to produce eggs, researchers spin the eggs in a centrifuge to break the eggs down. They then extract the proteins, membranes and cytoplasm and assemble nuclei in a test tube.

Researchers found the concentration of particular proteins -- the nuclear lamins -- appears to play a part in controlling the size of the cell nucleus.

"In almost all cancers, the nucleus, the structure present in most of our cells that contains our DNA, becomes enlarged," Levy said. "In fact, increased nuclear size is a key parameter used by pathologists to diagnose and stage many different cancers. What is not known is if this change in nuclear size is important for the growth of the cancer."

In Levy's laboratory, researchers are trying to understand why the nucleus becomes bigger in cancer cells.

SEE FROG EGGS, 27 >>

NSF grant boosts paleobotany, women in science

FIELDWORK - Ellen Currano, a University of Wyoming paleobotanist with a joint appointment in the Department of Botany and the Department

UNIVERSITY OF WYOMING PHOTO

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

Investigating Wyoming's ancient ecosystems to help understand its present and future is an important part of Ellen Currano's studies funded by a $450,000 National Science Foundation Faculty Early Career Development (CAREER) Program Award.

Just as significant is the University of Wyoming scientist's use of the award to help encourage women's involvement in the geosciences.

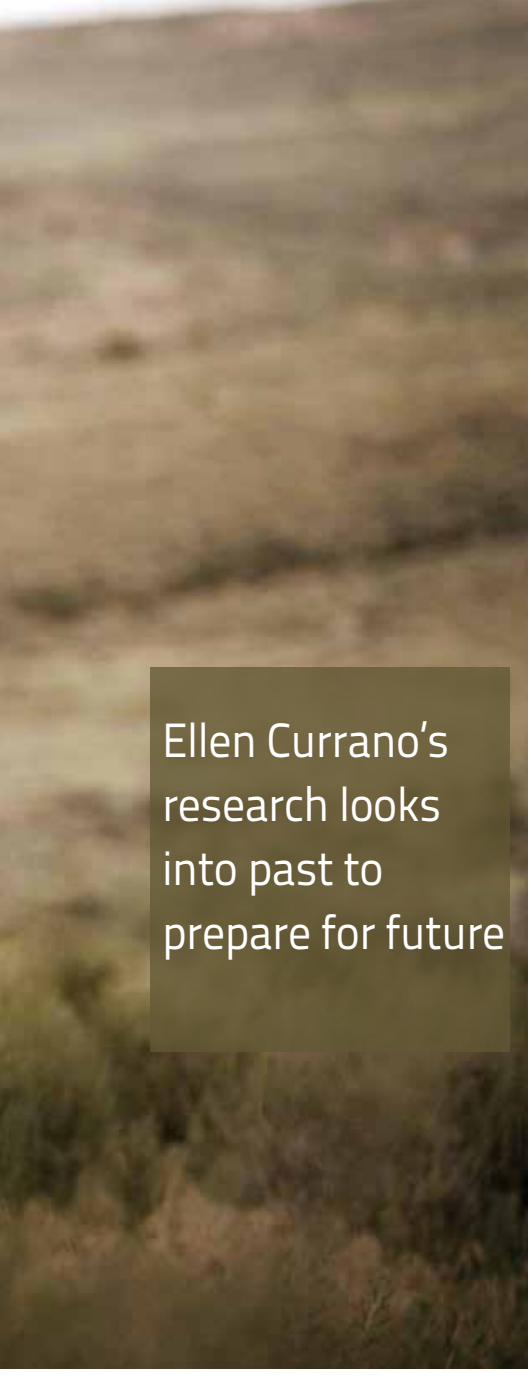
Currano, a paleobotantist, has a joint appointment in UW's Department of Botany and the Department of Geology and Geophysics. She received the NSF CAREER award for her project "Exploring Hothouse Ecosystems Through the Fossils of Wyoming and Colorado: A Suitable Job for a Woman."

The award allows Currano to expand and extend her research efforts in the region's geological past of 65-45 million years ago.

"Each summer, I spend about one month excavating fossil leaves in Wyoming and Colorado," Currano said. "Previous to this grant, I had stitched together small pots of money from many different smaller grants to fund the work. We were generally on shoe-string budgets and had to carefully plan exactly where and how long we could be in the field."

It was also time consuming to apply for the smaller individual grants.

"And that is time away from actually doing research," she said. "Thanks to the CAREER grant, I now have dedicated funds



Ellen Currano's research looks into past to prepare for future

of Geology and Geophysics, at work in the field.

for four summers of fieldwork."

Funds are supporting two undergraduate students to do summer internships, and one graduate student and one postdoctoral fellow to conduct research complementary to Currano's work.

"Because it is a four-year grant, we can also pursue longer term projects, like integrating new records from Wyoming basins, with the extremely well-resolved record from the Bighorn Basin," she said.

The science is about putting together the history of Wyoming, and tying together different parts of the state, she said.

"During the time period that I study, earth was a very different place: no ice at the poles; palm trees, ginger plants, crocodiles, giant terror birds, and tiny horses all over Wyoming," Currano said. "It is fascinating to drive around Wyoming now and be able to see the juxtaposition between the present and the Paleocene/Eocene hothouse; to know that areas that are currently desert, grassland, or sagebrush were once forested and subtropical."

As her research compares different parts of Wyoming, Currano hopes to answer questions such as what affect did the mountain ranges have, and were ecosystems similar across mountain ranges or did the warmer temperatures make mountain ranges appear as more severe barriers for living things to cross over?

"It's important to look at the past and see what we can learn about where we're headed," Currano said.

As part of the CAREER grant's educational component, Currano is using social media to address the need for more women scientists in paleontology and STEM research through "The Bearded Lady Project: Challenging the Face of Science" and the "An Unsuitable Job for a Woman" blog.

Currano said that overall response to her educational efforts has been very positive.

Her blog showcases prominent female geoscientists and the work they do, as well as updating readers about Currano and her students' time in the field.

"My blog has been widely read and even used in introductory-level college classes," she said. "Every woman that I have approached about being in it has agreed, and male colleagues are avid followers, including sending in recommendations on scientists they admire."

"The Bearded Lady Project" (TBLP), which challenges the concept of what a scientist is supposed to look like, has succeeded "beyond" her expectations. TBLP is an attempt to draw attention to the work of noteworthy female geoscientists by putting beards on women researchers to emphasize that some people don't take them as seriously as their male counterparts.

"Nearly every woman that we have approached has agreed to take part in the project, including some serious big shots, and representing a wide range of ages, ethnicities and types of research," Currano said.

Currano said a trailer of a video produced for the project was shown at the November's Geological Society of America meeting.

"The room was full of people we did not know, many of whom came up to us afterwards offering positive feedback, potential contacts, and resources," she said. "We have now also received money (and official support) from the Paleontological Society, and the Geological Society of America will be providing us space to premier our portraits in Denver in September at no charge."

Not everyone is complimentary of TBLP, she added.

"Of course, there are some scientists who don't understand why we need this project and have told me that I am wasting my time and should be focusing on getting science done," Currano said, "but they are definitely the minority."

In the feedback on TBLP she has received from a wide range of audiences, both in and out of science, she said the responses that have most interested her "are folks from other disciplines who are minorities within that discipline, and they can also relate and love what we're doing."

For more on Currano's work, visit her blog at www.ellencurrano.me. For more on TBLP, visit thebeardedladyproject.com, www.facebook.com/beardedladyproj or follow @beardedladyproj on Twitter.

"During the time period that I study, earth was a very different place: no ice at the poles; palm trees, ginger plants, crocodiles, giant terror birds, and tiny horses all over Wyoming."

-Ellen Currano, UW paleobotanist

ROBOLAB - Students interface at the the Laramie Robotics Club. UNIVERSITY OF WYOMING PHOTO

NSF Award to help evolve artificially intelligent robots

UW's Jeff Clune mimics evolution to improve robotic brains

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

Using nature as model to innovate new advances in artificial intelligence earned Jeff Clune one of three National Science Foundation (NSF) Faculty Early Career Development (CAREER) Program Awards made to University of Wyoming professors this past year.

"It is a game changer," said Clune, a UW computer science assistant professor. The award provides $507,465 to fund laboratory work, including support for two Ph.D. students and adding computational resources to UW's research supercomputer.

"It also funds important outreach activities, mainly allowing us to continue to run the Laramie Robotics Club," he said.

Observing animals in nature and how they adapt to their surroundings in the skies and in the seas provides inspiration for the challenges of advancing artificial intelligence. Animal brains are complex and extraordinarily designed, and using the same processes that influenced their development encouraged Clune to find ways to evolve the next generation of artificial intelligence.

"On a daily basis, we recreate evolution inside a computer to study how natural selection produced intelligence in animals, including humans, so that we can eventually evolve artificially intelligent robots," Clune said.

Using computers, Clune and his students create simulated robots that compete with each other. Only the smartest survive. As the research becomes more refined in the future, the brains of these simulated robots can then be downloaded to real robots, where they will eventually help society in numerous ways, from putting out forest fires and finding earthquake survivors to cleaning our homes.

Clune and his colleagues recently have shed light on the biological mystery of how structural organization evolved in animal brains and other networks in nature, such as protein, metabolic and genetic regulatory networks. They exploit that new knowledge to create computational simulations of evolution that produce those same properties in the brains of robots. Clune's CAREER award funds the next phase of research, which is to investigate how these properties improve the intelligence and capabilities of robot brains.

> **"We recreate evolution inside a computer to study how natural selection produced intelligence in animals, including humans, so that we can eventually evolve artificially intelligent robots. "**
>
> -Jeff Clune, UW computer science assistant professor

With his students, Clune is testing whether regularity, modularity and hierarchy, separately and in combination, improve the ability of robots to (1) learn to adapt to new

situations, (2) continue to function even when damaged, (3) deal with unreliable data from their sensors, and (4) generally become smarter, measured as the ability to solve challenges of varying complexities.

"We think that encouraging the evolution of structurally organized computational brains could help improve the ability of robots to do all of these desirable things, but we have to conduct the experiments to find out," Clune said.

Education is an essential outreach component of a CAREER award. Clune's grant will enable him and his students to continue to run and further improve the Laramie Robotics Club. Free to attend, the club teaches children a love for programming, science, technology, engineering and math (STEM).

Each week, students in the club get together and play with robots (see pictures and videos at www.LaramieRoboticsClub.org). They get to design their own challenges, such as having robots solve mazes or play robot tag. Because they want their robots to do something fun, they learn the programming and math required to accomplish their goals. Thus, they get to learn how exciting programming and robotics can be. Within the first year, one former member is now an engineering student at UW, and a former mentor is at the Massachusetts Institute of Technology on a full-ride scholarship.

Clune's educational goals extend beyond Laramie. His grant helps fund his plan to create a turn-key guide to "How to create a robotics club" that will be free for any community in Wyoming or beyond.

"People in Laramie and elsewhere in Wyoming are extremely excited about the Laramie Robotics Club. We have had many parents tell us it is their child's favorite activity," Clune said. "Overall the response has been heartwarming, encouraging, and very positive."

Computer programming and robotics represent a huge segment of the current and future economy. As the Seattle Times reports, there is a well-documented shortage of graduates in computer science nationwide. The Bureau of Labor Statistics projects that 70 percent of all newly created jobs across all STEM fields during this decade -- across engineering, the physical sciences, the life sciences and the social sciences -- will be in computer science.

"Any efforts to teach Wyoming children a love for programming, science, technology, engineering and math will ready them for the world they will grow up and work in, and it is rewarding to help them be able to be the leaders and innovators in a fast-paced, technology-driven economic and scientific world," Clune said.

"[The grant] also funds important outreach activities, mainly allowing us to continue to run the Laramie Robotics Club."

-Jeff Clune, UW computer science assistant professor

Jeff Clune works with members of UW's Robotics Club. Clune is one of the world's leaders in the study of artificial intelligence. UNIVERSITY OF WYOMING PHOTO

Clune has a bachelor's degree in philosophy from the University of Michigan, a master's degree in philosophy and a Ph.D. in computer science from Michigan State University, and was a postdoctoral fellow at Cornell University funded by an NSF Postdoctoral Fellowship. His research is frequently covered by the international media, including National Public Radio, NBC, *Discover,* the BBC, *The Economist, Wired, National Geographic and The Atlantic.*

For more about Clune's research, visit www.evolvingai.org/videos

FROG EGGS, FROM 23

"Reducing the size of the nucleus in a cancer cell might be a new way to treat cancer," Levy said. "While changes in nuclear size are observed in most cancers, in my lab we are currently studying prostate cancer and melanoma cell lines."

The nuclear lamina appears to provide the structural support for the cell's nuclear membrane and by adding or removing specific proteins, researchers observe how those manipulations affect nucleus size. Research results were reported in the Nov. 13 edition of The Journal of Biological Chemistry, published by the American Society for Biochemistry and Molecular Biology Inc.

The process appears to be the same in human cells, as Levy's laboratory grew cells and found the same results, in that increasing lamins enlarged nuclei size and reducing lamins decreased nuclei size.

The American Cancer Society grant provides funds for the phase of the research focusing on reducing the size of the nucleus in cancer cells.

Levy's research funding also has a direct relationship to Wyoming residents who help raise money for a cancer cure, said Lindsay Kowalski, Relay For Life senior manager for the American Cancer Society.

"That's cancer research happening right in their backyard," Kowalski said, adding it's uncommon that major grants are awarded to institutions without medical schools.

Since 1946, the American Cancer Society has funded research and training of health professionals to investigate the causes, prevention and early detection of cancer, as well as new treatments, cancer survivorship and end-of-life support for patients and their families.

"I am very excited that funds raised in Wyoming by the American Cancer Society are coming back into the state to support cancer research," Levy said. "The American Cancer Society is the largest nonprofit cancer research funder in the United States. Most of this funding comes from individual donations, so knowing that donations made by Wyoming residents are being used to support cancer research in Wyoming is wonderful."

To view a video about Levy's work, visit https://youtu.be/7P2UPGTO-64.

What songbird mating calls can teach us about behavior in both humans and animals

NSF award provides access to new, costly technology

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

University of Wyoming researcher Jonathan Prather listens to songbirds for more than just pleasant melodies; he's gaining insights into the decision-making mechanics of how behaviors in animals and humans occur.

Prather, an associate professor in UW's Department of Zoology and Physiology, is a recent recipient of an $850,000 Faculty Early Career Development (CAREER) Program Award from the National Science Foundation (NSF). He is one of three UW faculty members to receive the award in 2015.

"The award has made possible an entirely new avenue of what we do in this lab," Prather said of the research involving finches and sparrows. "We previously used several approaches to ask the nervous system in how it contributes to the behaviors we're interested in. There are new technologies available, that because they are new, they are quite expensive. This award allows us to tap into those resources, to get much more experimental power to figure out the relations between the structure and function in the brain and the behavior of these animals."

In laboratory and field studies, Prather and his student researchers are examining how female songbirds choose their mates based on the quality of songs produced by their male counterparts.

"Ultimately what that boils down to is a sensory experience to which the animal assigns some value, some attractiveness," Prather said of the female songbird's response to the male melody. "Then they use that information to take a selective action or not take that action."

There are pathways in the brain that are associated with reward and behavioral motivation in the songbird's response similar to that found in humans, he said.

"In a healthy state, they are beneficial for us," Prather said. "They are motivating and they are rewarding. In an unhealthy state, they give rise to addiction and other behaviors."

Prather said when a female bird evaluates the quality of a song, it's getting insight into the male's life history, such as how well he learned to sing, his nutrition while young and his present nutrition. In his studies, the male song is the most important factor that influences the female's choice of a mate. By using different males and their songs, the females decision-making process provides quantifiable reproductive behaviors.

Another interesting aspect of his research, Prather said, involves a phenomenon called mirror neurons. Those are thought to play a role in how humans and other animals learn through imitation.

"The challenge is that especially in something like vocalizations, the input comes in as an acoustic experience through your ears and the behavior goes out as a vocal performance through your throat," Prather said. "How do you match those up to learn through imitation? Humans do that as they learn their language and birds do it as they learn their songs."

Learning how the brain uses sensory experience to refine motor performance and get better and better at something is part of Prather's work.

"One idea is that you have to compare what you did, the motor command that executed that behavior, versus what occurred as a result – the sensory feedback associated with that behavior," Prather said. "By comparing the motor command versus the sensory feedback, then you can begin to learn whether you executed the task properly or not. That's very interesting to me as a means of how we learn through imitation as it is a part of our everyday lives."

The five-year NSF research grant will pay for graduate students, undergraduate research stipends and community outreach associated with the grant. More resources to conduct behavioral experiments are important to assuring the work in lab is exact. Prather said researchers should be wary about asking an animal to do something that is unusual in its naturalistic experience. If researchers do, "there are opportunities for the animal to act in an anomalous way or a way you don't intend."

"If you're learning about the neurophysiology of an actual behavior, you've got to make sure that actual behavior is there," Prather said. "We do that in the lab by performing tests again and again to ensure that if a female chooses a mate, it's not just that she chooses this male on this day and another male on another day, such that it's a whim. We test them over

"The award has made possible an entirely new avenue of what we do in this lab. "

- Jonathan Prather, associate professor in UW's Department of Zoology and Physiology.

and over to make sure that there is something about that signal that they're using to extract information and take action accordingly."

Prather's methods were reinforced when his research team went into the field to examine observations of songbirds by persons in New York State. Prather's team recorded different results when observing the songbirds in Pennsylvania which led to the discovery that birds have regional dialects. Prather also noted that neurophysiology properties as demonstrated by an American songbird species and a distantly related species found in Southeast Asia were also the same, again reinforcing the research methodology and results.

NSF CAREER Award stipulations require the award recipient to include an educational outreach component as part of receiving the grant money.

The research provides meaningful training opportunities for four graduate students, 20 undergraduate students and five high school science teachers. They will receive mentoring from Prather and other collaborators in critical thinking and a suite of behavioral, electrophysiological, molecular and educational techniques.

As part of the outreach component, Prather is partnering with high school science teachers from around the state to develop active-learning curriculum modules based on this research. All materials will be placed online to expand the impact and reach of the research beyond Wyoming.

Prather is working with UW's Berry Biodiversity Institute to sponsor a series of "science cafes" around the state, where the science could be discussed with the public in a relaxed and casual setting, such as in restaurants or libraries.

SONGBIRD EXPERT - Prather Jonathan Prather, an assistant professor in UW's Department of Zoology and Physiology, recently received an $850,000 NSF CAREER Program Award to study how female songbirds choose a mate, based on the quality of its song. UNIVERSITY OF WYOMING PHOTO

Three UW students get boost from the National Science Foundation

Master's and Ph.D. candidates honored by Graduate Research Fellowship Program

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

Three University of Wyoming students received National Science Foundation (NSF) Graduate Research Fellowships in 2015. They are gaining important experience and opportunities to become future leaders in science, technology, engineering and math.

¬The NSF program recognizes and supports outstanding graduate students who are pursuing research-based masters and doctoral degrees in science and engineering. ¬The award includes three years of funding for their education.

Out of 15,000 applications in 2015, the NSF selected 2,000 recipients, including the three at UW. There are eight current fellowship recipients at UW (see sidebar).

Delina Dority
-Wind Turbine Effects on Insects

Delina Dority, a senior majoring in biology from Casper, is pursuing her master's degree in zoology at UW. She is conducting research involving the 700-800 bee species in the state and the potential effects wind turbines may have on them. The research may help the Bureau of Land Management (BLM) in managing wind farms in the state.

"I'm really interested in insects in general," said Dority. "Pollinators are really important to ecosystems."

For the research, two wind farms and two control sites with similar terrain to where wind farms are built are being used as study sites in southeastern Wyoming. Currently, 80 percent of birds killed by wind turbines are passerines, or those birds that feed on insects, said Lusha Tronstad, an invertebrate zoologist with the Wyoming Natural Diversity Database (WYNDD) at UW and Dority's co-adviser.

Dority and Tronstad hypothesize that bees don't fly high enough to be killed by wind turbines. However, they do see the effects of birds being killed by wind turbines tapering down through the food web.

"If birds are dying (by striking wind turbines) and there are fewer birds at wind farm sites, we think we might have more insects at wind farm sites," Tronstad said. "We will investigate how wind farms affect the food web, and how pollinators might be affected."

"If there are more pollinators present near wind farms, then that might be an indicator of increased plant fitness," Dority said.

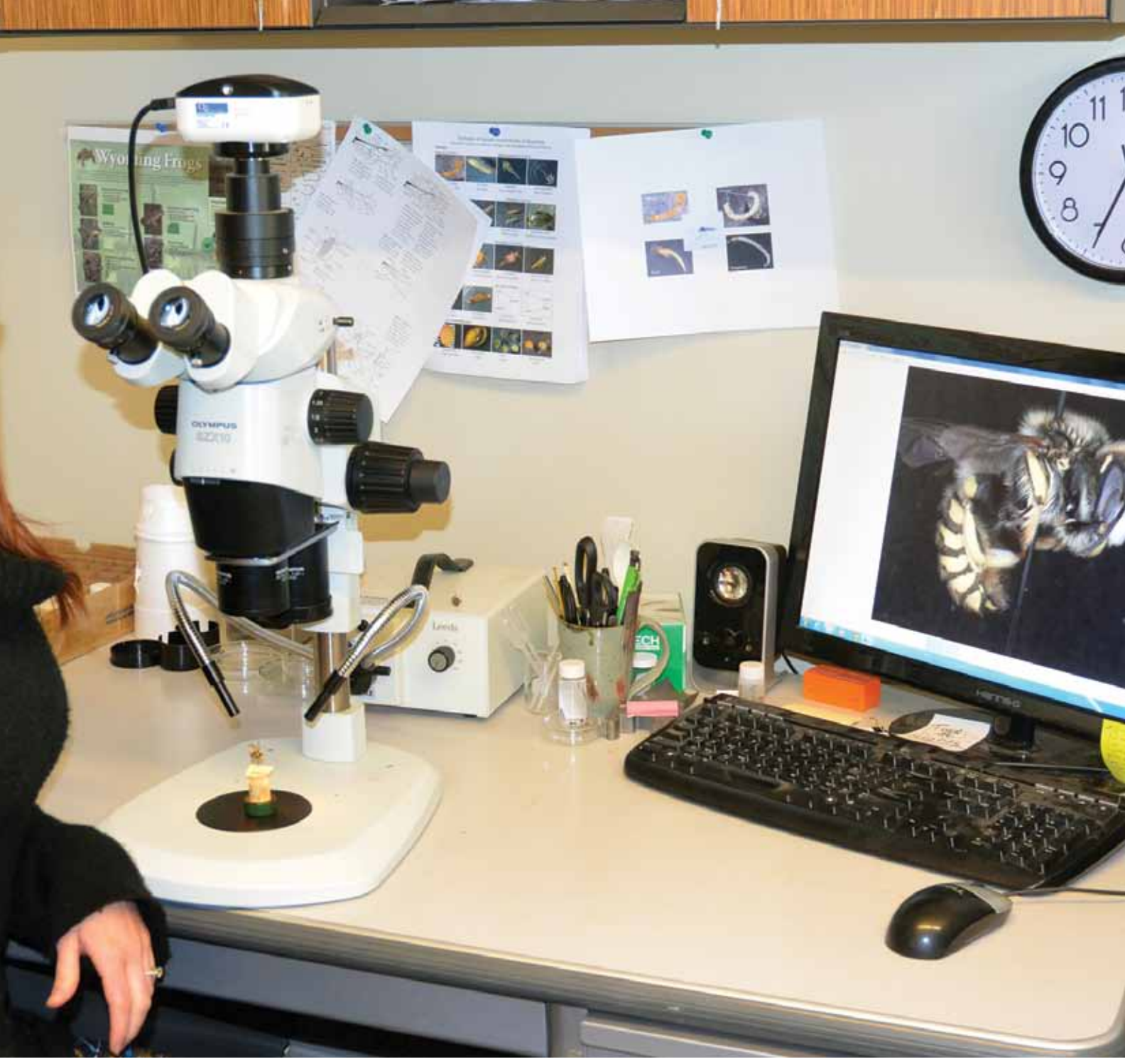
Dority developed the Fellowship proposal with Tronstad and Michael Dillon, a UW assistant professor in the Department of Zoology and Physiology, who is Dority's faculty advisor. Dority said she will conduct her research by collecting preliminary data around the turbines and by working with BLM officials.

"The BLM manages and permits wind farms in the state, and information collected from this research will help the organization make future decisions on permitting and design of wind farms," Dority says. "I feel like this research would help the BLM make good decisions."

QUEEN BEE – Casper's Delina Dority is researching

"I'm really interested in insects in general."

– Delina Dority, NSF Graduate Research Fellow



Wyoming's bees and the potential effect wind turbines may have on them. UNIVERSITY OF WYOMING PHOTO

UW recipients of NSF Graduate Research Fellowships:

- 2011 Shawn Billerman Life Sciences – Evolutionary Biology
- 2011 Guy Litt Engineering – Hydrologic Science
- 2013 Emily Beagle Engineering - Energy
- 2014 Lisa Barrett Life Sciences - Zoology
- 2014 Ellen Aikens Life Sciences - Ecology
- 2015 Lindsay Arvin Geosciences – Geomorphology
- 2015 Delina Dority Life Sciences - Ecology
- 2015 Marlin Jamell Holmes Engineering – Mechanical

WIND WIZARD - Marlin Holmes came to Wyoming to study wind energy and experience our world-class wind. UNIVERSITY OF WYOMING PHOTO

Marlin Holmes
- Wind Energy

As a child growing up in Buffalo, NY, and Charlotte, NC, Marlin Holmes asked a lot of questions. When his parents and grandparents didn't have the answers, they encouraged him to find out for himself, often taking him to the local library to do research -- and enrolling him in summer science camps to further stimulate his interests.

Marlin Holmes earned a bachelor's degree in aerospace engineering from the Georgia Institute of Technology (Georgia Tech) in 2013. He received notice of the NSF award during his second year of graduate studies in the Department of Mechanical Engineering, working under Professor Jonathan Naughton in UW's Wind Energy Research Center.

Holmes was encouraged to come to UW by his adviser at Georgia Tech, Associate Professor Marilyn Smith, who delivered a simple message when told of his desire to study wind energy.

"She said that, if I wanted to learn about wind energy, I needed to go where the wind is," Holmes said. "And if I would first go to Wyoming and learn the science, I'd then be able to go on and do anything I want."

Naughton, an associate of Smith with an international reputation in wind energy studies, "was the most responsive and most helpful" of any faculty member at the institutions to which Holmes applied for graduate school, he said.

While he's immersed in his intensive graduate studies -- which have the potential to significantly benefit both the wind energy and airline industries -- Holmes has made it a priority to help others. Through a separate NSF fellowship, he regularly works with young people around the state to encourage their interest in science, technology, engineering and mathematics through activities including building model wind turbines. He teaches mathematics during the summer in UW's TRIO Program for students who are economically disadvantaged, from ethnic minorities, have disabilities or are first-generation college students.

He's also a member of UW's Black Student Alliance, UW's Martin Luther King Jr./Days of Dialogue Committee and Alpha Phi Alpha Fraternity Inc., the first intercollegiate Greek-letter fraternity established for African-Americans.

"If I wanted to learn about wind energy, I needed to go where the wind is."

-Marlin Holmes

Lindsay Arvin

- Forest and Landscape Evolution

Lindsay Arvin of Chicago received her bachelor's degree in geological sciences from the University of Southern California (USC) and is pursuing graduate studies in the UW Department of Geology and Geophysics.

She is studying under Associate Professor Cliff Riebe and plans to earn a Ph.D. in geology in five years.

Riebe has been researching how bedrock influences forests and landscape evolution in California's Sierra Nevada Mountains. He and his students, last year, published groundbreaking research concluding that bedrock composition is just as important as climate in influencing the growth of plants, including the Giant Sequoia, the largest trees on Earth.

"Now, the challenge is getting at what's behind all the patterns they recognized," Arvin said. "Trying to find out what makes the conditions right for those trees to grow is just inherently interesting."

Arvin learned about Riebe's research from one of her USC professors and decided to apply for graduate school in UW's Department of Geology and Geophysics. Competition for the department's graduate openings is tight, and Riebe said Arvin stood out because of her enthusiasm for the work his group has been doing.

"Lindsay has the interest and background in all the right areas to really help us advance the research we have been doing," Riebe said. "I was thrilled that she had decided to come work with us, and that was before I heard about the NSF fellowship."

"Trying to find out what makes the conditions right for those trees to grow is just inherently interesting."

-Lindsay Arvin

ROCK STUDY – Lindsay Arvin is studying the impact that bedrock has on tree growth. Her group has discovered that what lies beneath the soil is just as important as climate in influencing plant growth. UNIVERSITY OF WYOMING PHOTO

Computers aid wind energy research at UW

Simulations can replicate terrain and atmospheric turbulences around Wyoming

BY PATRICK WOLFINBARGER
News@WyomingBusinessReport.com

State of the art computers are helping University of Wyoming scientists improve technology for wind energy.

"Computational science is now the third leg of science and engineering, along with theory and experiment," said Dimitri Mavriplis, director of the UW Computational Science and Engineering Group within the College of Engineering and Applied Science. "We have made a lot of progress over the last few years at UW. We have developed computational algorithms for performing analysis of individual wind turbines and complete wind farms."

Computational science results can be visualized in intuitive ways to provide great insight and understanding into the fundamental mechanisms for various engineering problems, he said.

"For example, our simulations of current and planned wind farms in the state of Wyoming can be used to illustrate the interaction between the atmospheric turbulence over complex geographical terrain and individual wind turbines within the wind plant," said Mavriplis, a UW professor in the Department of Mechanical Engineering.

A recognized international expert in computational fluid dynamics (CFD), Mavriplis came to UW in 2003 after working 16 years at NASA's Langley Research Center in Hampton, VA. CFD is a branch of fluid mechanics that uses computer-based numerical methods and algorithms to analyze and solve fluid flow and aerodynamic problems. Use of computer simulations to test aircraft designs, instead of costly and time-consuming wind-tunnel tests, has revolutionized aeronautical engineering.

The same processes that help Mavriplis analyze simulations to enhance aircraft flight to the edge of space, are giving UW researchers insight into improving wind turbines that will convert flowing air into energy for homes and industry.

"At UW we have access to some of the best computational resources in the country and better computational hardware than most other universities, including most of the top rated national engineering colleges," Mavriplis said. "This has allowed us to advance our simulation capabilities and to perform large scale simulations involving complete wind farms. These are some of the largest and most sophisticated simulations done to date and these accomplishments have been instrumental in helping us secure additional research funding from outside sponsors."

UW is home to powerful computer systems that provide Mavriplis and colleagues the tools needed for complex simulations. The Advanced Research Computing Center houses and manages campus wide high-performance computing hardware, such as the Mount Moran cluster.

The university is also a partner in the National Center for Atmospheric Research Wyoming Supercomputing Center (NWSC) in Cheyenne, which contains one of the world's most powerful supercomputers. NCAR will be installing a new supercomputer for 2017. It will be a 5.34-petaflop system, meaning it can carry out 5.34 quadrillion calculations per second, and be capable of more than 2.5 times the amount of scientific computing performed by Yellowstone, the current NCAR supercomputer.

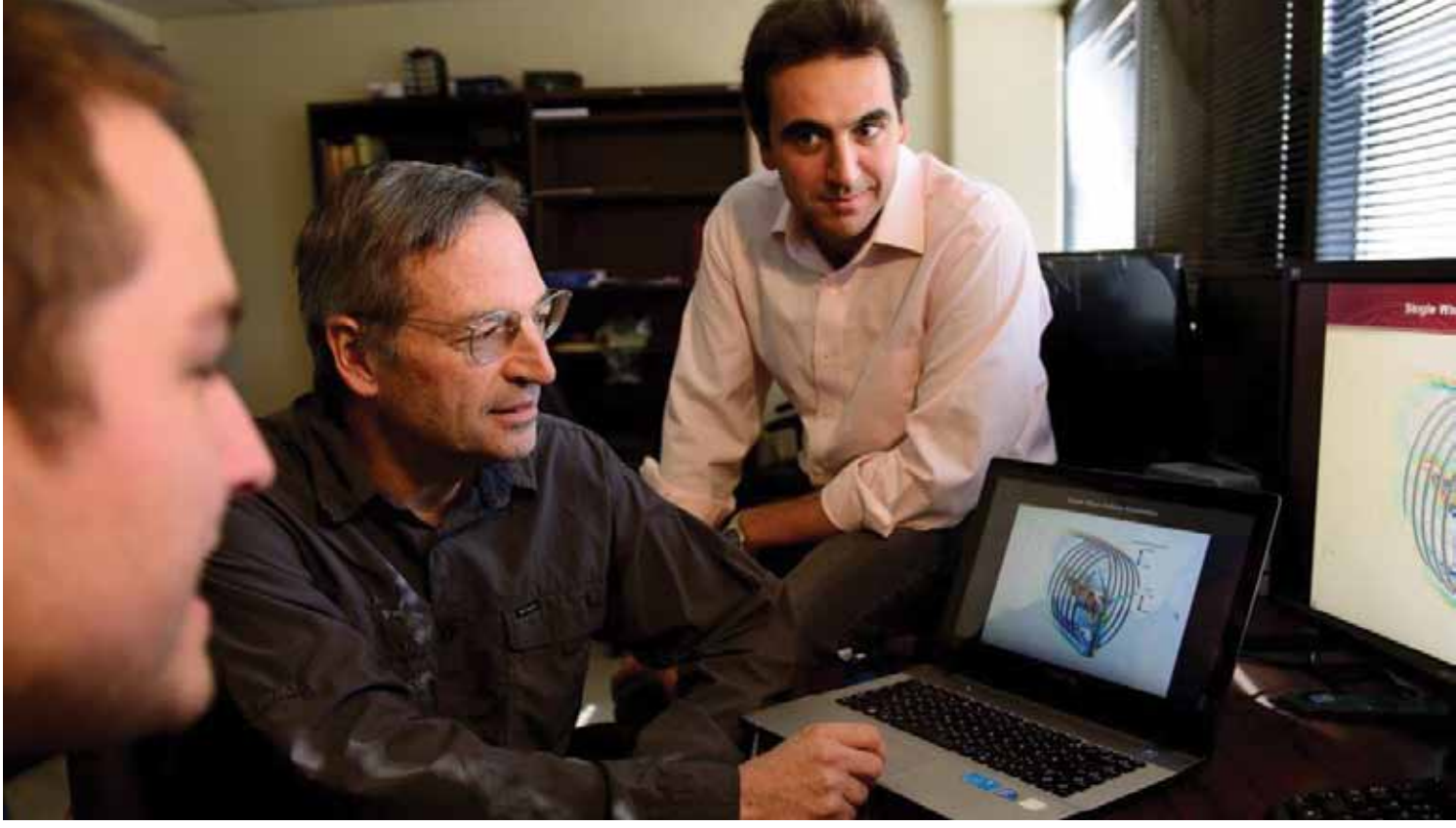
Mavriplis said the Computational Science and Engineering Group enriches collaboration between other areas of research within the UW College of Engineering and Applied Sciences.

"The group brings together complementary expertise in software algorithms, computer hardware, engineering applications and data processing and interpretation," Mavriplis said. "This expertise spans four departments within the college and has resulted in increased collaboration both at the scientific level and in our competitiveness for large institutional grants in computational science and engineering."

A collaborative effort, with Mavriplis as the principal investigator, is using the NCAR-Wyoming Supercomputing Center to demonstrate the feasibility of simulating entire wind farm installations (of 100 turbines or more) in order to improve wind farm siting decisions and wind turbine designs.

Titled "Computational Study of Wind Turbine Performance and Loading Response to Turbulent Atmospheric Inflow Conditions," the project includes Jonathan Naughton, Jay Sitaraman and Michael Stoellinger – all professors in UW's Department of Mechanical Engineering. The project also is tasked to develop computational models capable of incorporating effects of complex terrain on wind turbines/arrays. The project is supported by a Department of Energy grant and an Air Force Office of Scientific Research grant.

Mavriplis's work is also being enhanced by the designation last year of UW as a GPU Research Center by NVIDIA, the world leader in visual computing. The designation makes UW one of only 50 such centers in the nation. NVIDIA GPU Research Centers are institutions that embrace and use GPU (graphics processing unit) technologies across multiple research fields, and are at the forefront of some of the world's most inno-



TURBO GRAPHICS- Dimitri Mavriplis, center, University of Wyoming professor of mechanical engineering, conducts computational research that simulates the aerodynamics of aircraft wings, helicopter propellers and wind turbines. UNIVERSITY OF WYOMING PHOTO

vative scientific research. GPU computing leverages the parallel processing capabilities of GPU accelerators, enabling software to deliver dramatic increases in performance for scientific, artificial intelligence, deep learning, graphics, engineering and other demanding applications.

"We'll receive support from NVIDIA for our important and leading-edge research," said Mavriplis. "The product of our research can help demonstrate the benefits of their technologies."

As a GPU Research Center, UW will have pre-release access to NVIDIA GPU hardware and software; the opportunity to attend exclusive events with key researchers and academics; assistance from a NVIDIA technical support liaison; and access to specialized online and in-person training sessions.

Of the NVIDIA designation, Mavriplis added, "It gives us critical mass in our computational research program at UW rather than just operating as individual researchers."

Jeff Clune, a UW assistant professor in the Department of Computer Science, and Richard Loft, director of the National Center for Atmospheric Research's Technology Development Division, are the GPU Research Center's other principal investigators.

Mavriplis' CFD expertise involving aerodynamics continues to be sought at the highest levels. Recently he was one of the authors of a report that offers guidance to NASA regarding the computational resources it will need to design aircraft and spacecraft in the future.

He joined researchers from Stanford University, the Massachusetts Institute of Technology, Boeing, Pratt & Whitney, and the National Center for Supercomputing Applications to produce the report for NASA. Titled "CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences," the report includes recommendations for the nation's aeronautical research agency to continue advancing aerospace design.

Mavriplis also was part of the HELIOS software development team that won the 2013 Schroers Award for Outstanding Rotorcraft Research from the San Francisco Bay Area Chapter of the American Helicopter Society (AHS). The 11-member team, including UW colleague Sitaraman, was honored for its multiyear effort to bring multiscale and multidisciplinary physics to the entire rotorcraft technical community, including industry, government and academia.

"At UW we have access to some of the best computational resources in the country and better computational hardware than most other universities, including most of the top rated national engineering colleges."

-Dimitri Mavriplis, director of the UW Computational Science and Engineering Group

UW GRADUATES WORLD CLASS

In high demand in Silicon Valley

One of the main benefits of expanding and diversifying the Wyoming economy is providing high-quality, high-paying jobs for our graduates.

We know UW graduates are high quality because Wyoming provides a significant workforce to the Silicon Valley. In fact, Wyoming rankes 70th in the world when it comes to providing brain power to that region.

Top sources
1 Mexico
2 Texas
3 Arizona
4 Washingont
5 Illinois
6 Philippines
7 China
8 New York
9 India
10 Florida
11 Colorado
12 Japan
13 Virginia
14 Nevada
15 Massachusetts
16 South Korea
17 New Jersey
18 Oregon
19 Ohio
20 Pennsylvania
21 Georgia
22 Michigan
23 Canada
24 Alaska
25 Utah
26 Maryland
27 Other Middle East
28 Missouri
29 North Carolina
30 Connecticut
31Wisconsin
32 Vietnam
33 Hawaii
34 U.K.
35 Other Western Europe
36 Germany
37 Idaho
38 New Mexico
39 France
40 Minnesota
41 Other Eastern Europe
42 District of Columbia
43 Tennessee
44 Pacific Islands
45 Russia
46 South Carolina
47 Australia
48 Kansas
49 Thailand
50 Taiwan
51 Other Asia
52 Mississippe
53 Other Africa
54 Indiana
55 Brazil
56 Oklahoma
57 Turkey
58 Italy
59 Other South America
60 Arkansas
61 Other U.S. possessions
62 Other Southeast Asia
63 Louisiana
64 Alabama
65 Nebraska
66 Puerto Rico
67 Iowa
68 Spain
69 Guatemala
70 Wyoming
71 Rhode Island
72 Other Central America
73 Iraq
74 Kentucky
75 El Salvador
76 Eastern Africa
77 Noorthern Africa
78 Other Caribbean and North America
79 Honduras
80 New Hampshire
81 Cuba
82 North Dakota
83 Delaware
84 Egypt
85 Israel/Palestine
86 Montana
87 Ukraine
88Afghanistan
89 Nigeria
90 West Virginia
91 Maine
92 South Dakota
93 Vermont
94 Poland
95 Doninican Republic
96 Western Africa
97 Colombia
98 Saudi Arabia
99 Peru
100 Jamaica

Average annual influx of residents, 2008-12

●=100 people

Net migration (foreign and domestic) to Silicon Valley in 2013 reached 13,766, the highest in a decade.

GRAPHIC BY BLOOMBERG BUSINESS WEEK. DATA: 2005-2012 AMERICAN COMMUNITY SURVEY FIVE-YEAR ESTIMATES COMPILED BY INTEGRATED PUBLIC USE MICRODATA SERIES. VERSION 5.0. 2014 SILICON VALLEY INDEX: INTERNATIONAL BUSINESS TIMES: SAN JOSE MERCURY NEWS

AHH-SOME VIEW - UW's AMK Ranch, set in the forest on Jackson Lake, provides a serene setting for study. MARK WILCOX PHOTOS

"Science has an important role in informing policy decisions which may have to be made by the park source."

–Bill Gern, vice president UW Office of Research and Economic Development

TETON, FROM 19

"Any way we can help park services and state agencies is helpful in an outreach way to connect to people that want to visit this very special place on the planet," Bergman said. The research performed at the station continues to shape the park resources in the northwest corner of Wyoming.

That is a symbiosis that pushes Grand Teton and Yellowstone National Parks to contribute financially to the ranch through grant commitments.

"They recognize the important role of science in informing policy decisions which may have to be made by the National Park Service," said Bill Gern, vice president of UW's Office of Research and Economic Development.

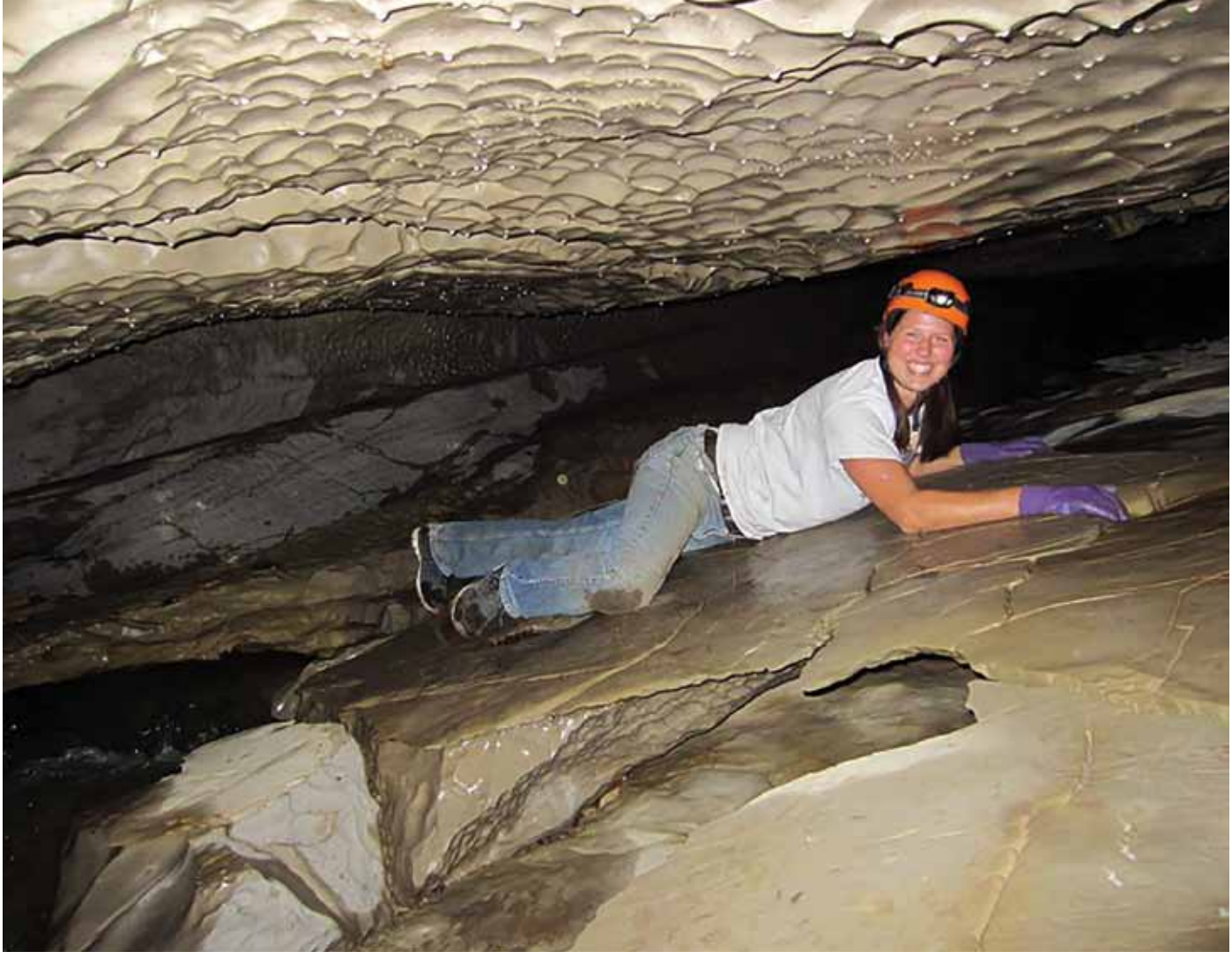
Given its location, the ranch also draws multi-day think-tank meetings, retreats and more that have to be "shoehorned in" around the many other activities happening at the ranch.

"Scheduling all these things is kind of a Rubik's Cube nightmare," Bergman said.

With complex ecosystems to study, researchers never want for topics to delve into. Among important themes are fire ecology related to the Yellowstone fires of 1988, the evolution of bark beetle penetration in the area, fault geology and its impact on the area and its residents, forest coerage as it relates to grizzly bear populations and more.

"Everything is complex, of course, but these researchers are trying to pick it all apart," Bergman said. And in doing so, they are providing some of the most visible research coming out of any part of UW.

"It raises UW's profile – that's an important part of our mission," Bergman said.



CAVE CRAWL- Wyoming Interns to Teachers Scholars (WTIS) summer intern Tonya Busse, a UW transfer student from Central Wyoming College, explores a cave in Sinks Canyon. PHOTO COURTESY JACQUELINE LEONARD

NSF, FROM 11

lege, Meramec Community College in St. Louis, Western Wyoming Community College, and Central Wyoming College. Together the interns served more than 100 K-8 students in Wyoming.

Leonard said the reaction to the programs has been very positive.

"Principals and teachers call and email to sign up for Visualization Basics," she said. "Several teachers have participated for two years or more. While there is a stipend, we have found through classroom observations that teachers learn as much as the students about robotics and game design. Some of the students' games have been phenomenal."

She added that WITS scholars have told their friends about the program and as a result two new scholars have been added in the spring.

"We are ramping up for recruitment for the next cohort," Leonard said. "Applications are due on March 1."

Information about WITS applications can be found at www.witsnoyce.com.

Leonard has plans for more programs to help prepare young students for STEM academics and careers. She and Bryan Shader, UW's special assistant to the vice president for research and economic development and a mathematics professor, are collaborating to get a team of UW researchers to work with the National Center for Atmospheric Research (NCAR) to submit a proposal to the STEM + Computing Partnerships program. She also plans to propose an ITEST scale-up this summer to take the Visual Basic program nationally.

"I really enjoy watching students learn and grow in informal science education programs," Leonard said.

"In both gaming and robotics, students are also learning to debug and apply the problem-solving process of trial and error ... These skills are absolutely important in the workplace."

-Jacqueline Leonard, director of the UW Science and Mathematics Teaching Center (SMTC)

on science. Gene came to Laramie to teach me how to be an entrepreneur using my research that I was doing at UW."

Carron said he and Watson went to Cheyenne and started their first company, Detection Limit. A few years later, using the SBIR program, they founded DeltaNu with partner Robert Corcoran.

Before selling DeltaNu in 2007, the partners had capitalized a profitable small business with $4 million in SBIR grants.

"My current company, Snowy Range Instruments, too grew with SBIR grants and has grown to over 30 employees and has just been acquired by Metrohm, a large Swiss instrument manufacturer," Carron said. "All together these business have brought in around $45 million to Laramie to date."

Carron said what he learned from Watson isn't "rocket science or requires a business degree."

"In fact, it is simple: keep your integrity," Carron said. "His business models are simple; make a product that works and don't oversell it. His stories of success come from Silicon Valley models of stock options and sharing the wealth with employees. It's a model that incentivizes everyone to work hard because they will all share in the success. Some of our best memories about our business are the families that we supported and improvements we made to people's lives. With Gene's simple entrepreneurial model we took instruments that the Denver Post described as the size of Volkswagens (the Bugs) to highly innovative systems the size of cell phones. I believe my story is just one of many about the people that Gene has helped since moving to Wyoming."

Watson's willingness to share his knowledge and mentor prospective tech entrepreneurs helped businesses around the state as well.

"Indispensable" is the word Bob Viola of Jackson uses to describe Watson's role in helping advance his business, Square One Systems Design, founded in 2002. The company recently received a contract to build the next generation of land mine-detection robots for the Department of Defense.

Viola said the first revenue his company ever received was through the WSSI program in 2004, and the company's been partnering with WSSI on opportunities ever since.

"It wasn't just the financial support through the Phase O program," Viola said. "It was the mentoring. It was the Gene-organized workshops on how to effectively write proposals. It was proposal reviews by professional reviewers. I don't even know where to start."

Viola credits Watson and Gern for developing a forward-looking plan to encourage and cultivate knowledge-based businesses.

"In our case, it was tremendously effective," Viola said.

Jon Benson, WTBC director, said Watson's work with SBIR played an important role for at least half of the companies that graduated from the incubator. Federal and state funding for technology start-ups is critical, he said, and there is less and less interest in funding them by "angel investors" (affluent individuals who provide needed capital).

"If you know what you want to do, go to work for the best company you can that does it ... If it's in your genes to be an entrepreneur, the day will come when you'll say 'I can do it better.' "

– Gene Watson

"In Wyoming, what you have to do is build up a base of technology companies, and Gene went all over the state promoting this," Benson said, "and we've always worked closely with his program and our clients. It takes time to develop a product, so SBIR is where you are going to go. Gene had tremendous impact on promoting that program."

Wyoming's efforts to diversify its economy through the technology sector in the future depend on more than just the continued support for entrepreneurial opportunities. It also is going to depend on increased awareness of the presence of technology companies already operating in the state.

Watson notes that there are Fortune 500 and international companies that operate in Laramie: RT Corporation is owned by Merck; Firehole Technologies is owned by Autodesk; IDES owned by Underwriters Laboratory; and Snowy Range Instruments is owned by Metrohm.

He has some advice for young entrepreneurs.

If you know what you want to do, go to work for the best company you can that does it," Watson said. "Do whatever kind of job you can, cleaning johns or what. The company will learn that you are a hard worker and you'll learn what they know. If it's in your genes to be an entrepreneur, the day will come when you'll say 'I can do it better.'"

SQUARE ONE - One of the robots created for mine fields. MARK WILCOX PHOTOS

INCUBATION: Nurturing Start-Ups to Success

WYOMING TECHNOLOGY BUSINESS CENTER
LARAMIE • CASPER • SHERIDAN

uwyo.edu/wtbc

Business incubation programs are proven tools for helping entrepreneurs grow successful businesses. The Wyoming Technology Business Center provides space, access to shared services, and business management advice for early stage, high-growth companies.

The WTBC is here to assist you in making your impact by commercializing technologies, creating jobs, and building wealth.

e2e Wyoming is an educational networking program with chapters in Laramie, Sheridan, and Casper designed to improve the climate for the start-up and growth of entrepreneurial companies. Visit our website for more information on the next event near you.

UNIVERSITY OF WYOMING

Western Research Institute (WRI), one of the world's foremost asphalt and petroleum laboratories, is moving research into new industry tools for gaining unprecedented insight into materials (asphalt and crude oils, additives, mixtures) for highway paving, roofing, oil production and refinery operations, blending, forensics, and new applications.

WRI research and engineering teams have brought forth more than 70 new tools to Expert Task Groups, the first step toward adoption as American Association of State Highway and Transportation (AASHTO) standards. These tools include test methods, performance and material models, practices, analytical programs, and software to better understand and design pavements, pavement materials, and additives, and predicting performance in the field.

With over a dozen patents, WRI inventions now enable asphalt users and producers to quickly identify bad asphalt materials and perform forensic studies. Conventional techniques take days and require large quantities. Using WRI patented automated SARAD™ (saturates, aromatics, resins, and Asphaltene Determinator) provides insight into asphalt "DNA" in just a few hours with mere milligrams of material. This method provides researchers, refiners, and asphalt material producers a way to screen out bad asphalt and produce high-value binders. The SARAD™ works on heavy petroleum products, asphalts, recycled asphalt pavements, shingles and re-refined engine oil bottoms.

To learn the latest asphalt research and tech firsthand, join us as we host over 300 asphalt experts and road builders from around the world in Jackson Hole at the International Society for Asphalt Pavements and WRI's 53rd Petersen Asphalt Research Conference.

WRI's coal combustion team is advancing Cleaner Coal Technologies, including novel oxygen production technologies to make CO2 capture and utilization affordable. At WRI's Coal Combustion Test Facility (CTF) is a nominal 70 kW 250,000 Btu/hr balanced-draft system designed to replicate a pulverized coal-fired utility boiler. The CTF simulates a tangential-fired boiler and is easily adapted to wall-fired or other configurations. The system also includes over-fire air injection ports for combustion staging and several ports for injecting sorbents into the furnace to test capture of regulated emission compounds. WRI's CTF is equipped with two baghouses, electrostatic precipitator (ESP) and spray dry absorber (SDA).

Since commissioning in 2000, WRI's CTF has been used for evaluating novel technologies for reducing air emissions from coal & biomass fired power plants and to determine combustion characteristics of different fuels: Coal, Biomass, and various blends of biomass and coals and various coals. Other testing operations have involved sensors and controls evaluation, performance of refractory materials and advanced alloys, and slagging and fouling issues from various unconventional feedstocks. The CTF is qualified for oxy-combustion to test and advance new oxygen production technologies to make CO_2 capture and utilization affordable.

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