2010

Quantum: Research, Scholarship & Creative Works at the University of New Mexico, Fall 2010

Office of the Vice President for Research

Quantum 2010

Research, Scholarship & Creative Works

in this issue:

Linguistics Professor Jill Morford and UNM's Visual Language and Learning Center seek to gain a greater understanding of the biological, cognitive, linguistic, and sociocultural conditions that influence visual language acquisition and knowledge.

by Carolyn Gonzales

Deaf children who are exposed to American Sign Language early on not only acquire that language more readily, but they also have an easier time learning another language--written English. This is one of many topics explored through NSF's Center for Visual Language and Visual Learning (VL2), a multi-institutional and interdisciplinary research center in which UNM participates.

When the National Science Foundation sent out a call for proposals for science of learning centers, Linguistics Professor Jill Morford was excited to see the NSF looking to fund interdisciplinary centers in the social sciences and humanities.

"In the past they have funded big science in engineering and the hard sciences, but this is a new strategy for the social sciences, and UNM has a lot to gain by participating in such a diverse and far-reaching Center," she says. The VL2 Science of Learning Center is one of six SLCs funded by the National Science Foundation. The purpose of VL2 is to gain a greater understanding of the biological, cognitive, linguistic, sociocultural, and pedagogical conditions that influence visual language acquisition and knowledge. VL2 is currently in its fifth year of NSF funding, and is being reviewed for an additional five-year funding period.

Morford, whose background is in psycholinguistics, came to UNM in 1996. Her decision was based, in part, on the depth of signed language research being conducted here. She says that UNM was "way ahead of the curve" in providing interpreting services for deaf students, as well as offering a signed language interpreting program.

What Morford and other VL2 researchers explore is how deaf individuals--experts at visual processing--learn. Subsequently, they apply these findings to other populations to understand how visual learning can be optimized. A topic that Morford is particularly involved in concerns how early access to sign language influences deaf children's ability to pick up reading. American Sign Language is not English, she says. So the children are, in essence, learning a second language.

Signed languages have emerged in many communities around the world because deaf people sought each other out. While there is no exact count, sign language typologists estimate that there are at least 1,000 different signed languages worldwide. "The deaf community is a linguistic minority. They are forced to work in a second language," Morford says. Linguists are beginning to understand how bilingualism functions in the deaf community.

"We are building capacity in our universities to provide direct communication and appropriate education so that deaf individuals can become researchers of their own signed languages. It is ironic that in the earliest era of sign language research, very few deaf people were able to obtain the qualifications needed to be involved in this research program. We aim to change that, and have already found that deaf researchers are bringing new insights to the study of visual languages," she says.

There are three deaf students at UNM currently working in Morford's laboratory, gaining training in research methods and other qualifications needed to be competitive graduate school applicants. She adds, "Professor Erin Wilkinson of the University of Manitoba, who is deaf, obtained her graduate training at UNM. She was the first graduate student funded by VL2 to land a tenure-track job following graduation. Without VL2 funding, it is unlikely that she would have finished her PhD as quickly as she did."

Wilkinson studied forty different signed languages, drawn from six different continents, Morford says. The analysis of kinship terminology in those languages was funded by VL2, but Wilkinson also worked with Morford on bilingualism between ASL and English. In spoken languages, words are reinforced in listening, speaking, and reading. What happens when a signer learns the written form of a spoken language?

"Hearing people associate print with spoken words that they already know. But for deaf people, learning to read is an entirely different process. One possibility that we're investigating is that print is associated with signs in the earliest stages of reading development," Morford says.

But associations between signs and printed words may not be the same for deaf people from every country. For ASL signers who are learning to read English, some signs incorporate a handshape that represents the first letter of the English translation of that sign, but that's rare in German Sign Language. " In Europe there's not too much fingerspelling. The focus is on mouthing words. Our collaborators in Germany think that signs are more loosely associated with print for deaf Germans than for deaf Americans because there are so few direct links between German signs and printed German orthography," she says.

Aside from being beneficial to the deaf community, understanding how the deaf learn to read could aid in teaching dyslexics. "We can teach ways to read based on the visual strategies that deaf people use," Morford says.

"Deaf people who have deaf parents engage visually and manage visual attention better because of early exposure to a visual language," says Morford. Managing visual attention is important because deaf people rely on peripheral vision to detect changes in their environment that are signaled by sound to hearing people, such as an approaching person, or a change in conversational turn.

Structured visual attention allows deaf individuals to shift attention to another signer at just the right moment to see what they are signing. Think about reading books aloud. Hearing children stare at the book while they listen to the story. Deaf children have to learn to shift their gaze between the words and pictures in the book and the parent or teacher who is telling the story in ASL. Early socialized visual attention comes readily for those who have early language access.

According to Morford, twenty percent of babies fail their first hearing test. Many parents don't follow up. As a result, many children receive their first diagnoses of deafness at two years of age. Those two years are lost time. "By age two, hearing children no longer hear Spanish and English the same. The brain is efficient at differentiating sounds," she says.

An area Morford explores is how distinguishing sign language handshapes is different with signers who were exposed to ASL from birth and signers who learned ASL later, outside the home. Language is delayed for deaf children without language exposure from birth. "Brain development hinges on language exposure from birth," she says. "One possibility we're exploring is that even subtle differences in 'seeing' signs may mean the difference between comprehending language easily and effortlessly versus struggling with everyday language use." Morford and colleagues are publishing these results in the *Deaf Studies Digital Journal,* the first journal to be published completely in sign language.

For more information on the VL2 Science of Learning Center, visit: http://vl2.gallaudet.edu

A Change in Culture

Deborah Helitzer is investigating the culture change needed to improve recruitment and retention of women in science.

by Luke Frank

Academic medicine is lopsided. Despite the recent dramatic growth in female higher education enrollment--2008-2009 was the first time women earned a majority of doctoral degrees in the U.S.--life events such as marriage, home, and family intervene. Over the succeeding years, what remains is predominantly full-time, tenured male faculty in health sciences leadership positions.

"One of the problems is that, generally, at the same time women become junior faculty, they're in their peak child-bearing years," says Deborah Helitzer, UNM professor of Family and Community Medicine and associate dean for Research Education. "What begins as a fifty-fifty male-to-female ratio in medical school quickly pares down to a sixty-five to thirty-five ratio in the associate professor group, as women seek part-time work, extended maternity leave, and other work/life balance opportunities."

Helitzer hopes someday in the near future women can better pursue career opportunities in academic medicine. She was recently awarded one of fourteen National Institutes of Health (NIH) grants to direct the investigation of the culture change needed to improve recruitment and retention of women in science. Ultimately, this research should lead to policy recommendations for professional development to improve women faculty representation at the highest leadership levels in academic medical institutions.

"Statistics show that, historically, retention and promotion of women in academic medicine have not kept pace with that of men in the same institutions," says Helitzer. "As a result, there have been national initiatives to improve these indicators. This project will help us determine whether participating in any one or more of these programs influences the retention and promotion rates of women faculty."

"This is important to the health sciences disciplines and the institutions that develop our future leadership," she adds. "Our research is becoming more team-based and outcomes-oriented. Females can be more collaborative and inclusive, and focused on the practical side of life. And, probably to our disadvantage, we tend to be less interested in personal advancement and more interested in institutional advancement."

Funded by an NIH million-dollar grant, the study will be conducted over four years by researchers from the University of New Mexico Health Sciences Center, the University of Texas M. D. Anderson Cancer Center, and Drexel University College of Medicine in Philadelphia. The Association of American Medical Colleges (AAMC) also is collaborating on the grant.

Specifically, the study will assess the impact of participation in intensive career-development training programs on individual women faculty at early and mid-career stages. The study will evaluate three long-standing, nationally-renowned programs: the AAMC Early Career Women Faculty Professional Development Seminar, the AAMC Mid-Career Women Faculty Professional Development Seminar, and the Hedwig van Ameringen Executive Leadership in Academic Medicine (ELAM) Program for Women at Drexel University College of Medicine and compare the career success of women who participated in the programs to women and men, at the same career stages, who did not participate.

Helitzer describes academic medicine as a three-legged stool. To support one's professional platform requires tireless hours in clinical care, health sciences research, and classroom teaching time--and all three are interdependent. It's an impressive professional grind; within about six years, one either moves up or moves out. "Clinical care drives the finances, while research and education are relatively undervalued," she says. "Most clinicians find it difficult to do much research."

Everything from personal desires to social mores, institutional standards to home support, and role models to gender expectations, will be investigated. "Our research will identify academic infrastructure and institutional support that make it more likely for anyone to succeed," Helitzer says. "We want to distinguish what makes successful women successful, and incorporate those findings into programs to help everyone advance.

For more information on the NIH study, visit http://womeninscience.nih.gov.

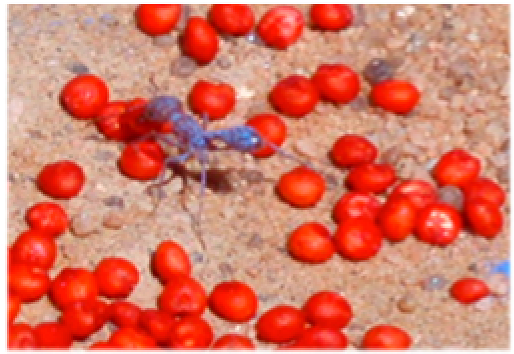
Melanie Moses crosses the boundaries between biology and computer science.

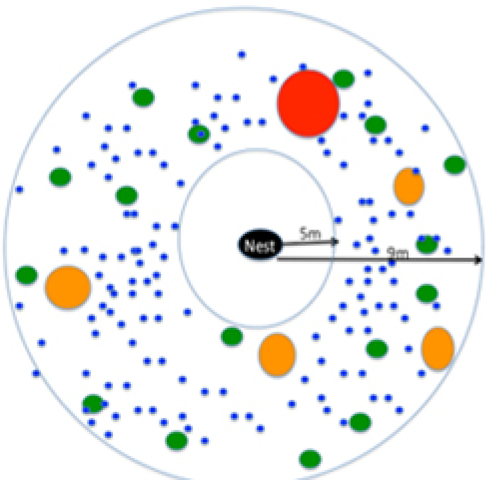
by Karen Wentworth

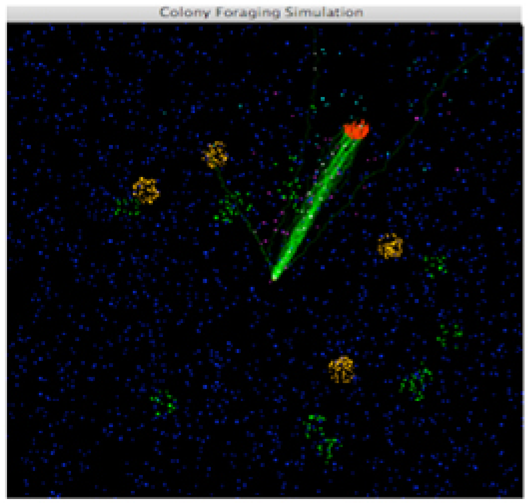
Is a mammal's growth dependent on its metabolism? Do colonies with fifty ants communicate as effectively as colonies with ten million? Can a road network be compared to blood vessels in a body? Melanie Moses, assistant professor of computer science, never asks herself the easy questions.

Moses came to UNM ten years ago after graduating from Stanford and working in computer security. She arrived at UNM as a doctoral student in biology and stayed when the computer science department opened a position for a computational biologist. Her research crosses the boundaries between biology and computer science and she is active in collaborations with others.

Currently she and her students have been conducting research on ant societies. "There's a theory that says it's the topology of networks that connects cells in an organism, and that puts a constraint on how fast their metabolism can go as a function of their size," she says. "I am interested in finding out if the same thing occurs with individuals in a society." She and her research group are examining ants in the real world and how they use information and communicate to improve their foraging success.







The group experimented with colored seeds scattered in small piles around ant colonies of various sizes, taking photos to document how long it took for ants to find piles of food and bring it back to the nest. They were surprised to find that each ant in a colony of fifty ants is as efficient at finding a pile of seeds and carrying them back to the nest as each ant in a colony of two-thousand ants. Now they are trying to understand why, by building a series of computer simulations that generate various parameters for ant behavior.

Moses has a National Science Foundation grant that is part of the program "Advancing Theory in Biology," which encourages her to search for answers to some puzzling questions. "How is it that an ant colony can work just fine with fifty ants or with ten million ants?" she asks. "And the same thing with the immune system--the immune system of a mouse or a tadpole has millions of cells, and the immune system of an elephant has trillions of cells. What has to change to have that many more cells interacting without any top down control? Everything in these systems is very decentralized." She wants to know what ants and immune systems have in common that make them so scalable.

"Of course, ultimately the idea is to take these principles and engineer network systems that can function effectively without top down control and scale up to large sizes. The smart power grid requires decentralized coordination and there's a trend toward decentralization with multi-core chips. Instead of having one chip with a single CPU, you might have 64 cores on a chip, how do you coordinate the actions of all these separate entities without one being in charge? I think a lot of the interesting questions in engineering take inspiration from the way biology has been solving these problems," she says.

Moses is always looking for a new way to make connections between biology and engineering, even when there's a challenge. Last summer, UNM began excavating land to build new student housing on UNM's south campus. The process wiped out the ant colonies she and her team had been observing and she's looking for new ant colonies to monitor. She's optimistic that she will soon be able to find a new site for observing ants somewhere close to the university. "The interplay between building models and experimenting with real systems is what makes studying complex biological systems so much fun."

The Maxwell Museum of Anthropology has teamed up with the Center for Advanced Research Computing to develop a digital archive of the museum's holdings.

by Karen Wentworth

The basement of Maxwell Museum of Anthropology is an amazing place. It stores artifacts collected and donated by generations of people intent on preserving elements of human history. Although the museum has thousands of artifacts, including pottery, objects, photographs, textiles, and more from throughout the world, it is most known for the unique collection of artifacts from the Southwest. Only a small fraction of the treasures at the museum can be displayed at any given time, but the museum's photo archivist Catherine Baudoin is working on opening the basement doors to everyone.

For the past five years, she and Tim Thomas at the Center for Advanced Research Computing (CARC) have been developing a way to allow the museum to photograph or scan the artifacts at the museum and make these images available online. A new grant from the Institute of Museum and Library Services will enable the Maxwell, CARC, and the New Mexico Palace of the Governors to work together to build a virtual repository of images that scholars, researchers, and students throughout the world can study.

"There have been many things said about how we are supposed to deal with the time, effort, and money that goes into getting images scanned or taking photographs of objects, and then you have all these lovely things documented, but what do you do with them?" says Baudoin. "And what do you do with them over time?"

Thomas established a way for the museum and the Palace of the Governors to purchase servers and partition them so that every time Baudoin has a high resolution scan of a prehistoric pot, she can save the image to the Maxwell server and the Palace of the Governors server at the same time, while allowing the supercomputers at CARC access to the file. That way there are at least two copies of each image file.

The goal is to expand the project to eventually allow many more museums in New Mexico to participate in the same system. The current grant will be used to set up the initial infrastructure, underlying software, and a web interface for the entire project.

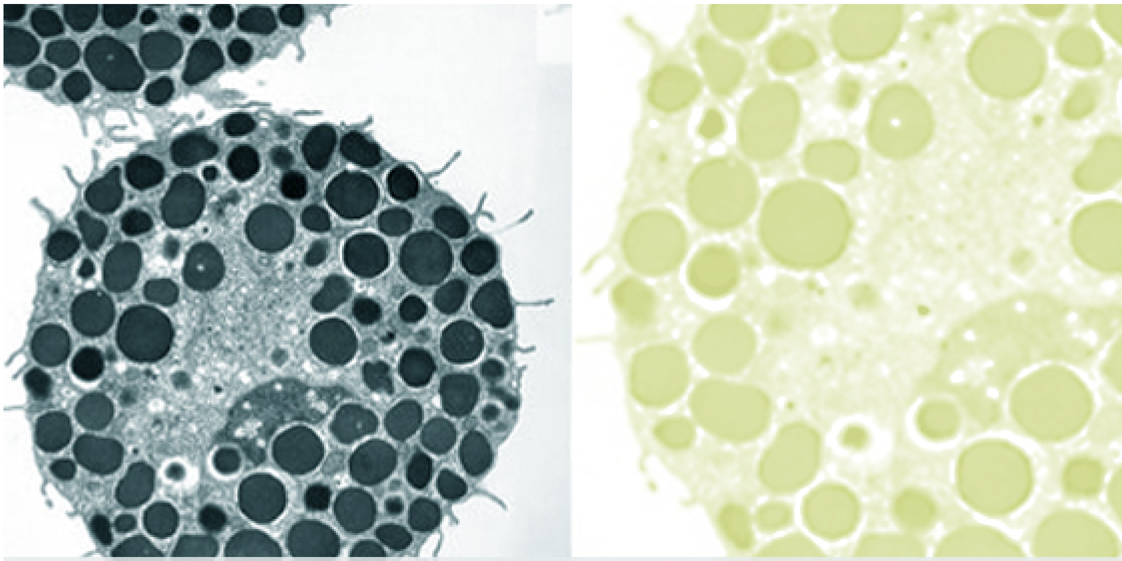
Thomas says they will use a system first originated at the University of California-Berkley called LOCKSS (Lots of copies keeps stuff safe). The system will eventually have several member museums keep at least seven copies of everything in the system.

The New Mexico Palace of the Governors, with the largest photo archive collection in the state, will have so many files that participating museums will have to maintain many terabytes of server space. It's an enormous project.

The initial grant covers the first steps of the project, and Thomas says they will eventually need to find a way to sort through all the information stored on the museum servers in a way that will allow for quick and helpful access to individual researchers. That's where CARC's supercomputers can be of use. For example, if a researcher comes across a pottery sherd with an unusual design, Thomas and Baudoin envision a system in which the researcher can photograph the sherd with a smart phone, connect to the system, and query to find any other object with a similar design. It would take a supercomputer to do a fast scan of all the stored data. The technology to do this at a basic level is already available in a Google application through web browsers, and software developed at Los Alamos National Laboratory might be licensed to do this for research purposes. Thomas thinks that this kind of system can be a working tool for researchers within a few years.

Baudoin and Thomas are applying for additional funding to take the project forward. Ideally, they would like to be able to do computational photography for some objects. That is a way of photographing an object in many different ways under different lighting setups to collect enough information for a researcher to be able to examine an object online and tell almost as much about it as if they had the actual object in hand.

They would also like to be able to do an encryption process, so that culturally sensitive objects can be protected, but available to scholars. Baudoin says that would truly change the treasures the museums hold into a resource anyone could use.



The Communication of Cells

Janet Oliver and Bridget Wilson study how cells in the human body continually, simultaneously, and effectively communicate to one another.

By Luke Frank

In its most fundamental form, effective communication is the process of transferring messages between a sender, who encodes the information, and a receiver, who decodes the information, through various methods or channels. The same principle applies at the cellular level, and the New Mexico Center for the Spatiotemporal Modeling of Cell Signaling Networks (STMC), led from the UNM Cancer Center, is aggressively studying how cells in the human body continually, simultaneously, and effectively communicate with one another.

The STMC is one of only 10 National Centers for Systems Biology funded through the National Institutes of Health/National Institute of General Medical Sciences. Specifically, the New Mexico center is integrating mathematical, statistical, and computational modeling into ongoing research of complex cell signaling networks. UNM Regents' Professor and Center Director Janet Oliver has developed a sophisticated network of her own to integrate terabytes of data tapped by biological investigation, and delivered and catalogued by physics and engineering.

Oliver's core team includes researcher specialists and students from numerous departments and centers in the Health Sciences Center, the School of Engineering, the College of Arts and Sciences, and from both Sandia National Laboratories and Los Alamos National Laboratory. "Through the NIH's National Centers for Systems Biology, we're quickly advancing Systems Biology Science by integrating mathematical, statistical, and computational modeling into ongoing research on complex cell signaling networks," says Oliver. "We're also providing students with the biological, mathematical, statistical, and computational tools needed to conduct complex biomedical systems research. And we are focusing the national labs' remarkable power in technology and computation on human health."

Much of the center's current research revolves around exploring cell signaling abnormalities leading to asthma, allergies, and a variety of different cancers. Asthma is a big health challenge in New Mexico--more than seven percent of our youth suffer from it--and cancer claims many lives in New Mexico and nationally. "By measuring signaling pathways and their integration, we might be able to determine what alerts cancer cells to multiply abnormally," Oliver says.

"We're very much focused on the organization of receptors in the cell membrane," adds STMC colleague and Professor of Pathology Bridget Wilson. "Receptors are in constant motion. And we know that the organization of the cell's plasma membrane affects signaling. We need to know how and why. If we can identify weak points in signaling specific to a disease or treatment, we can target new approaches to therapy." The center is also evaluating new drugs targeted to specific receptors to determine their mechanism of action, and has created a critical repository for research models and data sets.

Communication is a significant factor in how UNM's STMC tools and data are shared among other sites, which include Princeton, Harvard, MIT and Duke. Integrating reliable, compatible data from each National Center for Systems Biology should reveal a much more complete picture of human cell function.

Impressive Impressions

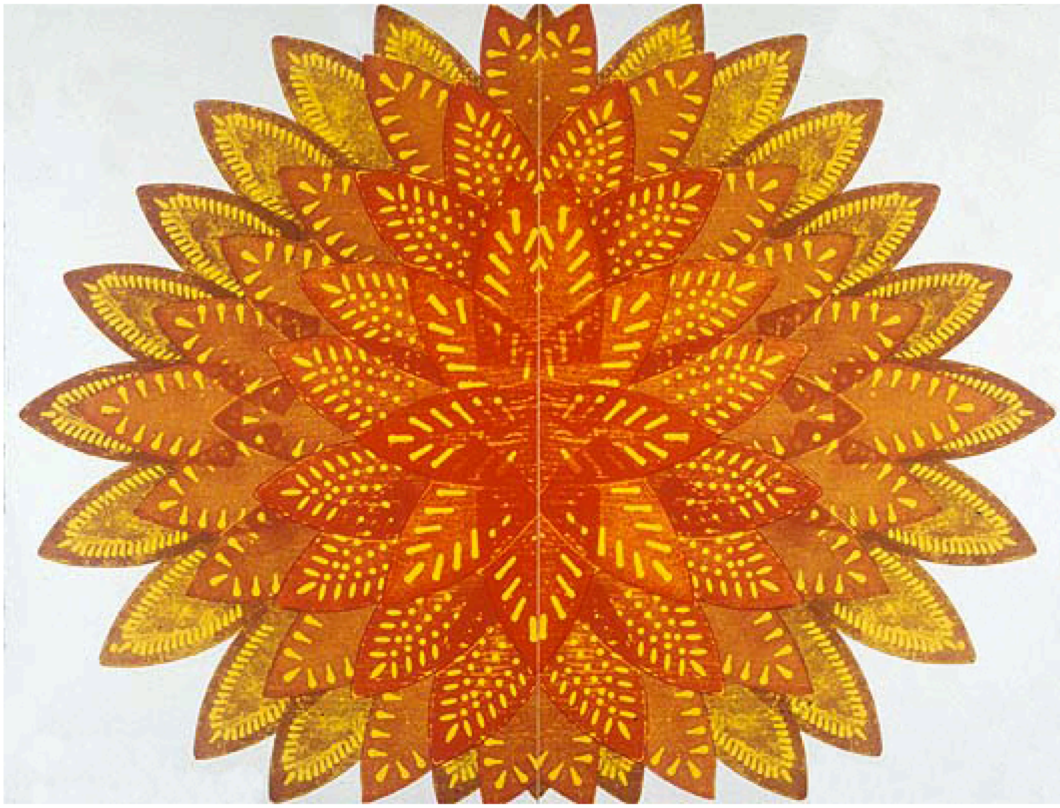
The Tamarind Institute of Lithography has been a leader in fine art lithography and printer education for fifty years.

by Valerie Roybal

This fall, the Tamarind Institute of Lithography celebrated 50 years of being a leader in fine art lithography and a source of printer education for students from around the world. With a new home in a 16,000 square-foot environmentally-friendly building on Central Avenue, equipped with a window-lit pressroom, a spacious gallery, and an apartment for visiting artists, Tamarind is geared up to lead lithography into the next 50 years.

Originally established in 1960 as the Tamarind Lithography Workshop in Los Angeles, Tamarind sought to preserve and protect fine art lithography, which was becoming a dying art.

In 1970, Tamarind relocated to the University of New Mexico, and founding Director June Wayne, along with Clinton Adams, and Garo Antreasian, established a number of ambitious goals. Among these goals were to educate and provide professional training for master printers who could create workshops throughout the United States, and educate others on the art of fine art lithography. Other goals included: fostering the art of collaboration between master printers and artists; helping to create and stimulate the market for fine art printmaking; and working with extraordinary artists, with diverse backgrounds and styles, while pushing the medium and encouraging experimentation.



Over the years, Tamarind has exceeded these goals and published numerous impressive editions by artists such as Josef Albers, Ed Ruscha, Roy DeForest, Hung Liu, Polly Apfelbaum, Willie Cole and, most recently, Jim Dine and Kiki Smith.

As director of the Institute for twenty-five years, Marjorie Devon has a long and storied history at Tamarind. Two years ago, she saw release of "Tamarind Techniques for Fine Art Lithography," re-written to replace the book the "Tamarind Book of Lithography: Art & Technique," which had been considered the "Bible of lithography" in printmaking workshops worldwide for the past thirty-eight years. The much-anticipated new volume has received complimentary reviews as the definitive guide for all things lithography.

Devon has been at the helm of a number of international collaborations and outreach projects, which include artist exchanges, exhibitions, workshops, and publications. With an amazing knowledge and a contagious enthusiasm that brings people together, she has been an ambassador for lithography. "We have moved well beyond the borders of our own country to make this special medium accessible to artists around the world and, in turn, have enriched our own community with diverse cultural influences," says Devon.

One of the more recent projects, "Links in Lithography: St. Petersburg Russia/Albuquerque, New Mexico," funded by a grant from the Mutual Trust for Understanding, involved an exhibition of Tamarind lithographs at the Anna Akhmatova Museum, workshops given by Tamarind printers and students in St. Petersburg, and a residency which brought six Russian artists to Tamarind.

Last year, Devon connected with Cuban artists by visiting Taller Experimental, a printmaking studio and gallery in Havana. "There is a vibrant community of artists in Cuba. The graphic arts have a strong tradition and continue to thrive with many contemporary artists working in print media at Taller Experimental, as well as in smaller private studios around Havana. We hope to bring a Cuban lithographer to Tamarind, and that this is just the start of an ongoing exchange with Cuba," says Devon.

Currently, the focus for Tamarind remains at home, and for good reason. "Tamarind Touchstones: Fabulous at Fifty, Celebrating Excellence in Fine Art Lithography," recently opened at the newly-renovated UNM Art Museum. Funded by the National Endowment for the Arts, the exhibition features 61 lithographs, representing the amazing range of editions that have been created at Tamarind over the past five decades. A part of the exhibition, "Legacies in Lithography," inaugurates the Tamarind Gallery and includes prints by artists who significantly contributed to lithography in America. Additionally, an exhibition catalog with three essays, including one by Faye Hirsch, associate editor of Ar*t in America, ha*s been published by UNM Press.

These exhibitions kicked off Tamarind's "Fabulous at 50 Symposium and Birthday Bash," a celebration that included presentations by Tamarind founders June Wayne and Garo Antreasian, Tamarind-trained printers from around the world, and conversations between Jim Dine and Ruth Fine, and Ed Ruscha and Dave Hickey.

"We are so lucky to be where we are, with such an incredible past and an amazing future," says Devon. We look forward to more great projects that will help to ensure the future of lithography for at least another fifty years."

Felisa Smith's research suggests the extinction of large mammals by humans influenced global climate.

By Steve Carr

More than 13,000 years ago, millions of large mammals such as wooly mammoths, mastodon, shrub-ox, bison, ground sloths, and camels roamed the Americas and may have had profound influences on the environment.

The extinction of these large herbivores, which also included horses, llamas, and stag moose probably led to an abrupt decrease in methane emissions and atmospheric concentrations of the gas. This gas may have had a strong affect on climate change, says Felisa Smith, Associate Professor of Biology at the University of New Mexico.

About 13,400 years ago, the Americas supported a mammal fauna that was richer than that of Africa today, says Smith.

"Around 11,500 years ago, and within 1,000 years of the arrival of humans in the New World, 80 percent of these large-bodied mammals were extinct," says Smith. "This is arguably the first detectable influence of humans on the environment going back 13,400 years to when humans first arrived on the continent," says Smith. "I think that it's intriguing because there are a lot of ramifications. Potentially, if the decrease in methane, which is synchronous with an this spell was actually the cause, then humans contributed to the Younger Dryas cold episode."

Along with co-researchers Scott Elliott from the Climate, Ocean, Sea Ice Modeling Team at the Los Alamos National Laboratory, and Kathleen Lyons in the Department of Paleobiology at the National Museum of Natural History at the Smithsonian Institution, Smith has found that herbivores produce methane as a by-product of cellulolytic-microbial fermentation during the digestive process. Enteric emission occurs when methane (CH_4) is produced in the rumen as microbial fermentation takes place; most of this is released as burps. Past studies have shown that domestic livestock are an important contributor to greenhouse gas concentrations and can represent about 20 percent of annual emissions. The study says that this influence may have been greater in the Pleistocene epoch when methane concentrations were considerably lower.

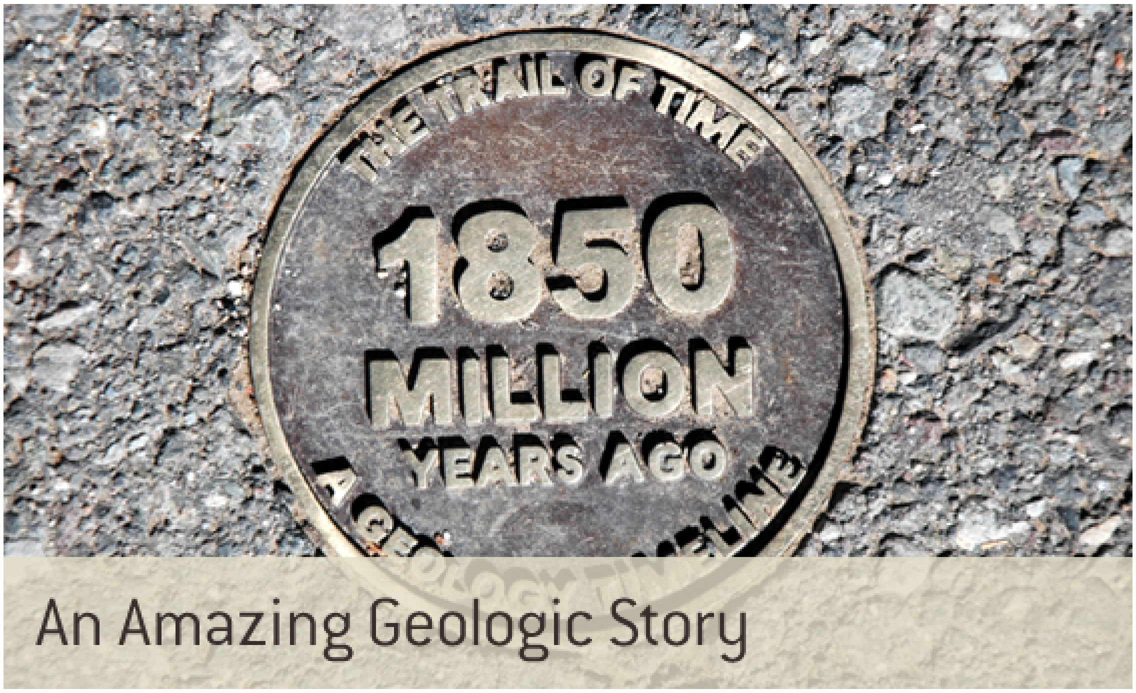
The researchers looked at 114 different herbivorous species that were eliminated from the Americas at the end of the Pleistocene epoch. Using ice cores to determine the amount of methane during the onset of the Younger Dryas cooling period, they found the extinction of megafauna closely coincides with an abrupt drop in atmospheric methane concentration.

"If you look at the ice cores, which record things like methane, you see this huge drop in methane that perfectly coincides with when humans arrived on the continent," says Smith. "We looked at all the other drops in methane over the last million years and this one is quite different. It happens about 2-40 times more rapidly than the others." Armed with that information, the researchers then decided to try and determine how much methane was produced by these species. They came up with an estimate of the number of animals and then an estimate of how much methane those animals actually produced. Other animals such as elephant, giraffes, and hippos have been studied by putting a gas mask type of apparatus on them to determine how much methane they produce in a day.

"We were able to come up with an estimate, which turns out to be about 10 teragrams. This is really pretty enormous," says Smith. "When you bracket it, at the very minimum, the demise of all these animals explains 12 percent of the decrease in methane seen at this time. At the maximum, it explains the entire decrease. This suggests that the extinction of megafauna by humans caused a detectable impact on the environment long before the development of agriculture and the industrial age."

Ice core records from Greenland suggest the methane concentration change associated with a 1 degree Celsius temperature shift ranges from 10 to 30 parts per billion by volume with a long term mean of about 20 ppbv. A drop of 185 to 245 ppbv methane drop observed at the Younger Dryas stadial is associated with a temperature shift of 9 to 12 degrees Celsius. The calculations suggest that decreased methane emissions caused by the extinction of New World megafauna could have played a role in the Younger Dryas cooling event.

The researchers hope that their discoveries could lead to better understanding of environmental changes over extended periods of time, as well as the impact of human presence on the earth, even 13,400 years ago.



UNM scientists lead the Trail of Time, a timeline using Grand Canyon vistas and rocks to interpret 1.8 billion years of the Earth's history.

by Steve Carr

The world's largest geoscience exhibit at the site of the world's grandest geologic landscape--the Grand Canyon--has recently opened after fifteen years of planning and hard work. Under the leadership of scientists at UNM, the nearly three-mile long interpretive Trail of Time utilizes the magnificent rocks and vistas within the Grand Canyon to tell an amazing geologic story.

Professors Karl Karlstrom and Laura Crossey in the Department of Earth and Planetary Sciences conceived the project in 1995 and led the planning and installation of the exhibit along the South Rim of the Grand Canyon. They collaborated with the National Park Service and the National Science Foundation, which funded the project with a $2.1 million grant.

Other significant contributors to the project include Assistant Professor Steve Semken of the School of Earth and Space Exploration at Arizona State University, Professor Michael Williams of University of Massachusetts, and UNM graduate student Ryan Crow. Judy Bryan, chief of interpretation at Grand Canyon National Park, was the primary collaborator between the team and the National Park Service.

"The Trail of Time would have never happened without many people and many contributors," says Karlstrom. "We think it's important, as scientists, to partner with interpreters, evaluators, and exhibit and museum specialists who make their living talking to people. For us, the fact that this exhibit came from scientists, with a passion to bring new knowledge to the public is a special thing about the trail."

The idea for the Trail of Time came from Karlstrom's research group supported by the National Science Foundation. They had been working for about five years at the bottom of the canyon on river trips. One day they came up to the rim and wondered, 'what sorts of things do the public know about ongoing research, about the geology, and how well the Park is doing at interpreting geology?'

"We were really disappointed at the time," says Karlstrom. "The Yavapai Museum had been dismantled and there was very little geology interpretation at the park. So we said, 'guess it's our job as researchers to invigorate the park and improve geoscience education for the people from all over the world who visit the Grand Canyon.'"

Building the Trail

Creating the trail presented a number of challenges for the researchers, some nearly as enormous as the Grand Canyon's splendor. Originally, the vision involved bringing up, by helicopter, huge Volkswagen-sized rocks from each of the layers. These would be placed along the timeline at their proper time period, so visitors could get a sense of all the varieties of rock. However, the National Park Service saw things a little differently.

"That early picture showed children climbing on these big rocks and the National Park Service freaked out," says Karlstrom. "They said, 'this is a jungle gym--it's like Disneyland. That's not what the park does."

"The idea of taking big rocks out of the canyon also raised questions about environmental impact, so the approval to get rocks was ten years coming. I think we had to convince the park, and they had to convince themselves that seeing, touching, and appreciating rocks is part of the geologic understanding."

Karlstrom and the project team traveled along the Colorado River to collect most of the samples. Once the rocks were found and agreed upon, it took four strong individuals to carry the rocks out on a stretcher.

"We rafted along the Colorado River where you go through almost every rock layer," says Karlstrom. "We had these great searches for the best rocks. Some of them are so big or so remote that we had to get helicopter access. By this time the park had bought into the idea that the rocks were an essential part of the exhibit. They were very gracious in letting us use the park helicopter, and in one case, a heavy lift helicopter."

After the rocks were collected, they were shipped to Belen, New Mexico, and slabbed by New Mexico Travertine.

"They did a beautiful job with these very special rocks," says Crossey. "Even though, in the early stages of the design, we were somewhat resigned that we would not be able to have the rock specimens. We were really pleased when that approval finally did come through. It's now clear that the rocks are the stars in this exhibit.The rocks are really the highlight for all ages."

The rocks were shipped back to the Grand Canyon and mounted along the trail on slabs of concrete with the age and type of rock emblazoned on the slab.

Students also took part in the project leaving their mark on the Trail of Time. "The Earth and Planetary Sciences Department has been dedicated to promoting undergraduate research in many forms," says Karlstrom. "We used classes to help formulate ideas. In Phase 1, students helped place 4,500 tick marks along the trail. The actual markers are bronze insets into the Trail--we were trying to create an unobtrusive exhibit that does not detract from the beauty of the Grand Canyon."

Along the Trail

The Trail of Time spans along the South Rim beginning at the Yavapai Observation Station. Walking west, each step takes visitors back in time one million years. The carving of the Grand Canyon is completed in the first six steps, the equivalent of six million years. The asphalt trail, with markers inset every ten meters, represents ten million years of Earth's history, and continues through the formation of Grand Canyon rock layers to the oldest rock in the canyon--recording a geologic history dating back more than 1.8 billion years.

"Geological time is the key to understanding evolution of the Earth and of life, and all three of these are core scientific ideas," says Semken of Arizona State. "Our hope is that Trail of Time visitors will walk away with a better understanding of how human time scales relate to geologic time scales."

By walking the trail, visitors can get a sense of how long geologic time is. "Only" six million years ago, the carving of the canyon by the Colorado River began. The next major milestone is the Kaibab Formation, which is the top layer of the Grand Canyon. It was deposited 270 million years ago beneath a shallow sea. The lowest flat layer, Tapeats Sandstone, is 525 million years old. It's the oldest of the horizontal rock layers, but not the oldest rock in the canyon.

The Grand Canyon Supergroup, which includes a bright orange Hakatai Shale, is between 742 and 1,255 million years old. These layers were tilted and partly eroded before the flat layers were deposited on top. The Oldest Rocks are dark Basement Rocks that are between 1,660 and 1,840 million (1.66 to 1.84 billion) years old.

"It's like a trail of bread crumbs," Karlstrom says. "The vast majority of visitors can't go down into the canyon. The Trail of Time makes the Grand Canyon more accessible in a spectacular walk along the trail. The trail is also completely handicapped accessible."

"The Grand Canyon National Park has about five million visitors every year. Through the exhibit, we are making a major effort to catch people at a moment when they are inspired with the grandeur of the canyon, and want to understand more about how the landscape was shaped by geologic events," Karlstrom says.

"The high visitation and the spectacular geological landscape at Grand Canyon are two of the main reasons that we persevered so long to have this kind of a geoscience exhibit at this particular place," adds Crossey. "It's a place that's on everybody's must see lifetime list no matter where you are in the world."

Into the Future

As part of the grand opening, a symposium was held to come up with ideas to improve the Trail of Time.

"We think of the trail as a template for lots of other things, but don't know what all they'll be," says Karlstrom. "We hope these sorts of partnerships will continue and that the symposium we conducted will come up with some ideas with ways to expand the trail and continue on.

"It's a very important endeavor to increase science literacy in the U.S. and globally. The Grand Canyon has a tremendous international visitation. I want to look for other opportunities like the Trail of Time at other parks, and find ways to enhance its usefulness for visitors of the Grand Canyon."

A "Time Accelerator" portion of the trail will help visitors through a gradual transition in timescales from Yavapai Point to Grandeur Point. A Web-based Virtual Trail of Time is also planned to provide additional resources.

For more information about the Trail of Time visit: http://tot.unm.edu.