Sandia working to improve nervous system control of prosthetics

By Sue Major Holmes

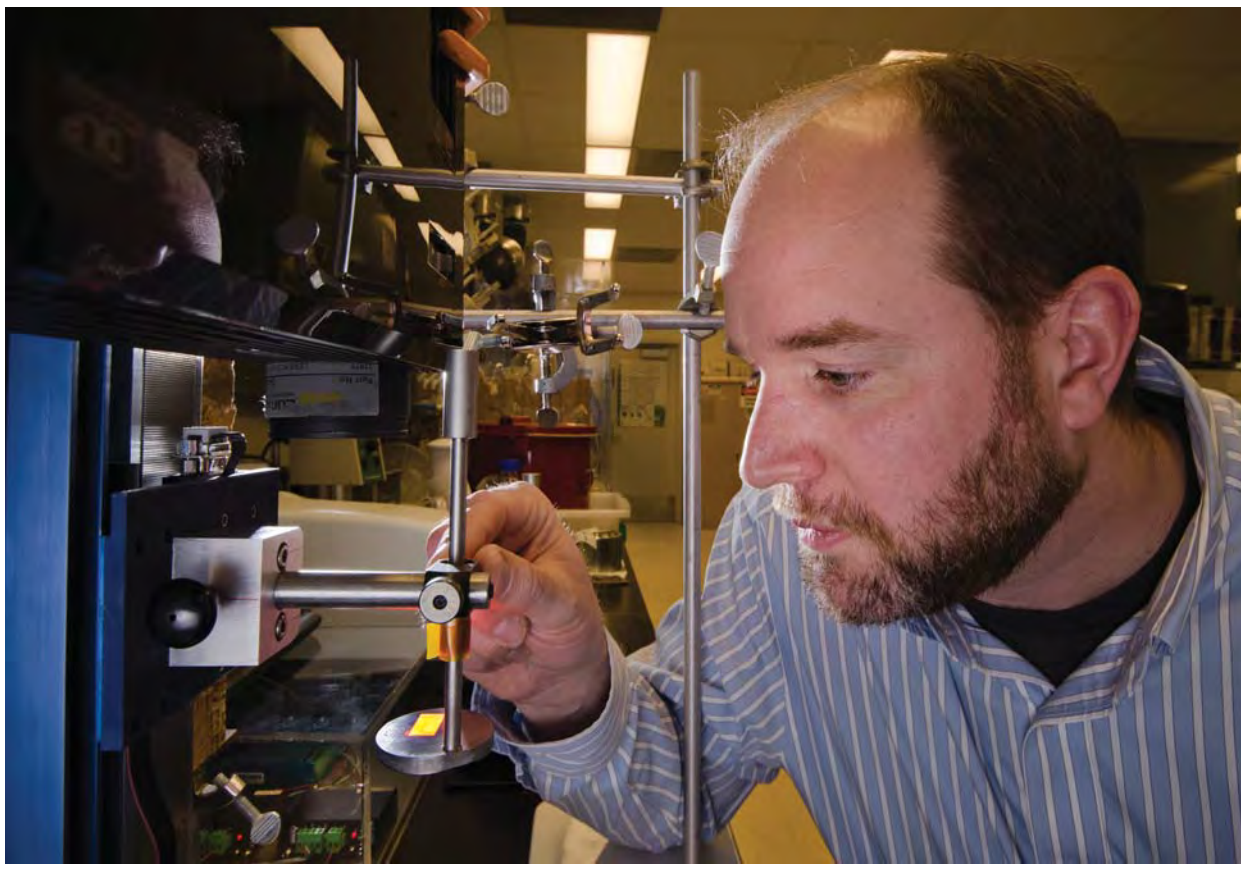
Sandia researchers, using off-the-shelf equipment in a chemistry lab, have been working on ways to improve amputees' control over prosthetics with direct help from their own nervous system.

Organic materials chemist Shawn Dirk (1821), robotics engineer Steve Buerger (6533), and fellow researchers are creating biocompatible interface scaffolds. The goal is improved prosthetics with flexible nerve-to-nerve or nerve-to-muscle interfaces through which transected nerves can grow, putting small groups of nerve fibers in close contact to electrode sites connected to separate, implanted electronics.

Neural interfaces operate where the nervous system and an artificial device intersect. Interfaces can monitor nerve signals or provide inputs to let amputees control prosthetic devices by direct neural signals, the same way they would control parts of their own body.

Sandia's research focuses on biomaterials and

(Continued on page 4)



ORGANIC MATERIALS CHEMIST Shawn Dirk (1821) focuses a projector during work on neural interfaces, which are aimed at improving amputees' control over prosthetics with direct help from their own nervous systems. Focusing prior to exposing polymers ensures that researchers pattern the desired feature sizes for the interfaces. (Photo by Randy Montoya)

Sandia's impact on the economy and the community. Story on **page 6**.

Sandia LabNews

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Sandia National Laboratories

Initial geothermal investment comes full circle in new project

Polycrystalline diamond drill bits open up options for geothermal drilling

By Stephanie Holinka

Nearly two-thirds of the oil we use comes from wells drilled using polycrystalline diamond compact (PDC) bits, originally developed nearly 30 years ago to lower the cost of geothermal drilling. A recent demonstration project by Sandia and the US Navy brings the technology full-circle, potentially helping geothermal drillers reap the benefit of the original technology, as well as decades of subsequent oil and gas industry R&D.

Sandia and the Navy's Geothermal Program Office (USN GPO) conducted the Phase One demonstration tests as part of a geothermal resources evaluation at the Chocolate Mountains Aerial Gunnery Range (CMAGR) in Imperial Valley, Calif.

Sandia has a long history of involvement with both geothermal and drill bit technology development. Three decades ago Sandia geothermal researchers played a large role in the development of PCDs for drilling applications. That work focused on resolving material issues, laboratory testing, and development of data and design codes that

(Continued on page 5)

Elton Wright (6916) shows a torsional spring that's used to simulate the rotational vibration of the drill string in a Sandia experiment. (Photo by Randy Montoya)

Z machine praised for 'impactful year'

By Neal Singer

Sandia's Z machine — the most powerful producer of X-rays on Earth — has had a very productive year, "by far the most impactful year we've ever had," says Pulsed Power Sciences Center 1600 Director Keith Matzen.

Both Congress and DOE have recognized the value of the experiments conducted on Z by Sandia and its partner laboratories, Los Alamos (LANL) and Lawrence Livermore (LLNL), in support of NNSA's Stockpile Stewardship Program.

The Senate's Subcommittee on Energy and Water Development's 2012 appropriation bill commented that "The Committee understands that (two Z) experiments (on plutonium) yielded fundamentally new and surprising data about the behavior of plutonium at high pressure and this new data has been one of the most valuable contributions to the stockpile stewardship program. The Committee continues to strongly support the weapons physics activities at Sandia's Z facility that are critical to sustaining a safe, secure, and effective nuclear stockpile."[p.101]

Wrote NNSA Deputy Administrator for Defense Programs Don Cook regarding the joint plutonium work on Z carried out by Sandia and LANL,

(Continued on page 5)

Office of Science visit

During a visit to Sandia/California, William Brinkman was briefed on research at the Combustion Research Facility, and Sandia's cyber security and biological and materials science programs. See photos from the visit on **page 3.**

$4.92 million pledged

Sandia employees in New Mexico pledged to give $4.663 million to nonprofits in 2011 — a record-breaking total of $4.92 million when combined with employee donations in California. Read more about it on **page 6**.

Science Café examines fate of the mammoths

Mark Boslough discussed his role in a NOVA episode, which examined the speculation that rapid climate change led to the fall of the Clovis culture. Read more about it on **page 8**.

That's that

The other day one of my colleagues (who will remain unnamed) let his/her Kerberos password expire. It's not like he/she hadn't been given fair warning. As the expiration date for your current Kerberos password approaches, you get increasingly urgent email messages reminding you to go into the Kerberos application – or else. Or else what? Or else you basically might as well stay home, because without Kerberos, you can't get on your computer; you can't check email, run the applications you use every day, anything. So totally dependent are we on access to our information tools that there really aren't many sit-down jobs at the Labs that can be performed offline.

So far, I've never missed a change-your-Kerberos deadline, but I do remember once, years ago, coming into work without my badge. Back in those pre-9/11 days, you could just drive on the base if you had a Sandia sticker on your car, so it was possible to get to your office (if you worked outside the Tech Area) without a badge. Since my job at the time almost never required me to go into a Limited Area, I figured I could skate through the day with no problem. The Fates, though, had other ideas. On this, of all days, I got summoned to a meeting where I would have to present a badge, which required me to go to the Badge Office (located back then in Bldg. 800) for a temporary credential. Getting the day-use badge was no problem, but I wish I hadn't bothered. At the meeting, the first thing the host said to me was, "So you got an idiot badge today, huh?"

After sputtering a response, I sat there feeling like a school kid who'd spilled water down the front of his pants. You do everything you can with strategically placed hands and elbows and shirttails to disguise the source of your embarrassment. Later, back in the safe confines of my office, I filed the entire episode away as a lesson learned. And boy did I learn it. In all the years since, I have never again (knock on wood) forgotten my badge.

* * *

Speaking of Kerberos passwords, the procedure for accessing your email from an outside computer seems to me pretty robust from a security perspective. You have to use a Cryptocard -generated random number and a Kerberos password to get into your account. That got me to thinking the other day . . . I was listening to an ad for a product that claims to protect you from identity theft. And maybe it does. But it occurred to me that if our social security numbers and credit card numbers were based on a technology along the same lines as our Cryptocard/Kerberos combination, we wouldn't need to pay a private company $20 a month or whatever to protect us. I don't know exactly how it would be implemented but there has to be a way to use modern technology to make private information more secure and much, much harder to steal.

* * *

As I write this, my wife and I are getting ready to make a trip to New Zealand to visit our son, who's a student at a university in Wellington. It's a 30th anniversary trip for us, the proverbial "trip of a lifetime." We are, of course, excited by the prospects, but I'm finding some aspects of the trip a bit hard to get a handle on; not intellectually, but culturally and physiologically. Consider: You cross the equator, so the seasons are reversed; when it's February here, it's high summer in New Zealand, the equivalent, in seasonal terms, of our August. You cross the international dateline, so when it's today here, it's tomorrow there. The time difference is currently 20 hours, so that when we leave on Thursday, we arrive on Saturday, losing a Friday that we'll never get back. (On the other hand, we'll get an extra Sunday on our return). We're culturally acclimated to think south equals warm, but in the southern hemisphere, the farther south you go, the cooler it gets. These are all obvious things, of course, but you'd be surprised at how your experiences as a Northern Hemispherian shape your world view. And finally, there's this: They drive on the wrong side of the road (but don't tell them that). My wife has expressed a bit of concern over that, but I have a ready answer: if it were really that big a deal, the rental car companies wouldn't rent you a car without some sort of training course. Would they?

See you next time.

Bill Murphy (505-845-0845, MS 0165, wtmurph@sandia.gov)

Sandia News Brief

National Academies report lauds commitment of labs' technical staff, but questions NNSA oversight

A National Academy of Sciences panel led by a former national lab director last week questioned the management relationship between the National Nuclear Security Administration and the nuclear weapons labs at Sandia, Los Alamos and Lawrence Livermore, but praised the quality of science and engineering at the Labs.

The report, "Managing for High-Quality Science and Engineering at the NNSA National Security Laboratories," is the first part of a study Congress commissioned in 2009 to determine the impact on the NNSA labs of management by private corporations. Co-chair of the 14-member panel is Charles Shank, former director of the Department of Energy's Lawrence Berkeley National Laboratory.

"Most individual scientists and engineers perceive the Lab management as having a clear view of S&E goals, and as intending (and succeeding in) allocating investment for providing well-planned interesting, cutting-edge, and core work," the report stated.

However, the panel continued, "At all three Labs, scientists and engineers voiced strong concerns that increasing daily administrative reporting burdens . . . leaves commensurately reduced time for S&E."

The report added, "Operational formality, which has been the by-product of the loss of trust in the Laboratories' ability to maintain fiscal integrity and the safety and security of its work, is not a good basis on which to conduct productive, creative, experimental work."

The report concluded by recommending that NNSA, Congress and Labs management recognize that safety and security systems are strong enough to "no longer need special attention," and asked them to find ways to reduce administrative costs so more can be spent on essential research. It also recommended that NNSA reduce reporting and administrative burdens on the Labs to "purposely free directors to establish strategic direction at the Laboratories."

In a prepared statement, NNSA Public Affairs Director Josh McConaha said, "NNSA is an organization that has continuously improved the way we do business, and we're going to keep looking for ways to operate more efficiently, maintain effective oversight, and work as one NNSA. We're proud of our leadership in developing a new vision for interagency strategic cooperation, and we are pleased to see the Academy's endorsement of this significant initiative.

"We also continue to view laboratory-directed research and development as an essential scientific component of a laboratory's ability to recruit and retain top scientists and engineers, shape the future of nuclear security, and to seed innovation in critical national security areas. We are already actively working to reshape the relationship between the laboratories, sites and headquarters; engage in efforts to examine and reduce the number of budget reporting categories; enact a series of management reforms intended to both improve the way we do business and increase the efficiency of our operations; and maintain a safe, secure, and responsible security posture at our sites."

The report was followed on Feb. 16 by a hearing (http://1.usa.gov/zjSyWS) of the Strategic Forces Subcommittee of the House Armed Services Committee at which former Sandia Director C. Paul Robinson and other former NNSA and national lab officials testified. The National Academies issued the following news release (http://bit.ly/AuMoWt) to accompany the full report (http://bit.ly/yzqzxe).

Sandia LabNews

Sandia National Laboratories

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John C De Baca (age 86) . . . . . November 11
Gene A. Lucero (90) . . . . . December 14
Sally A. Sawyer (81) . . . . . December 19
D. R. Deatherage (76) . . . . . December 21
Richard H. Marmon (87) . . . . . December 22
Roy E. Hollenbach (88) . . . . . December 24
Richard A. Rael (82) . . . . . December 29
Roberta Rainhart (91) . . . . . January 2
Frederick Schelby (87) . . . . . January 26

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2012 Labs Accomplishments

The 2012 *Labs Accomplishments* special edition of the Sandia *Lab News* will be published March 8 this year. This annual publication serves as the primary way significant technical and administrative accomplishments are recognized institutionally. It also serves as an important way to publicize in one place, at the beginning of each year, the Laboratories' tangible value to the nation.

FBI brings Community Relations Executive Seminar Training to Sandia

By Patti Koning

THE FIRST FBI CREST Seminar held at Sandia provided the opportunity for members of the workforce to focus on security and counterintelligence awareness with special agents from the FBI.

One morning last month, 19 Sandians took a break from their regular work routines to focus on security and counterintelligence awareness with the Federal Bureau of Investigation (FBI). Several special agents and support employees from the San Francisco Division came to Sandia to give a Community Relations Executive Seminar Training (CREST).

"A primary risk mitigator in counterintelligence is awareness, and our central theme has been to provide content-rich venues that offer a non-traditional view of the topic," explains the team lead for the Sandia Counterintelligence Office in California. Another Sandia counterintelligence officer attended the FBI's Citizens Academy at the San Francisco Division, an intense six-week course that covers FBI methods and top priorities. "Since Sandia has priorities that align with the FBI, she worked with the FBI's community outreach specialist to bring CREST, a shorter, more focused version of the Citizens Academy geared more towards Sandians," says the Sandia counterintelligence team lead.

Stephanie Douglas, special agent in charge of the San Francisco Division, presented the FBI's top six priorities: counterterrorism, counterintelligence, cybercrime, public corruption, civil rights, and other criminal programs. She also talked about some common misperceptions of the FBI — Elliot Ness was not an FBI agent (he worked for the U.S. Treasury), the FBI does not prosecute (it investigates), and the FBI does not take over investigations from local law enforcement ("Only in the movies," says Douglas). She also talked about counterintelligence as it relates to Sandia employees.

"Foreign governments look for people like you. They look for opportunities to meet you outside of your job, especially on foreign travel. They are professionally trained to acquire illicit information," she says. "Don't be naïve about this — it is absolutely happening. Many countries have a huge capacity for these activities."

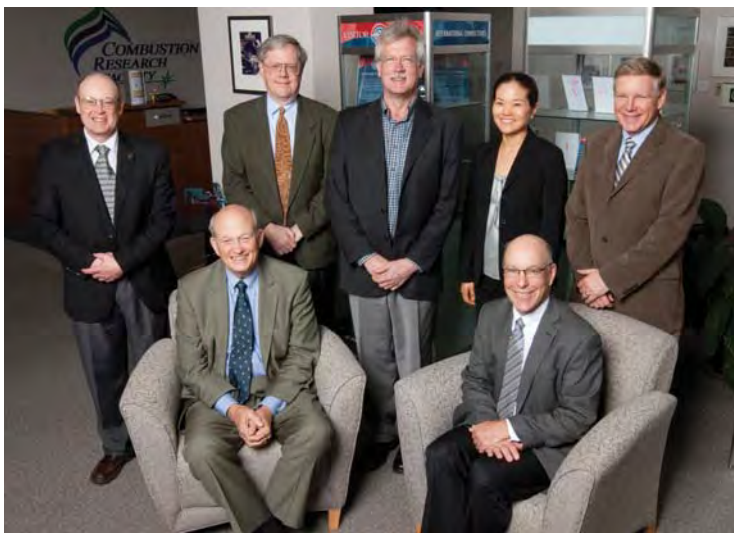
FBI Supervisor Scott Newton described the four national labs within the San Francisco Division — Sandia, Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, and the Stanford Linear Accelerator Center — as the crown jewels for counterintelligence.

"Physical security at these facilities is tight, so spies look for insiders. Sandia, with its classified research as well as unclassified research that could lead to cutting-edge technology, is definitely a target. Every agency has internal spies. No one is immune," he says. "But, I'm happy to tell you, 99.9 percent of individuals are invulnerable to an approach from an intelligence service. We look for that one-tenth of 1 percent. It is out there. Twice in my professional career I have had to take stock of my cases because of spy activities within the FBI: Robert Hanssen and JJ Smith."

This was the first FBI CREST seminar held at Sandia, but the Sandia Counterintelligence group hopes to make it an annual event. "My goal is for the attendees to gain a greater appreciation for the role the FBI plays in counterintelligence and apply that understanding at work. As Sandians, we all share with the FBI the great responsibility to help protect our nation's most valuable assets," a counterintelligence officer explains.

For the FBI special agents, the seminar provided an opportunity to gain a greater appreciation for the talented staff and valuable assets that Sandia maintains as well as the diversity of the work performed here. For more information about the FBI Citizens' Academy program, contact the FBI San Francisco Community Outreach Specialist at 415-558-2505.

Sandia CaliforniaNews



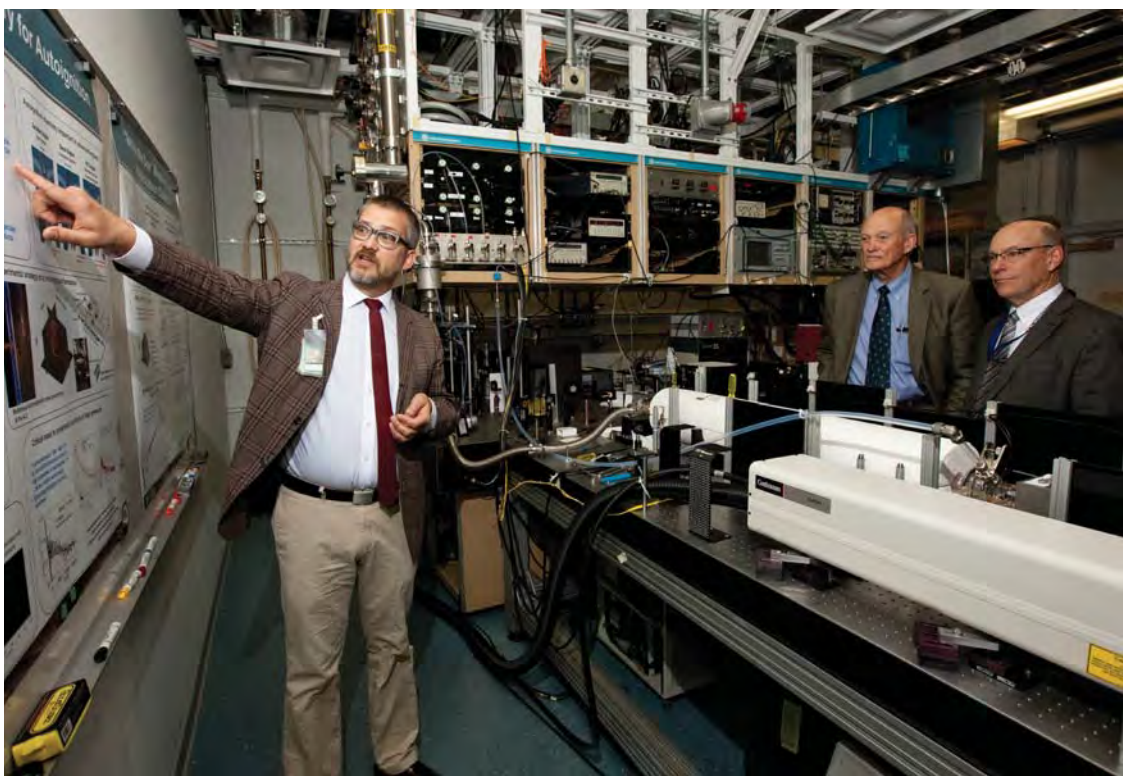
DOE Office of Science chief William Brinkman visits California lab

On Thursday, Feb. 2, Sandia/California VP Rick Stulen (seated on right in photo at left) hosted William Brinkman (seated on left), director of DOE's Office of Science.

During his visit, Brinkman was briefed on the Livermore Valley Open Campus, the Combustion Research Facility, and Sandia's cyber security and biological and materials science programs. Joining Brinkman and Rick were (left to right, back row): Charles Barbour (1100), John Binkley (1900), Jerry Simmons (1120), Dawn Manley (8350), and Bob Carling (8300).

In photo at bottom left, David Osborn (8353) shares breakthrough tools for chemical discovery in the kinetics and mechanisms laboratory. At bottom right, Craig Taatjes (8353) explains how fundamental chemistry governs auto ignition in the laser chemistry laboratory.

(Photos by Randy Wong)



TAKING CONTROL

ROBOTICS ENGINEER Steve Buerger (6533) displays implantable and wearable neural interface electronics developed by Sandia as he sits in the prosthetics lab, where prosthetic components are on display. He is part of a research team that is working on ways to improve amputees' control over prosthetics with direct help from their own nervous system. (Photo by Randy Montoya)

(Continued from page 1)

peripheral nerves at the interface site. The idea is to match material properties to nerve fibers with flexible, conductive materials that are biocompatible so they can integrate with nerve bundles.

"There are a lot of knobs we can turn to get the material properties to match those of the nerves," Shawn says.

Researchers are looking at flexible conducting electrode materials using thin evaporated metal or patterned multiwalled carbon nanotubes.

The work is in the early stages and it would be years before such materials could be used. Studies must confirm they function as needed; then they would face a lengthy Food and Drug Administration approval process.

But the need is there. The Amputee Coalition estimates 2 million people in the United States are living with limb loss. The Congressional Research Service reports more than 1,600 amputations involving US troops between 2001 and 2010, more than 1,400 of them associated with the fighting in Iraq and Afghanistan. Most were major limb amputations.

The Amputee Coalition estimates 2 million people in the United States are living with limb loss. The Congressional Research Service reports more than 1,600 amputations involving US troops between 2001 and 2010, more than 1,400 of them associated with the fighting in Iraq and Afghanistan.

Before joining Sandia, Steve worked with a research group at MIT developing biomedical robots, including prosthetics. Sandia's robotics group was developing prosthetics before his arrival as part of DOE-sponsored nonproliferation projects dealing with humanitarian programs.

The crux of the problem

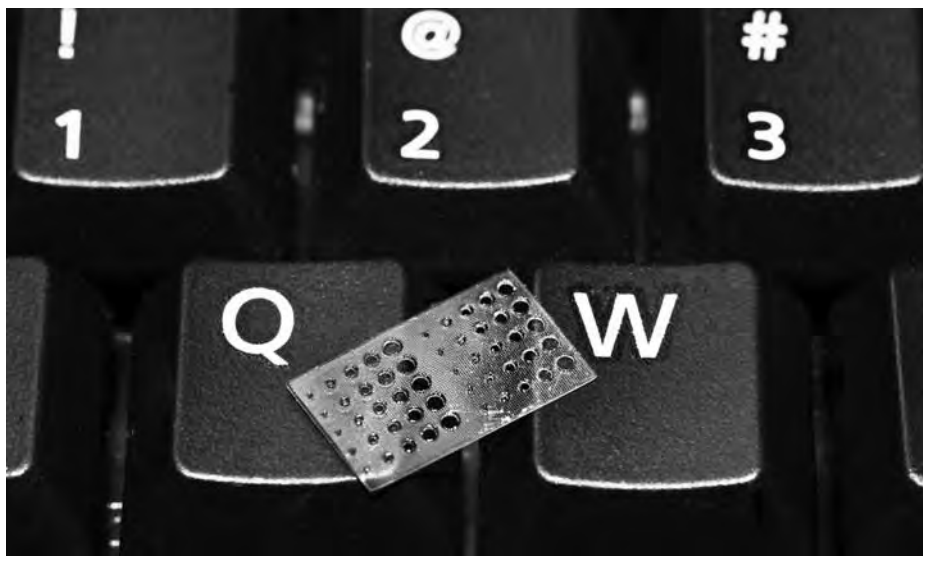
Robotics approached the problem from a technical point of view, looking at improving implantable and wearable neural interface electronics. But Steve says that didn't deal with the central issue of interfacing with nerves.

Working with Shawn's team "goes after the crux of the problem," he says.

The challenges are numerous. Interfaces must be structured so nerve fibers can grow through. They must be mechanically compatible so they don't harm the nervous system or surrounding tissues, and biocompatible to integrate with tissue and promote nerve fiber growth. They also must incorporate conductivity to allow electrode sites to connect with external circuitry, and electrical properties must be tuned to transmit neural signals.

Shawn presented a paper on potential neural interface materials at the recent Boston meeting of the Materials Research Society, describing Sandia's work in collaboration with the University of New Mexico and MD Anderson Cancer Center in Houston. Co-authors are Steve, UNM assistant professor Elizabeth Hedberg-Dirk, UNM graduate student and Sandia contractor Kirsten Cicotte, and MD Anderson's Patrick Lin and Gregory Reece.

The researchers began with a technique first patented in 1902 called electrospinning, which produces nonwoven fiber mats by applying a high-voltage field between the tip of a syringe filled with a polymer solution and a collection mat. Tip diameter and solution viscosity control fiber size.



THIS TINY TEST STRUCTURE was fabricated from the same photo-crosslinkable PDMS material implanted into rats as part of the MD Anderson Cancer Center-UNM-Sandia collaboration. The test structure helps researchers characterize the performance of their microprojection lithography system. (Photo by Randy Montoya)

Collaborating with UNM's Center for Biomedical Engineering and department of chemical engineering, Sandia researchers worked with polymers that are liquid at room temperature. Electrospinning these liquid polymers does not result in fiber formation, and the results are sort of like water pooling on a flat surface. To remedy the lack of fiber formation, they electrospun the material onto a heated plate, initiating a chemical reaction to crosslink the polymer fibers as they were formed, Shawn says. Researchers were able to tune the conductivity of the final composite with the addition of multiwalled carbon nanotubes.

The team electrospun scaffolds with two types of material — PBF, or poly(butylene fumarate), a polymer developed at UNM and Sandia for tissue engineering, and PDMS, or poly(dimethylsiloxane).

PBF is a biocompatible material that's biodegradable so the porous scaffold would disintegrate, leaving the contacts behind. PDMS is a biocompatible caulk-like material that is not biodegradable, meaning the scaffold would remain. Electrodes on one side of the materials made them conductive.

Patents applied for

Sandia's work was done under a late-start Laboratory Directed Research & Development (LDRD) project in 2010; afterward, the researchers partnered with MD Anderson for implant tests. Sandia and MD Anderson now are seeking funding to continue the project, Shawn says.

Steve says they are using their proof-of-concept work to obtain third-party funding "so we can bring this technology closer to something that will help our wounded warriors, amputees and victims of peripheral nerve injury."

Sandia and UNM have applied for a patent on the scaffold technique. The Labs also filed two separate provisional patent applications, one in partnership with MD Anderson and the other with UNM, and expects to submit full applications this year.

The MD Anderson collaboration came about because then-Sandian Dick Fate, an MD Anderson patient who'd lost his left leg to cancer, thought the hospital and the Labs were a natural match. He brokered an invitation from Sandia to the hospital, which led to the eventual partnership.

Dick, who retired in 2010, views the debilitating effect of rising health care costs on the nation's economy as a defense- and security-related issue.

"To me it seems like such a logical match, the best engineering lab in the country working with the best medical research institution in the country to solve some of these big problems that are nearly driving this country bankrupt," he says.

After Sandia researchers came up with interface materials, MD Anderson surgeons sutured the scaffolds into legs of rats between a transected peroneal nerve. After three to four weeks, the interfaces were evaluated.

Samples fabricated from PBF turned out to be too thick and not porous enough for good nerve penetration through the scaffold, Shawn says. PDMS was more promising, with histology showing the nerve cells were beginning to penetrate the scaffold. The thickness of the electrospun mats, about 100 microns, were appropriate, Shawn says, but weren't porous enough and the pore pattern wasn't controlled.

The team's search for a different technique to create the porous substrates led to projection microstereolithography, developed at the University of Illinois Urbana Champaign as an inexpensive classroom outreach tool. It couples a computer with a PowerPoint image to a projector whose lens is focused on a mirror that reflects into a beaker containing a solution.

Sandia researchers set up the system with a Dell laptop and an Epson projector. Shawn says they initially tried using a mirror and a 3X magnifying glass, but abandoned that because it produced too much distortion. They now use the magnifying glass to focus UV light onto the PDMS-coated silicon wafer to form thin porous membranes.

While the lithography technique is not new, "we developed new materials that can be used as biocompatible photo-crosslinkable polymers," Shawn says.

The technique allowed the team to create a regular array of holes and to pattern holes as small as 79 microns. Now researchers are using other equipment to create more controlled features.

"It's exciting because we're getting the feature size down close to what is needed," Steve says.

Geothermal

(Continued from page 1)

now form the basis of the bit industry. Since then, Sandia has received geothermal funding to improve PCD bits. The work was intended to increase access to geothermal resources in the continental US by enabling the drilling of deep, hot resources in hard, basement rock formations.

Geothermal drilling more demanding

Because oil and gas drilling is easier than geothermal drilling, PCDs were appropriated for oil and gas resources.

"Because of the greater challenges associated with geothermal drilling, drilling for oil and gas has been traditionally easier than drilling for geothermal resources," says principal investigator David Raymond (6916).

"Oil and gas drilling is normally done in softer and less-fractured rock, resulting in fewer problems with fluid circulation to remove debris and cool the bit. Oil and gas drilling also doesn't usually involve the higher temperatures that geothermal wells exhibit."

But as the oil and gas industry looks for new sustained resources in deeper reservoirs, it encounters more difficult drilling conditions similar to those found in geothermal drilling.

"Oil and gas drilling must now go deeper into the ground, into harder and sometimes fractured rock types, and in hotter environments," says David.

He says geothermal resources are typically associated with igneous and metamorphic rocks, which are harder than the sedimentary rocks through which oil and gas wells are drilled. Igneous and metamorphic rocks also can contain large amounts of abrasives such as quartz, which can quickly damage drill bits through vibration and accelerated wear. These types of rocks are also often fractured, which can change the impact loading on drills, causing further drill damage.

"Drilling for geothermal energy is still the most difficult drilling on a cost-per-foot basis," says David. "You have to go through the hardest rock, sometimes at high temperatures and pressures. The DOE vision for advanced geothermal development is to drill to great depths, up to 30,000 feet, to access heat for geothermal."

Oil and gas industry has a bigger appetite for risk

In addition to technical problems, the economic risk profile for oil and gas wells is different. Because many more oil and gas wells are drilled per year, the oil and gas industry has the resources and risk appetite for significant research and testing to improve the ability to drill under increasingly difficult conditions.

The geothermal industry advances far more slowly than the oil and gas industry. Because geothermal drillers create only a small number of new wells each year, the drilling service industry finds it difficult and expensive to support innovation, when each well represents a substantial risk.

The Sandia/Navy demonstration project called for a test hole to evaluate geothermal resources in the Camp Billy Machen/Hot Mineral Spa region that would have been otherwise undetectable at the surface. The basement rock at the Chocolate Mountains includes granite and andesite, typical formations encountered during geothermal drilling.

A key part of the demonstration project was to test and evaluate PDC bits and related technologies in a real-world drilling environment. Sandia worked with PDC bit manufacturer NOV Reed Hycalog to specify PDC bit solutions. NOV provided both commercially available drill bits and knowledgeable on-site personnel to counsel the drilling contractor during drilling runs.

Sandia worked with the USN GPO drilling contractor Barbour Well in evaluating the subject drilling technologies during the production drilling process.

Sandia, Prime Core, and the Barbour Well mud logging company Prospect Geotech fielded instrumentation on the Barbour rig to allow monitoring of drill rig during the drilling process.

In the tests, two test bits drilled 1,291 feet of the overall well depth of 3,000 feet. The two bits were in the well just over four days, penetrating approximately 30 feet per hour throughout their drilling interval, an improvement of nearly a factor of 3 over the standard roller bit that was being used. The downhole data was successfully retrieved from both bits and downloaded for subsequent analysis.

Phase two will evaluate drill performance

The collected data will be compiled and analyzed to provide insight into bit performance at the site.

In a planned second phase of the project, Sandia will continue work with Reed Hycalog to evaluate drill performance and improve the bit design and materials for subsequent demonstration.

Sandia personnel include David Raymond, Steve Knudsen (6916), Jiann Su (6916), Dennis King (6916) and Keith Barrett (6916). Elton Wright (06916), a technologist in the geothermal research department, has supported laboratory testing of PCD technology for nearly two decades.

Cooperative work between the USN GPO and Sandia was covered by a Memorandum of Understanding between the Department of Defense and the Department of Energy addressing collaborative development of renewable energy resources.

Phase one and two of this work are funded an ARRA project, "Technology Development and Field Trials of EGS Drilling Systems," under the supervision of DOE.

How PCD cutters are made

Polycrystalline diamond compact cutters on the cutting faces of bits allows the drilling to be more aggressive than bits traditionally used for geothermal drilling. They are created by a sintering process. A one-millimeter layer of graphite powder is applied to the leading face of a cutter made of tungsten carbide. The cutter is compressed in three directions at pressures of 1 million pounds per square inch. When heated to a transition temperature, the graphite converts to synthetic diamond.

Elton Wright (6916) examines a prototype drill bit used for an experiment in Sandia's Hard-Rock Drilling Facility. (Photo by Randy Montoya)

For Sandia's Z machine 2011 was a 'very impactful' year

(Continued from page 1)

"These high-quality data will likely provide new insights and challenge our fundamental understanding of [plutonium,] this extraordinarily complex material… This accomplishment has been one of our most valuable technical contributions to our Stockpile Stewardship Program."

Other significant work on Z this year included several series of experiments on the equations of state of materials important to the stockpile and the response of non-nuclear components to hostile radiation environments. Experiments with LLNL validated certain physics models for the nuclear explosive package.

Understanding the structure of the sun

In addition, experiments on Z explored innovative concepts to achieve fusion with pulsed power drivers.

Finally, in two weeks of collaborations with universities and other national laboratories, data created from fundamental science experiments furthered understanding of the structure of the sun, made measurements of the simulated plasma atmosphere around white-dwarf stars (which are used as one of the chronometers for the age of the universe), and simulated photoionization in black hole accretion disks and the formation of astrophysical jets.

"It's been a very busy and productive year for work at Z," says Keith.

In other news, since FY2012 is the last year of the multiyear National Ignition Campaign (NIC) primarily conducted on the National Ignition Facility (NIF) at LLNL, an NNSA-led meeting was held at Sandia Jan. 18-19 to discuss the national Inertial Confinement Fusion (ICF) program plan for FY2013-FY2018. The goal of NIC, established in 2005, is to achieve fusion ignition (defined as when fusion energy produced by the target exceeds the laser energy on target) on NIF.

Since understanding the physics that can lead to ignition is important to the stewardship program, the meeting at Sandia concluded that the pursuit of X-ray drive ignition should continue in parallel with the pursuit of alternate concepts, including directly applying NIF's laser beams to the fusion capsule and direct-drive pulsed power fusion experiments at Z. Results from the three approaches to fusion would offer complementary views on the physics of assembling ultra-high-energy-density fusion plasmas and if successful provide a unique source of neutrons and high energy radiation for the stewardship program.

Understanding the 'why'

New data from "exquisitely diagnosed experiments," says Keith, will facilitate code development and validation, leading to a better quantitative understanding of high-energy-density physics.

"We have to understand the 'why' for both the agreements and disagreements between the experimental results and the code predictions," says Keith.

Over the past few years, he says, NNSA's ICF facilities have delivered important results for the stockpile and stockpile stewardship, and the national ICF program will continue to be responsive to the needs of the stockpile.

Making an impact in the economy

New Mexico companies did $400 million in business with Sandia

By Nancy Salem

Sandia spent close to $1 billion overall on the procurement of goods and services in fiscal year 2011, and small businesses across the nation were awarded more than half those dollars, $540 million or 59 percent, according to the Lab's latest economic impact report.

The 2011 Sandia National Laboratories Economic Impact on the State of New Mexico report breaks down Sandia's spending and spotlights its role in the state's economy. The annual report shows New Mexico companies secured nearly $400 million in business with Sandia in fiscal year 2011.

"Sandia National Laboratories is committed to strengthening our relationships with the New Mexico business community and, in particular, to be a strong advocate for New Mexico's diverse, small business suppliers," says Don Devoti, manager of Small Business Utilization Dept. 10222.

Sandia reaches out to local businesses through a variety of programs. It holds public forums with the supplier community and civic leaders to discuss contracting opportunities, and lists contracts on its Business Opportunities website, http://supplier.sandia.gov/opportunities/selection.aspx. It supplies small business owners with information on doing business with Sandia and seeks qualified potential suppliers.

"Sandia's Small Business team and all of the Procurement organization work diligently to seek out qualified, capable small businesses that Sandia can partner with to achieve our national security mission," Don says. "We continue to make ourselves available to the community, to be as transparent as possible with our procurement processes, to provide maximum contracting opportunities to small businesses, and to be creative and innovative in our work approaches."

Here are some numbers showing Sandia's overall economic impact in 2011:

•$1.4 billion was spent on labor and non-contract-related payments.

• $921 million went to contract-related payments.

•$65.6 million was sent to the state of New Mexico for corporate taxes.

•$73 million was spent through procurement card purchases, in which Sandia employees use credit cards to buy low-priced commercial goods and services necessary to conduct business.

Sandia employs 9,948 people, 8,856 of them in Albuquerque, according to the report.

FOR MORE about Sandia's economic impact, and to download the "2011 Economic Impact on the State of New Mexico" brochure, go to http://www.sandia.gov/about/community/economy.

The 2011 data is based on Sandia's fiscal year beginning Oct. 1, 2010, and ending Sept. 30, 2011. The report reflects Sandia's continued commitment to small business. Labs advocates encourage buyers to do business with small companies.

The Small Business Act mandates that federal contractors use small businesses, including those that are small disadvantaged, owned by women or veterans and service-disabled veterans, and small businesses in impoverished areas — called Historically Underutilized Business (HUB) zones. Sandia's Small Business Utilization Department oversees the mandate and negotiates small business subcontracting goals with NNSA.

Sandia President and Laboratories Director Paul Hommert has expressed his full understanding and support of the Small Business Act. "Sandia National Laboratories has a long and distinguished record of encouraging and partnering with highly qualified, diverse small business suppliers who assist us in achieving our national security mission," he says. "We are fully committed to continuing this track record."

Sandia's total small business expenditures for fiscal year 2011 and New Mexico breakouts:

Total	New Mexico
• *Total small businesses:*	
$540,428,000	$296,112,000
• *Woman-owned small businesses:*	
$142,505,000	$115,016,000
• *Businesses in impoverished areas (HUBZone)*	
$20,998,000	$11,212,000
• *Business owned or co-owned by socially and economically disadvantaged person 8(a):*	
$65,604,000	$55,089,000
• *Veteran-owned small businesses:*	
$30,130,000	$13,395,000
• *Service-disabled, veteran-owned sm. businesses (SDVOSB)*	
$11,168,000	$536,000

Sandia also helps the state's economy through the New Mexico Small Business Assistance (NMSBA) program established by the state legislature in 2000 to help companies receive technical support from the Labs. In 2010, the Sandia NMSBA provided nearly $2.4 million in technical assistance to 194 New Mexico small businesses in 22 counties. Since 2000, it has provided more than $19.8 million in assistance, according to the report.

The 33 companies in the Sandia Science & Technology Park, a 250-acre master-planned research park adjacent to the Laboratories, employ more than 2,200 people at an average annual wage of $71,612. Investment in the park is more than $351 million.

Sandia employees gave a record-breaking $4.66 million in 2011 to the United Way of Central New Mexico. They logged more than 120,000 volunteer hours in 2010. And they donated more than 1,800 books, a truckload of school supplies, 69,478 pounds of food, 500 holiday gifts, and 518 pairs of new shoes to the community in 2011.

. . . and the community

Sandia employees donating $4.92 million

By Stephanie Hobby

Sandia employees in New Mexico pledged to give a record-breaking $4,663 million to nonprofits through the United Way of Central New Mexico during the annual Employee Caring Program campaign. With contributions from Sandia's employees in Livermore, Calif., the total raised for charitable causes is nearly $4.92 million.

"Our goal was to exceed last year's donation of $4.3 million, and we are thrilled our employees and retirees are contributing even more this year," says Kim Sawyer (0003), Deputy Labs Director and Executive VP for Mission. "Giving back to the community where we live and work has always been a high priority for Sandia, and our employees are committed to making a difference in the lives of those around us."

"Employees at Sandia National Laboratories have been the backbone of the United Way of Central New Mexico annual fund drive since 1957, providing up to 20 percent of the dollars raised each year," says Kathleen Avila, chair of the board for United Way of Central New Mexico. "We have relied on Sandia to provide many volunteer leaders in each of those years and they have consistently done so. The corporate and employee citizenship of Sandia National Laboratories cannot be overstated or overvalued. United Way of Central New Mexico applauds Sandia for their exemplary commitment to our community."

Employee Caring Program

Since 1957, Sandia employees have participated in the annual Employee Caring Program (ECP), which facilitates employee and retiree donations to the community through the local chapter of the United Way. Participants can designate their gift to any 501(c)3 nonprofit agency or to local community funds to help those most vulnerable in the local area. For two weeks last fall, ECP hosted fundraising and awareness events, including book fairs, socials, and health walks. Retirees continue to contribute to the successful campaign, pledging more than $655,988 this year. Lockheed Martin, on behalf of Sandia, contributes $100,000 to the United Way Corporate Cornerstone program, which covers United Way administrative overhead costs so that all donations by employees go directly to the organization of their choice.

Sandia serves military families in need

By Patti Koning

When Mark Cordes (8511) heard that there would be no Christmas for three families of airmen stationed at Travis Air Force Base, he knew exactly where to turn—Michele Clark (8005), co-chair of the site's Veterans Outreach Committee, and Heather Egtervanwissekerke (8511), who in the past has coordinated adopt-a-family programs for U.S. Security Associates.

Michael Hazen (4000), vice president for Infrastructure Operations, presents Heather Egtervanwissekerke with a certificate honoring her work in bringing Christmas to three military families in need. (Photos by Randy Wong)

Within two weeks, Michele and Heather had collected over $1,000 cash, three complete turkey dinners, a truckload of gifts, and a complete bedroom set for one family with a newborn baby. They also collected a high chair, playpen, swing, baby bath, and other necessities.

"In all honesty, I delegated," says Mark. "I called Michele and Heather and asked for their help. This never would have happened without their efforts and the generosity of many coworkers and friends. Many people aren't aware that NCOs at the E-1, -2, and -3 levels are paid below the poverty level and these families really struggle while serving our country."

Michele contacted a few friends and coworkers through email and phone calls, made a few posts on her Facebook page, and asked site SMAs to spread the word. "I was overwhelmed by the response," she says. "We are truly thankful for everything people contributed. Everything—even the donations of a few dollars or signed cards—made a difference."

Heather also put the word out to friends and family through phone calls, email, and Facebook and marshaled the resources of the Security Operations Department (8511). The group has a tradition of adopting several families during the holidays; this year, they directed those efforts toward the families of the three airmen and were responsible for a large part of the cash collected.

"The responses I got were incredible and truly restored my faith in the spirit of giving," says Heather. "I know times are tough, but so many people were willing to pull together to help these families."

LT. COL. SIEGFRIED RICHERT shows Division 8000 vice president Rick Stulen a poster of the C-17 Globemaster, which his unit supports. The C-17 Globemaster, says Richert, can take the fight anywhere, under any circumstances, and supports medical and humanitarian missions.

While many at Sandia/California know Mark as a Security Police Officer and locksmith, he's also a master sergeant in the 945th Air Force Maintenance Squadron at Travis Air Force Base with 28 years of military service. One of his claims to fame, he says, is getting Michele into the military. She served as a respiratory therapist in a Critical Care Air Transport Team at Travis and Sheppard Air Force Base in Texas.

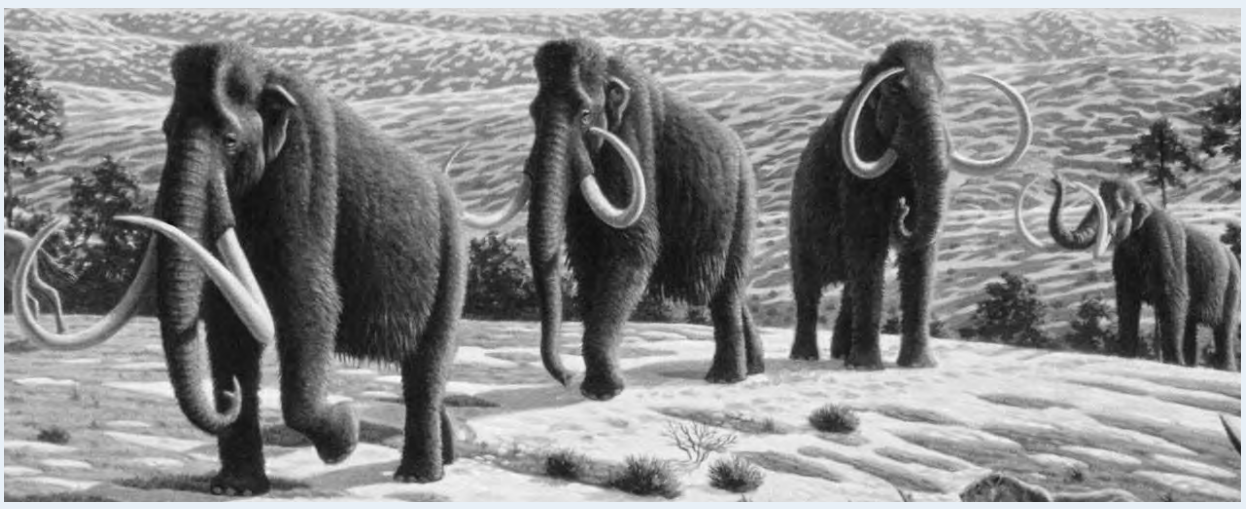
At the February Tri-Level meeting, Mark's commanding officer, Lt. Col. Siegfried Richert honored him, Michele, and Heather for their good work. Michael Hazen (4000), vice president for Infrastructure Operations, attended the recognition and handed out Sandia Military certificates. "This is a great day to be in the service of our wonderful nation. You all inspire me," he said.

"These three young airmen are early in their career and now they see they are truly part of the Air Force family," said Richert. "They see that someone went to significant effort to do something for them. The little everyday things really do make a big difference. This is what service is all about — it's about thinking of others."

He presented a letter of recognition to Sandia/California vice president Rick Stulen with a Commander's Coin — a specially minted, limited-quantity military coin that commanders are allowed to present to individuals who have made worthy contributions.

Mark Boslough packs in spectators at January Science Café

'What killed the mammoths' a thought-provoking crowd pleaser



By Stephanie Holinka

Mark Boslough (1465) spoke to a standing-room-only crowd at KNME's January Science Café, held at its new location in the historic Los Poblanos Inn & Cultural Center on Rio Grande Boulevard in Albuquerque.

The talk began with a clip from the 2008 *NOVA* episode titled "Last Extinction" that examined the speculation that rapid climate change led to the fall of the Clovis culture. Mark appeared in the program, disputing the Younger Dryas Boundary (YDB) Impact Hypothesis, which the episode put forth as a possible explanation for the end of the Clovis culture.

Since the episode first aired, researchers have expressed skepticism over the conclusions and the reproducibility of results brought forth by the hypothesis.

During his talk, Mark described the origins of his own curiosity and interest in science, and wove it through the story that led up to the *NOVA* program.

He also discussed how science programs such as *NOVA* use storytelling as a method to explain scientific research to a public that doesn't always understand the scientific method or scientific processes.

The Science Café audience was enthusiastic, peppering Boslough with questions about everything from research methodology to technical questions about airburst.

"I think it was well-received, and people were interested," says Mark.

His role in the *NOVA* episode was unusual for Mark. "I'm not used to being the naysayer," he says. "It's not as much fun as being the 'star' but it's an important role; somebody has to do that. But it's way more fun to speculate and promote some novel idea."

KNME holds its Science Café on the last Saturday of the month. Sponsors of KNME's Science Café include Sandia/Lockheed Martin, Applied Research Associates, and UNM Office of the Vice President for Research and Economic Development. Refreshments were donated by Los Poblanos Inn & Cultural Center.

MARK BOSLOUGH appearing on the 2008 *NOVA* episode, 'Last Extinction.' In the program Mark assumed the role of naysayer, which, he says, is "not as much fun as being the star," but is an important role in scientific inquiry.