

This energy source is really green

Better monitoring, diagnostics tackle algae biofuel pond crash problem

By Mike Janes

Growing algae, fuel of the future, from benchtop to raceway

By Stephanie Hobby



GREEN GOLD — In the natural environment, algae often thrive in ponds of slow-moving water. In the budding biofuel industry, algae is grown in controlled, farm-like ponds. (Photo from Wikimedia Commons)

Sandia is developing a suite of complementary technologies to help the emerging algae industry detect and quickly recover from algal pond crashes, an obstacle to large-scale algae cultivation for future biofuels.

The research, which focuses on monitoring and diagnosing algal pond health, draws on Sandia's longstanding expertise in microfluidics technology, its strong bio-science research program, and significant internal investments.

Because of the way algae is grown and produced in most algal ponds, they are prone to attack by fungi, rotifers, viruses, or other predators. Consequently, algal

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Biofuels from algae are a promising option to help reduce the nation's dependence on foreign oil, but there is still a lot to learn about the tiny green organisms before we can start relying on them to fuel our cars.

A highly interdisciplinary team led by Jeri Timlin (8622) embarked on a three-year, multidisciplinary LDRD project to learn more about the fundamental biology of algae, what makes it productive, and how to sustain populations from the benchtop to the raceway.

The project took a three-tiered approach to better understand how to turn algal

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Sandian takes command of N.M. Air National Guard 150th Fighter Wing

Clark Highstrete has walked two paths in his professional life. One went toward science and led to physics research at Sandia. The other went to the skies and a career as an Air Force pilot. Read about Clark's new role in a story on [page 8](#).

Dreams come true

Scientists team with entrepreneurs to make business happen

By Nancy Salem

Hurricane Katrina whipped up huge, powerful waves that caused severe destruction in 2005 along the Gulf coast from Florida to Texas. The size and strength of those waves convinced Phil Kithil of Santa Fe that there had to be a way to harness that energy.

His first thought was a device that would use wave action to pump deep, cool seawater to the surface to dampen the intensity of hurricanes, which thrive on warm water. He proved the concept with a simple tube and one-way valve attached to a buoy, but the idea had no commercial potential due to the random nature of hurricanes.

The wave-action pump also brought to the surface concentrated ocean nutrients such as phosphate and silicate that promote the growth of phytoplankton. "Phytoplankton take in CO₂ to metabolize nutrients and give off oxygen," Kithil says. "We felt the pumps had a role to play in climate change."

But the business potential evaporated when governments participating in the 2009 United Nations conference on climate change could not agree on a mecha-

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NICE! the brain as model for future supercomputers?

By Neal Singer

The brain's reputation took a hit in 1997 when an IBM supercomputer defeated world chess champion Gary Kasparov in a match reported around the world.

But, in what might be considered the second round, the brain is back.

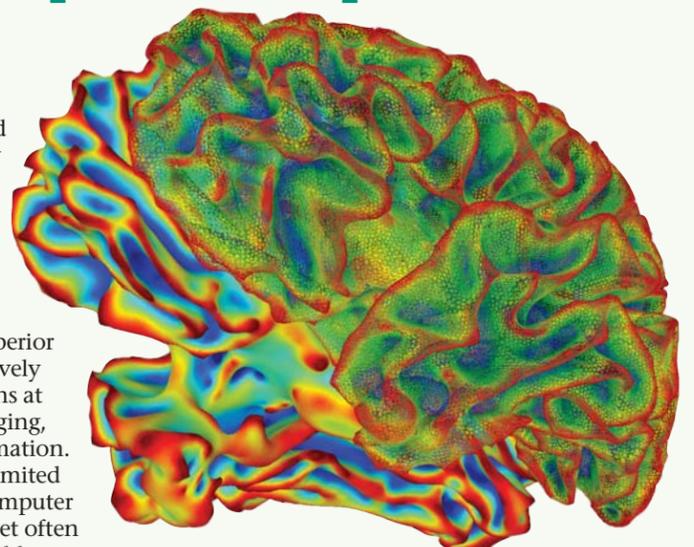
A Sandia-supported workshop called NICE (Neuro-Inspired Computational Elements workshop, held in Albuquerque Feb. 25-28), discussed ways to use the brain's superior ability to send electrical signals along massively parallel channels, with multiple intersections at downstream nodes, to handle rapidly changing, high-volume and high-consequence information.

The hope is that rather than using the limited "if this, then that" logic of conventional computer architectures to absorb steadily increasing yet often incomplete data, cognitive systems will be able — like the brain — to learn, adapt, hypothesize, and then suggest answers.

As Julia Phillips, Div. 7000 VP and Chief Technology Officer (7000) put it in her opening talk, "Neuro-inspired computing is at the intersection of cognitive S&T, nano devices, microsystems, and computer and information sciences. It transcends our traditional approaches."

It also happens to fit in at the major crossroads of Sandia research areas, she pointed out.

Of course, conventional architectures still predominate and Moore's Law isn't dead yet — just "eroding," as Sandia director of computing research (1400) Rob Leland put it in his own introduction. But when it becomes impossible to shrink circuits any smaller, as it seems will be the case in the next 10 years — what's next? And as the von Neumann/Turing architecture of the last 60 years staggers beneath the weight of uncertainties increasingly inherent in working with huge realms of fuzzy data, what then? Workshop participants proposed using the con-



RESEARCHERS are turning to the brain as the model for next-generation Big Data computer systems. The hope is that rather than using the limited "if this, then that" logic of conventional computer architectures to absorb steadily increasing yet often incomplete data, cognitive systems will be able — like the brain — to learn, adapt, hypothesize, and then suggest answers.

(Brain scan image from National Institute of Health)

figuration of the brain as a model. First, isolate the brain tissues that control aspects of behavior. Then analyze — microscopically, and in very small time steps — the shape and behavior of the neurons sending the signals. Then duplicate that arrangement using conventional hardware and software, or most likely, a new solid-state substrate.

As Rob put it, "National security challenges — Sandia's main interest — have historically been addressed in the physical domain, which remains vitally important. But these challenges today have intrinsically a cognitive aspect concerning the behav-

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That's that

Have you heard about the "Ten Hundred Words of Science" challenge? The concept is simple: Can you – the scientist or engineer – describe your work using only the 1,000 most common words in the English language?

Several hundred scientists from around the country have already taken on the challenge, typing their job descriptions into a clever text editor created by geneticist Theo Sanderson especially for the purpose. The app automatically rejects any but the "ten hundred" (the word "thousand" isn't on the list) most commonly used words in the language.

The movement to Simplify! Simplify! was inspired by comic artist Randall Munroe, who decided to try to describe a Saturn 5 rocket using only those thousand words. He found out immediately that "rocket" wasn't on the list. Nor was "Saturn." Hmm. This was going to be tough. He ended up calling the spacecraft the "Up-Goer 5."

A couple of science bloggers wrote about the Saturn 5 cartoon, and with the wave of publicity generated by the blogs, the challenge took off (so to speak). Now lots of people are joining in the fun at the Ten Hundred Words of Science Tumblr website, (<http://tenhundredwordsofscience.tumblr.com/>), which includes a link to Sanderson's Up-Goer Five text editor.

Though I'm not a scientist, I thought I'd take the challenge myself:

I work at a place where people try to learn more about hard things. As an editor, as a writer, as a word worker I write articles, stories that I hope other people will read, describing, informing, telling them things that I think they will like to know or need to know. My goal is to inform, entertain, amuse, and inspire. make people think, smile, laugh, dream, and maybe even cry a little bit sometimes. I take stuff other word workers write and put the stuff together with photographs, pictures that help tell stories. I write and edit check stories about science and technology, how things work in the world and about people who do interesting things to help us understand those things better. I put all of these stories and pictures together in newspapers, news papers every two weeks that we send to employees, workers and retirees used-to workers of this place where I work.

If you want to take the challenge, I'd be happy to find a way to get your write-up in an upcoming *Lab News*. When you have some time (at home), check out that Tumblr site I mention above, open the text editor and give it a go.

* * *

Did you see where mission controllers have announced that *Voyager 1*, our incredible space probe launched back in 1977, either has left or is about to leave the Solar System and journey out into interstellar space? (*Voyager 1* and its sister craft, *Voyager 2*, are the third and fourth spacecraft, following *Pioneer 10* and *11*, to depart the Solar System.) These astonishing instruments, surely among the great science and engineering triumphs of all time, may prove to be the most enduring objects ever crafted by the human species.

The *Voyager* twins are still doing science at this point, sending back unfathomably faint signals about the heliopause, the boundary area between our Solar System and interstellar space. In a few years, when their onboard nuclear power systems fail, we will lose all contact with the craft and say goodbye. The *Voyagers*, though silent, will continue to drift through space, ruled by the laws of physics, held and carried by the forces that bind the stars.

How long will they last? Will the dust of interstellar space eventually wear them down, as sand grinds down the mountains? Will they collide with larger objects and be annihilated, or perhaps be caught in the gravitational well of another star system, eventually to trace a final fiery arc across an alien sky? Will we, bestriding the galaxy via technologies not yet imagined, perhaps someday retrieve them, these relics from our past? And if we do, who exactly will "we" be?

I like to think these craft will voyage on forever, or at least as near to forever as matters. They will ride out and survive the looming collision, in a mere four billion years, of the Milky Way and Andromeda and be flung into intergalactic space. And they will announce, down the inconceivably vast corridors of time: "We were here."

Or – is it possible? – maybe even: "We are here."

See you next time.

Bill Murphy (505-845-0845, MS1468, wtmurph@sandia.gov)

Sandia's Climate Change and National Security Speakers Series

Richard Alley, a climate and energy lecturer famed for his academic achievements, understandable presentations, and sometimes humorous delivery will be the next speaker in Sandia's Climate Change and National Security Speakers Series, to take place in Steve Schiff Auditorium on Wednesday, May 1, from 9-10 a.m.



RICHARD ALLEY

Described by *New York Times* blogger Andrew Revkin as "a cross between Woody Allen and Carl Sagan," the former oil company employee, self-described Republican, contributor to the 2007 United Nations Intergovernmental Panel on Climate Change, and current professor of geosciences at Penn State University will speak on the national security implications of climate change.

A blurb for an Alley-hosted PBS program in 2011 called "Earth: the Operator's Manual," which discussed energy and climate change, put it like this: "[the show] dispenses with politics, polemics, or punditry; instead, it presents an objective, accessible assessment of the Earth's problems and possibilities."

Alley is a member of the National Academy of Sciences and a Fellow of the American Geophysical Union (AGU). He has been awarded a Packard Fellowship, a Presidential Young Investigator Award, the AGU Revelle Medal, the first Agassiz Medal of the European Geosciences Union's Cryospheric Section, the Seligman Crystal of the International Glaciological Society, and the Tyler Prize for Environmental Achievement. At Penn State, he received the Wilson Teaching Award and the Mitchell Innovative Teaching Award of the College of Earth and Mineral Sciences, the Faculty Scholar Medal in Science, and the Eisenhower Teaching Award.

With more than 170 refereed papers, Alley also is the author of a popular book titled *The Two-Mile Time Machine*, which was selected as the science book of the year by Phi Beta Kappa in 2001. He received his doctoral degree in 1987 from the University of Wisconsin at Madison.

— Neal Singer

Take our Daughters and Sons to Work Day, Earth Day observed April 25 in New Mexico



Sandia's New Mexico site will observe Take our Daughters and Sons to Work Day and Earth Day with a full suite of activities on Thursday, April 25.

Sandia employees and contractors can invite children to visit their workplace to learn more about their hosts' work and Sandia's mission. This event can also be an avenue to encourage students to pursue science, technology, engineering, and math careers. Children in grades 5-12 are invited to attend and guests can include children, relatives, or friends. Registration is required for all guests. Management approval is required.

Plan to spend some time on Hardin Field between 10:30 a.m. and 1:30 p.m. enjoying lots of hands-on activities or head over to the Steve Schiff Auditorium to check out the Earth Day displays.

Visit the website (<http://info.sandia.gov/todtwd/registration.html>) to view registration requirements, download the registration form, view lists of scheduled activities, and review safety and security requirements.

Bring two copies of the completed form with you to Bldg. 825 (Steve Schiff Auditorium/TTC) or Bldg. 10600 (International Programs Building, Research Park) on April 25 between the hours of 6:30 and 9:30 a.m., to register for the event. After 9:30 a.m., registration will take place at the badge office in the IPOC building.

Questions to Pam Catanach (3652) at 284-5211.



Sandia National Laboratories

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Albuquerque, New Mexico 87185-1468

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Bill Murphy, Editor 505/845-0845

Randy Montoya, Photographer 505/844-5605

Mike Janes, California site contact 925/294-2447

Michael Lanigan, Production 505/844-2297

Contributors: Michelle Fleming (Ads, Milepost photos, 844-4902), Neal Singer (845-7078), Patti Koning (925-294-4911), Stephanie Holinka (284-9227), Darrick Hurst (844-8009), Stephanie Hobby (844-0948), Heather Clark (844-3511), Sue Holmes (844-6362), Nancy Salem (844-2739), Jennifer Awe (284-8997), Cathy Ann Connelly (284-7676), Jim Danneskiold, manager (844-0587)
Lab News fax 505/844-0645
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Tackling algae biofuel pond crash problem

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pond collapse is a critical issue that companies must solve to produce algal biofuels cost-effectively. The issue was identified as a key component in DOE's National Algal Biofuels Technology Roadmap.

A three-pronged technical approach

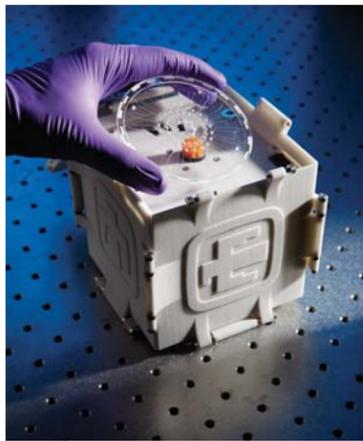
Sandia is addressing the algal pond crash issue in three complementary ways:

- Developing a real-time monitoring tool for algal ponds that can detect indications of a problem days in advance of a crash.
- Successfully applying pathogen detection and characterization technologies honed through the Labs' Rapid Threat Organism Recognition (RapTOR) work.
- Employing its innovative SpinDx diagnostic device to dig deeper into problems after they've occurred to identify specific biological agents responsible for crashes.

Sandia's Tom Reichardt (8128), a researcher who works in Sandia's remote sensing unit, led development of an online algal reflectance monitor through an internally funded project. The instruments are typically set up alongside the algal pond, continuously monitoring, analyzing the algae's concentration levels,

examining its photosynthesis activity, and performing other diagnostics.

"In real time, it will tell you if things are going well with the growth of your algae or whether it's beginning to show signs of trouble," says Tom. However, he cautions, while this real-time monitoring will warn pond operators when the ponds have been attacked, it may not be able to identify the attacker.



SANDIA'S SPINDX-LIKE device could run early detection tests for algal pond operators whenever they sensed instability in their ponds. Issues could then be investigated more thoroughly, with SpinDx helping to determine the root biological cause of the problem.

(Photo by Jeff McMillan)

Quick ID is key

To help pinpoint the problems, a Sandia team led by researcher Todd Lane (8623) recently developed a process to quickly and accurately identify pond crash agents through ultra-high-throughput sequencing using RapTOR.

RapTOR, originally developed for homeland security purposes, was developed to solve the "unknown unknowns" problem — lethal agents that could be weaponized from ordinary viruses or disguised to look harmless. It was designed to serve as a tool to rapidly characterize a biological organism with no pre-existing knowledge.

Todd's team also created a method for creating a field-ready assay for those agents, something that works quickly and is relatively inexpensive. They are applying SpinDx, a device developed by other Sandia/California researchers that can, among other capabilities, analyze important protein markers and process up to 64 assays from a single sample, all in a matter of minutes.

Finally, a Sandia team led by researcher Jeri Timlin (8622), in collaboration with the University of Nebraska's Van Etten Lab, enhanced the RapTOR diagnostics by studying interactions of a certain virus with algal cells. Using hyperspectral imaging, they identified spectroscopic signatures of viral infections arising from changes in algal pigmentation. These signatures potentially could be exploited for early detection and subsequent mitigation of viral infections in algal ponds.

An 'arsenal' for pond operators

"It's important for the growth of an algal industry to develop a method where algal pond operators can learn immediately when there's a problem with their ponds from a biological agent standpoint," says Todd. "It's equally important that they learn — within a very short period of time, like 24 hours — what specific



SANDIANS Tom Reichardt, left, and Aaron Collins, center, chat with John McGowen of the Arizona Center for Algae Technology and Innovation (AzCATI). Sandia has developed several complementary technologies to help the algae industry detect and recover from pond crashes, and is making use of the AzCATI test-bed facility to collect data and apply its technologies.

(Photo by Steffan Schulz)

Sandia California News

agent is eating away at their algae, and have a technology available that could develop an assay to combat the agent. Our tools come very close to accomplishing all of those things.

"We couldn't really do an exhaustive characterization of all of the kinds of agents that could be at the root of pond crashes," Todd says. "But we confirmed some that had been identified before, and we found some others that weren't familiar to the research community. The important achievement was to develop the methodology, which hadn't existed before."

In practical terms, the process developed by Sandia involves a central facility where pond operators would send samples of agents that have appeared in their ponds, and assays that could be deployed back to the pond site. That's where SpinDx comes in.

Pond site operators, Todd says, know their environments best and, especially with instruments like those developed by Tom, understand the signs that could indicate "sick" ponds. He envisions pond operators using a SpinDx-like device as part of their regular arsenal of equipment so they could run early detection tests whenever they sensed instability in their ponds. They could then provide samples to an off-site facility, which in turn would send back assays to allow the operator to investigate the problem more thoroughly and ward off pond crashes before they occur.

"That's the beauty of SpinDx," says Todd. "The disks are inexpensive, require little technical expertise, and can be manipulated by non-scientists."

Next step: More robust demonstrations

Now that the core principles of pathogen detection and characterization technologies for pond crash forensics have been successfully proved, the next step will be to conduct more robust demonstrations. Serendipitously, Todd's and Tom's groups will be continuing their work as part of the Algae Testbed Public-Private Partnership (ATP3) led by Arizona State University (ASU), the first national algae testbed. The Sandia team will apply the technologies, collect more data, and seek additional collaborations.

"Our results over these past couple of years have been compelling, but now we need to deploy the technology into real-world ponds," Todd explains. The original work, he says, has moved from the laboratory environment into the operational realm, with only modest research and development now necessary.

Sandia will make use of an algal test bed facility at ASU known as the Arizona Center for Algae Technology and Innovation (AzCATI). The facility features algal ponds and closed photobioreactor algae cultivation systems of various sizes and serves as a hub for research, testing, and commercialization of algae-based products.

To view brief interviews of Sandia remote sensing researcher Tom Reichardt, Sandia biochemist Aaron Collins (8622) and AzCATI program manager John McGowen, visit Sandia's YouTube channel.

Growing algae

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ponds into usable fuel. The first goal was to better understand the basic biology of algae, including the effects environmental stressors have on growth and lipid production. The team used input from those experiments to devise technology that could perform real-time monitoring of the health, growth, and productivity of the algae. Having such knowledge in the field would help growers take actions that would result in more productive algal harvests. Finally, the third goal was to incorporate all of that knowledge to build a model for algae health and productivity at the large, open-channel raceway-style ponds.

"What many companies are focused on is the production goal — growing as many gallons of algal biofuels a year as possible — and they use empirical knowledge and prior experience to attempt to grow algae favorably, but key information linking environmental conditions to algal response is missing," Jeri says. "So our underlying theme was to understand the fundamental relationships of algae and their environment."

The systems at work in an algae pond are complex, and stressors, such as tweaks to heat, light, pH, and salinity, abound. It isn't well understood how an individual cell will respond to a given stressor, and even very similar algae can respond differently to the same environmental conditions. To make matters more complicated, several stressors are dynamic and often changing. What makes it even trickier is how fast those

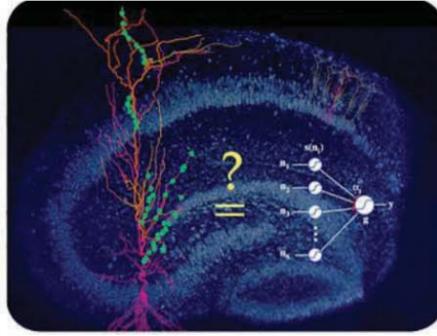


GREEN TEA? — Kyle Parchert (8622) left, and Anne Ruffing (8622) right, were part of a team to learn more about the fundamental biology of algae, causes of productivity, and how to sustain algal populations.

responses happen.

An unfavorable change in conditions can take a healthy pond to the verge of collapse in only a matter of hours to a day, as compared to traditional agriculture, which can take days and weeks to respond to changes in the environment. In such a fast-paced, high-stakes environment, algal growers would really benefit from automated ways to monitor their ponds in real time and have information to make decisions quickly. If a grower can't keep up with changing conditions, the consequences can be costly.

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Brain+computer

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ior of the individual and group, so just the physical realm isn't going to be sufficient to address these issues. Our aspiration is to deepen our understanding of cognitive science so we can address these problems in the behavioral realms." He listed possible domain intersections that included tissue-based and in-vivo sensors, optical nanosensors for chemical analysis within cells, regulated nanoassembly of circuits, digital antibodies, and virus-sized logic chips.

Jim Olds, from the Krasnow Institute at George Mason University, went further in not only predicting the end of Moore's Law but denying it ever had the importance the computing world assigned it. He presented what he called "the great stagnation argument: that Moore's Law is not like the industrial revolution or electricity" because it produced few jobs and lately, no real economic growth.

A brain-inspired industrial revolution

"There's been a slowed-down technological revolution, despite our feelings to the contrary," he said. Because Facebook, "for all its enormous market capitalization," and Google have few employees compared with Ford Motor Company, "it's clear that technology from Moore's Law isn't translated into day-to-day lives. For some reason, we're not seeing opportunities for getting ahead by hard work. It's enabled us to enjoy leisure, and load movies onto iPads, but flying cars haven't come to pass." To the contrary, he said, real median household income, which increased dramatically since the beginning of the 20th century, stopped increasing in the last 10 years. To work this problem so that "researchers are not sitting alone in their silos . . . we need a new, brain-inspired industrial revolution."

And that, he felt, might be found in the Obama administration's recently announced project to map the neurons and network functions of the human brain. The project, which received a mixed reception from the neuroscience field, will launch in 2014 with \$100 mil-

lion in funding and may continue for 10 years.

"This is a transformation from letting a million flowers bloom — from single PIs [principal investigators] to a major strategic investment," he said.

"Brains are highly parallel, can reconfigure themselves dynamically in a few minutes, and use molecular signal transduction [to pass messages]," he said. "In message-passing they use little power and finesse around bottlenecks [that would slow silicon] parallel computing systems."

But it's not, apparently, speed in which the brain will be superior. The brain uses wet-ware, Olds said, and is therefore slow compared to the speed of silicon chips, though more powerful in many aspects.

A modest proposal

Slow signal speed didn't faze Christof Koch, chief scientific officer of Allen Institute for Brain Science. "I have a modest proposal," he told the group. "Imagine a one-kilogram, three-dimensional block of silicon, or stacks of chips, all with 10 kilohertz clocks and each consuming microwatts of power. There's much more silicon, and therefore it's very expensive and heavy, like the brain. But, much less cost for heat sinks, much less air conditioning."

The Allen Institute, he said, was founded in 2003 to support basic research in the brain sciences with a staff of 210, including 50 PhD's.

"There are a thousand different cell types in the brain," Koch said. "Every time we look at the brain, we see more and more complexities, like astronomers looking at the universe every 10 years."

The problems include science's inability to simultaneously record more than .0001 percent of firing neurons, and, before the Obama proposal, "no central unifying projects. There are 10,000 labs with different questions, methods, protocols, and standards, heading off exuberantly in all directions. Universities are not set up for large-scale systematic efforts," he said.

How to take this out of the realm of talk and into practical engineering was essayed by Jacob Vogelstein, a program manager at Johns Hopkins' Applied Physics Laboratory. He described taking slices of mouse brain 2 to 3 millimeters on a side, 49 nanometers thick. "Line

them up on top of each other and extract the [neuronal] network," he said. Inputs and outputs can be simulated with Monte Carlo techniques.

Is brain really the right model?

Again, the difficulties could not be minimized. "In a tiny [brain] region, there are 25,000,000 synapses and cell bodies working through dendrites and axons," Vogelstein said.

And of course, there is always the question of whether the brain provides the right model, cautioned Mike Vahle, Sandia chief information officer. "Computer problems are taking characteristics that the brain seems particularly well-suited to handle," he said. "But is pattern-matching the right paradigm? Is the technology attainable, are the ethical and cultural issues understood? Can we avoid the pitfalls that plague modern computers and networks: viruses, worms, hacking, and computer security [problems in general]?"

Murat Okandan, who proposed and helped organize the workshop for Sandia, suggested that the brain did indeed show the path for dealing with large, incomplete, noisy data sets. "First we'll work with conventional CMOS devices and tools, with simulations of conventional system and architectures, and we'll cross-pollinate. The ultimate goal would be to learn from the motifs we see in neural computation and instantiate that capability in a massively interconnected, self-reconfigurable substrate that natively does the computation. The question will always be, how much fidelity do you need to get the functionality you want?"

"It's national reinvention: time to lead again," said Olds. He prophesied that the brain's secrets, morphed into new computers, would "enhance the range of productivity to include retirement years; increase levels of safety and security so that normal decline of physical and mental abilities are lessened; improve methods of wealth development leveraging Moore's Law. And help develop enhanced modeling of societies to keep life meaningful."

"To do that, we need to prime the pipeline with the right kind of folks: a transdisciplinary scientist who enhances Team Science approaches," he said.

Murat says videos of the entire conference soon should be available at <http://nice.sandia.gov>.

Growing algae

(Continued from preceding page)

The Algal Biofuels Roadmap, produced by the Biomass Program of DOE's Office of Energy Efficiency and Renewable Energy in 2010, suggests developing a toolkit to help growers make better decisions at the pond level. Ideally, this toolkit would provide sensitive, selective methods to predict and identify early fluctuations in algal health and productivity. Such capabilities would lead to increased productivity and an extended growing cycle, and ultimately reduce costs associated with producing algal biofuels.

One way to do that is by using spectroscopy and/or hyperspectral imaging to identify biomarkers, unique biological flags whose presence indicate something is amiss. Photosynthetic pigment molecules that harvest sunlight and convert it to chemical energy within the algal cells interact in a specific way with the different wavelengths of light. This forms the basis for its spectral signature, and like fingerprints, every signature is unique. Taking advantage of the many advanced bioanalytical imaging techniques and remote sensing technologies that Sandia is known for, Jeri and her colleagues, Thomas Reichardt (8128), Howland Jones (8622), and Aaron Collins (8622) identified hyperspectral reflectance and fluorescence biomarkers for algal growth and productivity at the subcellular, single cell and ensemble levels. By examining the spectral signatures, the team was able to assess algal health by measuring growth and productivity at the lab, greenhouse, and raceway scales.

Specifically, these experiments provided information on areas such as the efficiency of carbon dioxide capture in collaboration with professor David Hanson at the University of New Mexico, a necessary step for photosynthesis, and how the gas gets converted into the fuel-rich lipids in algae. Additionally, Amy Powell (8635) and



AARON COLLINS (8622) was part of a group that identified biomarkers for algal growth and productivity.

Kylea Parchert (8622) studied genetic regulation in high salt conditions, which are very important considerations when siting algal ponds in the desert Southwest. Such understandings are important to engineer and operate an algal biofuel production plant.

Of the available algae growth options, outdoor open ponds are attractive because they are cost-effective to build and maintain. Such ponds offer the most bang for the buck, but there are more factors to consider in raceway style ponds. Temperature, incident radiation, whether to cover a pond with a greenhouse, nutrient distribution and availability, depth flow characteristics, geometry and channel dimensions, and predation all have an impact on algal health, and are much more difficult to control in a raceway pond. Previously, Sandia researchers Scott James and Patricia Gharagazloo (8365) had begun to develop a computational model, which relied on modified versions of models from the EPA and the US Army Corps of Engineers, to predict algal growth in outdoor raceways under a variety of system configurations.

"Using our discoveries in basic algal biology and the technology we developed, we were able to replace variable relationships gathered from sparse literature with highly improved and accurate measurements relevant to production strains of algae. This results in a predictive model where you could change conditions or understand — using a computer — what is going to happen to a pond without building it," Jeri says.

The LDRD wrapped up last year, and Jeri says she is thrilled with the amount of knowledge her project contributed to both the industry and Sandia. "We brought

several of Sandia's capabilities together in a unique and interdisciplinary fashion to study a largely unexplored area of biofuels," Jeri says. "In doing that, we made important contributions to Sandia's biofuels infrastructure, developed new technical capabilities that enabled key algal biology discoveries, and helped add more visibility to Sandia's biofuels program. It is important work, and I'm extremely pleased with the hard work of our team and our contributions to the field."

Celebrating innovation in New Mexico



THE WAVE — Phil Kithil, left, CEO of Atmocean Inc. of Santa Fe, and Phillip Fullam, chief engineer of Reytek Corp. of Albuquerque, worked with Sandia modeling specialist Rick Givler (1514) to assess the feasibility of their pump system that turns wave power into electricity. Rick's findings helped Atmocean attract a six-figure investment for continued product testing and component manufacturing. (Photo by Norman Johnson)



CARRIE QUADE of Santa Fe offers artistic retreats through her company Sculptures. The business foundered when her method of using pigmented clay to produce monoprints didn't work. She teamed with Sandia materials researcher Amy Allen (1819) to solve the problem and resume business. (Photo by Norman Johnson)

(Continued from page 1)

nism or legal framework to address concerns.

The third idea was the charm. Kithil and his company, Atmocean Inc., partnered with the Albuquerque firm Reytek Corp. to produce a pump system that converts wave power into electricity. The two companies worked through the New Mexico Small Business Assistance (NMSBA) program to perfect the technology and get it closer to market by attracting a significant investment.

Atmocean and Reytek were among 349 small businesses in 27 counties that participated in 2012 in NMSBA, a public-private partnership among Sandia, Los Alamos National Laboratory, and the state of New Mexico that connects small business owners with scientists and engineers who give technical assistance. The program provided \$4.5 million worth of help last year.

Ten projects that achieved outstanding innovations through the program in 2012 were honored April 4 at NMSBA's annual Innovation Celebration Awards luncheon at the Technology Ventures Corp.'s Deal Stream Summit at the Tamaya Resort in Bernalillo.

"NMSBA has been bringing small businesses together with scientists and engineers from Sandia and Los Alamos national laboratories for more than 12 years. We are so thankful to the principal investigators who work with New Mexico's small businesses," says Jackie Kerby Moore, manager of Technology and Economic Development Dept. 7933. "Together they are implementing innovative ideas and stimulating our state's economy."

Atmocean and Reytek received the first Honorable Speaker Ben Lujan Award for Small Business Excellence as the honoree that demonstrated the most economic impact.

Kithil and Phillip Fullam, chief engineer of Reytek, worked with Sandia's Rick Givler (1514), a specialist in modeling physical systems, to assess the feasibility of their concept. Rick was able to prove that, given a typical wave and a certain number of seawater pumps, con-

siderable pressurized water would reach the onshore array of Pelton water impulse turbines, which extract energy from moving water.

Sandia's findings helped Atmocean attract a six-figure investment to continue product testing, add staff, and boost component manufacturing at Reytek. "Rick's work was absolutely essential to our moving forward with the business model," Kithil says. "We think our system is very viable and we'll do more testing this summer."

A mystery involving clay led to another NMSBA success story. Carrie Quade, a Santa Fe sculptor, offers art workshops through her company Sculptures Inc. and teaches a unique method of monoprinting using pigmented clay. The technique worked well in Pennsylvania, where she previously lived. But in New Mexico the clay didn't print.

Materials researcher Amy Allen (1819) used electron microscopy and mass spectroscopy to determine that a surfactant film on the clay — likely caused by New Mexico's dry weather — prevented printing. "It was such a puzzle," Quade says. "Amy told me to treat the clay with a vinegar solution and that solved the problem. It was wonderful working with her."

Other honorees

Here are some other projects recognized at the Innovation Celebration:

- **Kids Hardware Kompany** owner Tina Bagon worked with Sandia design engineer Trish Selcher (2547) after finding that the fastener for her company's shoehorn for children could be removed, causing a choking hazard. Trish investigated design options and prototypes and used 3D printing to provide a visual representation of the final design.

- Stephen Lueckenhoff, a registered respiratory therapist and president of **Inspyrd Products**, was concerned with the safety of in-home medical concentrators or liquid oxygen systems. He invented the Tube-B-Gone, a device that retrieves up to 50 feet of oxygen tubing and eliminates tripping hazards, and

worked with Sandia electromechanical design engineers Ernie Garcia and Ken Pohl (2129) to address tangling problems, implement a low-voltage DC motor and radio frequency controller, and improve the unit's design.

- **MuleShoe Engineering** designed a device that can separate natural gas from the water pumped out of gas wells. Marion Vance of LANL analyzed MuleShoe's device using various simulations that provided insight into the physics of how it works. The device is able to collect the natural gas that would otherwise be waste, and can now be sold.

- Chantal Lau of **PediBioMetrix** worked with LANL engineers Jim Watts and Larry Bronisz to develop devices to shorten neonatal intensive care stays and save money.

- **Farmers and ranchers in eastern New Mexico** asked NMSBA for help exploring the renewable energy potential of their land. Loren Toole of LANL and Craig White of the University of New Mexico offered a five-course class covering wind data evaluation, wind turbine siting, power markets and pricing, and other factors affecting wind energy development.

NMSBA was created in 2000 by the state legislature to bring national laboratory technology and expertise to small businesses in New Mexico, promoting economic development with an emphasis on rural areas. Since its inception, the program has provided 2,036 small businesses with more than \$34 million worth of research hours and materials. The program has helped create and retain 2,874 New Mexico jobs at an average salary of \$38,647, increase small companies' revenues by \$145 million, and decrease their operating costs by \$72.6 million. These companies have invested \$43 million in other New Mexico goods and services and received \$52 million in new funding and financing.

For information about NMSBA, call Genaro Montoya (7933) at (505) 284-0625 or visit www.NMSBAprogram.org.

Mileposts

New Mexico photos
by Michelle Fleming



Bryan Burns
35 5300



William Cook
30 9530



Waylon Ferguson Jr.
30 10670



Jill Hruby
30 6000



Jim Krupar
30 2132



Mae Lambert
30 10655



Paul Schlavin
30 4826



Randy Watkins
30 1532



Ronald Ralson
25 5333



Steve Schafer
25 243



David Crawford
20 1525



Ireena Erteza
20 5962



Charlotte Perry
20 3523



Cynthia Baldonado
15 10626



Recent Retirees

Retiring and not seen in the *Lab News* pictures:
Bernice Lucero (3521), 25 years.



Jodi Case
29 3521



Martha Trujillo
25 11100



Sandra Smith
13 3521



Rose Mary Chavez
15 10599



Alex Horvath Jr.
15 2917



John Kilbane
15 4121



Normand Modine
15 1131



Jeremy Plake
15 9535



Ron Rhea
15 5952



Roberta Rivera
15 3503



Karen Tafoya
15 4229



David Theriot
15 5764



Ronald Thomas
15 2136



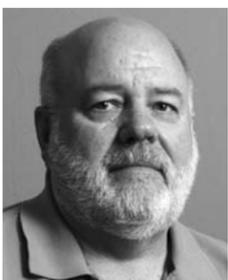
Angel Urbina
15 1544



William Vance
15 4241



Rosalinda Vargas
15 2663



Russell Walker
15 2662



Laura Whittet
15 4242



Lisa Wilkening
15 5515

Sandia-built ion trap gets its close-up

By Neal Singer

Sandia researchers built the ion trap featured on the cover of the journal *Science's* March 8 issue.

The trap uses precise voltage sequences to confine and transport individual ions. This enables it to serve as a data bus for a prototype quantum information processor. Such traps were the subject of a featured *Science* article, "Scaling the Ion Trap Quantum Processor" by Chris Monroe of the University of Maryland and Jungsang Kim at Duke University in that issue. Both researchers collaborate with Sandia.

The Sandia trap was designed in Dept. 1725 in 2008 in collaboration with David Lucas at Oxford University and Rainer Blatt at the University of Innsbruck. It took six months to fabricate. Copies have been delivered to more than 10 academic ion-trapping groups in five countries since then.

"Because it has proven very robust, that trap has been used by more groups than any other microfabricated ion trap," says Dan Stick, who worked with other members of the ion trapping team (all 1725) to design that device and more advanced ones.

The trap works by applying a combination of radio frequencies and static control voltages to confine ions approximately 80 microns above the trap's surface. The ions are then laser-cooled using beams directed across the surface of the trap. Cooling reduces the ions' motion; using a combination of laser cooling techniques, the state of least motion can be achieved.

The trap consists of four lithographically fabricated levels of metal. This complicated arrangement is made possible by Sandia's microfab capa-

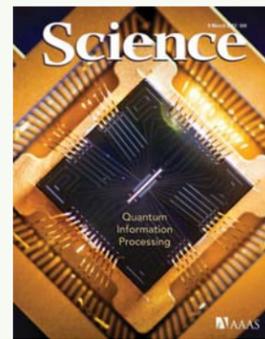
bilities. "This allows us to realize a wider range of trap geometries than other fabrication groups," says Dan. "These devices are able to both store and transport individual ions, forming the structural framework for ion-transmitted information, one of the leading methods contending to serve quantum information processors."

In addition to ions, other quantum information processing possibilities include neutral atoms, superconducting Josephson Junctions, quantum dots, and donors in a semiconductor, to name a few. Ions are a particularly promising candidate for quantum computing because their quantum information is protected in the internal energy structure of the ions at the same time that their net charge allows them to be trapped and moved.

The process of building an ion trap starts when collaborating laboratories provide operating specifications such as size and transport recipes. "We then perform electrical simulations to determine the optimized electrode layout that fits within our design rules," says Dan. "We have a unique capability to realize many of the structures they want — particularly those with complicated electrical routing schemes."

The *Science* image, he says, is the simplest trap built by the Sandia group. "This first linear trap set the stage for much more sophisticated microfabricated traps, able to confine more ions, that we've subsequently designed, fabricated, tested, and delivered."

Sandia's continuing work in the area of trapped-ion quantum information processing is funded by the Intelligence Advanced Research Projects Activity.



Sandia Classified Ads Sandia Classified Ads Sandia Classified Ads Sandia Classified Ads

MISCELLANEOUS

MICROWAVE, Sharp, black, 1-cu. ft., 1000-W, good working condition, \$40. Hill, 205-1496.

MATTRESS, queen, posturepedic, only 5 yrs. old, like new, w/foundation & steel frame, \$250 firm. Duvall, 881-4406.

SOFA SET, Broyhill, no tears, rips, stains, good condition, \$500; queen bedroom set, 4-pc., w/mattress, \$1,000. Salmon, 505-899-8749.

BABY ITEMS; furniture; clothes 0-2T (girls); jumpers; swings; car seats; toys; have twins, so 2 of everything, call/text for photos & pricing. Willis, 206-9108.

ENTERTAINMENT CABINET, Pier 1, 56" x 42" x 23", photos available by email, originally \$599, asking \$100. Giering, 803-5299.

TIMESHARE, Wyndham, Durango CO, Aug. 16-21, 1-bdr., sleeps 4, kitchen, indoor pool, \$500. Safley, 912-320-2100.

UPRIGHT FREEZER, Frigidaire, 13.7-cu. ft., auto defrost, like new, \$250. Ayers, 505-349-1793.

BREAST PUMP, Medela Pump In Style advanced, on-the-go tote, \$150. George, 505-730-6030.

LEATHER COUCH, chestnut brown, w/2 automatic recliners, great condition, \$1,200. Jennings, 303-845-0940.

JVC RECEIVER, 7000VBK, \$30; Sony CD/DVD player, s330, \$10; both in excellent condition. Haass, 505-463-8157.

BIKE TRAILER, Burley, \$75; Tough Traveler kid carrier, \$35; see at <http://flic.kr/s/aHsjCzvDSL>. Sjaardema, 856-6139.

DINING ROOM CHAIRS, new, photos available, \$125 ea., \$700/set of 6. Walraven, 505-291-8242, jwalraven1@comcast.net.

POOL TABLE, 6-ft. Connelly, slate, good quality, you move it, \$600. Carter, 897-0529.

GOLDEN RETRIEVER PUPPIES, purebred, AKC registered, first shots, ready to go, 4 male, 2 female, License #VLL 0012. Fullmer, 505-916-4825.

WASHER, GE GHWP1000M0WW, from Home Depot, \$250; unused 15-in. rims, 4-lug holes, 165/55 tire, \$75. Wolfgang, 505-414-1483.

ELLIPTICAL EXERCISE MACHINE, Precor 5.17i, rarely used, excellent condition, paid \$2,700, asking \$1,200. Allen, 856-7891, ask for Jerry.

BIG TEN CRAFT SHOW, April 27, 10 a.m.-2:30 p.m., N. Domingo Baca multi-generational center, 7521 Carmel. Edney, 281-4779.

IG SOLAR HEATING SYSTEM, SunHeater, product number S601, four 20' x 2' solar collectors, \$200. Duran, 505-839-7353.

CAT PET HOUSE, white, brand new, assembled, \$50; kitchen table, antique, maple, 38"L x 27"W, 8-in. extensions fold out, \$125. Willmas, 281-9124.

'JERSEY BOYS' TICKETS, 2, Sat. May 25, 8 p.m., 9th row center, orchestra, Popejoy, valued \$160, asking \$150. Drayer, 401-7872.

COMPUTER/HOBBY ARMOIRE, solid oak, 2 closing doors, excellent condition, photos available, \$400 OBO. Hussong, 505-332-3523.

DOG STAIRS, 4 steps, 30"H x 16"W, never used, \$25. Hammond, 505-821-0284.

UTILITY TILT TRAILER, 4' x 8' w/2' side steel racks, w/new spare tire, \$800 OBO. Gonzales, 823-2081.

GARAGE SALE, Great Pyrenees Rescue group, April 20, 9 a.m.-1 p.m., 4685 Corrales Rd., clothes, books, household items, furniture, plants. Summerlin, 275-3703.

MULTI-FAMILY YARD SALE, 615 Ridgcrest Drive SE, Albq., April 27, 8 a.m. Prior, 239-9586.

CHAISE LOUNGE CHAIR, Ashley Signature line, taupe micro fiber, new, \$250 OBO. Hill, 897-2968.

FUNDRAISING CONCERT, Mariachi Tradicional, benefits Legacy Academy Fine Arts, April 26, 6:30 p.m., Legacy Church (7201 Central). Legacy, 923-3659.

TREADMILL, ProForm 6.0 TXP, variable spd. up to 6-mph, excellent condition, \$200. Bauer, 299-0640.

UTILITY TRAILER, w/ramps, 16' x 76", rated for 7000-lbs., new electric brakes, tires, wiring, heavy-duty jack, \$2,100. Quinby, 480-5294.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday. Submit by one of these methods:

- EMAIL: Michelle Fleming (classads@sandia.gov)
- FAX: 844-0645
- MAIL: MS 0165 (Dept. 3651)
- DELIVER: Bldg. 811 Lobby
- INTERNAL WEB: On internal web homepage, click on News Center, then on Lab News link, and then on the very top of Lab News homepage

"Submit a Classified Ad." If you have questions, call Michelle at 844-4902. Because of space constraints, ads will be printed on a first-come basis.

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

BARBERSHOP EXTRAVAGANZA, featuring international quartet Storm Front, May 17 & 18, www.newmexichords.com. Taylor, 323-6435.

TABLE & TWO BAR STOOLS, 50's-style, black top & black upholstered seats, \$175; Foosball table, classic sport, full size, \$225. Barba, 507-1461.

POOL TABLE, fixable broken leg, w/balls & pool cues, you pick up, \$200. Jaramillo, 505-228-0636.

BEDROOM SET, blonde wood, 4-pc., nightstand, chest-of-drawers, dresser w/mirrors, \$60. Simmons, 856-8247.

DUMBBELLS, adjustable power block, 5-50-lbs. in 2.5-lb. increments, Olympic weight; leg press/hack squat machine, perfect condition; call for details & prices. de la Fe, 974-8670.

SIBERIAN HUSKY PUPPIES, 1 boy, red w/blue eyes, 1 girl, black & white, 6 wks, located in Bernalillo, \$350 ea. Gomez, 261-6402, ask for Terrie.

SLIDE PROJECTOR, Revere, 40" x 40" screen & 45 slide trays, excellent condition. Berg, 898-2100.

TRANSPORTATION

'01 JEEP WRANGLER SAHARA, very good condition, \$9,000. Duncan, 505-306-7614.

'97 SUBURBAN 3/4-TON, 2WD, SLT trim, 7.4L gas engine, 14.7K miles, \$3,000. Thalhammer, 298-8521.

'94 HONDA CIVIC, manual, sedan, after market parts, IN-JEN intake, 17 XXR wheels, HID headlights, new transmission, \$3,000. Petraglia, 459-6195.

'02 PONTIAC FIREBIRD, convertible, V6, AT, 96K miles, excellent condition, \$6,850. Greene, 505-250-3192.

'06 TOYOTA 4RUNNER SR5, V6, 4x4, 83.3 miles, extra clean, drives perfect, \$16,800. Raether, 505-363-1631, ask for Jesse.

'86 MAZDA B2000 PICKUP, manual steering, manual transmission, 130K miles, great condition, \$2,500. Pullen, 507-0467.

'07 JEEP LIBERTY, V6, AT, 4x4, clean inside/out, 71K miles, \$11,500 OBO. Delgado, 505-933-5393.

'10 KIA SOUL, AT, power, 4-cyl., white, 16K miles, like new, \$15,000. Campbell, 294-6000.

RECREATION

FAMILY CANOE PKG., West Branch 169 by Old Town, 2 yrs. old, used once, \$800. Farr, 505-259-2316.

'01 FOUR WINNS BOAT, open-bow, family ski boat, in-board/outboard, 285-hp motor, 21-ft., swim platform, \$12,000. Waymire, 505-615-6030.

'98 KAWASAKI KLX300R, Enduro tuned, Scotts equipped, 1,300 miles, like new, \$6,000 invested, \$3,600. Miller, 281-3655.

MOUNTAIN BIKE, large Scott Carbon Spark 10, full suspension, Magura brakes & fork, tubeless wheels, \$1,400. Bonaguidi, 505-688-6146.

'08 SUZUKI SV650SF, garage kept, never dropped, suspension upgraded, 10.9K miles, super clean, \$4,750. Kucera, 402-212-9690.

REAL ESTATE

10.33 ACRES, San Pedro Creek Estates, great views, private, owner will finance, \$151,000. Fahrenhorst, 366-8020.

2-BDR. HOME, 2 baths, 2-car garage, new carpet/evaporative cooler/refrigerator, 1.5 miles from base, www.gaar.com, MLS#755245, \$124,500. Couto, 281-8757.

4-BDR. HOME, 2 baths, 2,050-sq. ft., 1-story, 2-car garage, near Osuna/Moon, good schools, new roof, water heater, large yard. Lyo, 299-6470.

2-BDR. HOME, + loft, 2 baths, large master bdr. & bath, 1,700-sq. ft., near base, convenient to I 40, \$189,000. Marrufo, 505-221-0411.

3-BDR. HOME, 1-3/4 baths, 1/4-acre lot, updates throughout, across from park, Rio Rancho, \$154,900. Cuoco, 505-994-8585.

3.5 ACRE HOME SITE, level, square, water, temp. electricity, phone, new road, private setting, cul-de-sac, \$129,000/terms. Mihalik, 281-1306.

WANTED

WEBER CHARCOAL GRILL. Romero, 505-917-7066.

ROOMMATE, 4-bdr. house, walking distance to CNM/UNM, \$360 mo. for 8-mo. lease, share utilities, \$300 deposit. Garcia, 505-553-0616.

GOOD HOME, Red Heeler mix, 10 mos. old, neutered, housebroken, very affectionate, all shots up-to-date. Hill, 205-1496.

SOFA, for student apartment. Ashby, 281-1573.



Sandia on to Washington as a Freedom Award finalist

Sandia was named one of three New Mexico finalists for the 2013 Secretary of Defense Employer Support Freedom Award. It is the highest recognition given by DoD to employers for their support of employees who serve in the National Guard and Reserve. Nominations come from a Guard or Reserve member who works for the organization, or from a family member. Twenty-one New Mexico companies were nominated for the award in three categories — public sector, large employer, and small employer. One nominee in each category was entered into the national competition. Joining Sandia as finalists are the city of Albuquerque Fire Department and Hospice de la Luz in Albuquerque. The national award is presented annually to the country's 15 most supportive employers, with five winners in each category. They are recognized during a special ceremony hosted each September by the secretary of Defense in Washington, D.C.

The New Mexico committee of the Employer Support of the Guard and Reserve (ESGR) held a nomination recognition luncheon April 11 in Santa Fe. In the photo here, Sandia Deputy Labs Director and Executive VP for Mission Support Kim Sawyer holds the finalist plaque. She is surrounded by, front row from left, Toni Leon Kovarik (10222) of Sandia's Military Support Committee (MSC); Labs' Chief Diversity Officer Esther Hernandez (3010); Gary Wright (1741), who nominated Sandia for the Freedom Award; Div. 3000 VP Pamela Hansen Hargan; Rose Gehrke (10617) of the MSC; Andrew Salas, adjutant general of the New Mexico National Guard; Raymond Battaglini, N.M. ESGR state chairman; back row from left, national ESGR chairman James Rebholz; New Mexico Lt. Gov. John



(Photo by Randy Montoya)

Sanchez; Jody Thomas (2995) of the MSC; Div. 4000 VP Michael Hazen; and Col. Clark Highstrete (5643), commander of the New Mexico Air National Guard 150th Fighter Wing at Kirtland Air Force Base.

— Nancy Salem

Sandia's wingman

Physicist takes command of Air National Guard 150th



TAKING COMMAND — Physicist Clark Highstrete (5643) is the new commander of the Air National Guard 150th Fighter Wing at Kirtland Air Force Base. He says the post is the ultimate test of what a traditional, part-time Guard member can accomplish. (Photo by Randy Montoya)

By Nancy Salem

Clark Highstrete has walked two paths in his professional life. One went toward science and led to physics research at Sandia. The other went to the skies and a career as an Air Force pilot.

Clark works in Sandia's Quantum Information Sciences Dept. 5643 and is a colonel in the New Mexico Air National Guard with more than 2,500 flying hours including 200 in combat in Bosnia and Iraq. He recently assumed command of the Guard's 150th Fighter Wing at Kirtland Air Force Base, made up of

New ANG commander to mingle at Cup of Joe get-together



Sandia's Military Support Committee (MSC) will introduce Col. Clark Highstrete to the Labs' community of veterans and others at a Cup of Joe get-together May 15 at the Steve Schiff Auditorium.

"This is an opportunity to meet the colonel in an informal setting," says Jody Thomas (2995) of the MSC. "We want to wish him well on this unique journey."

Clark (5643), a physicist, colonel in the New Mexico Air National Guard, and new commander of the Guard's 150th Fighter Wing at Kirtland Air Force Base, will be introduced by Jeff Isaacson, VP of Div. 5000.

Cup of Joe is a quarterly networking event that brings together veterans who work at the Labs. It was recently expanded to include all Sandians. The Cup of Joe program includes introducing new Labs employees who are veterans and welcoming home Sandia veterans returning from deployment.

Cup of Joe begins at 9 a.m. with the program and concludes with coffee and red-white-and-blue cakes. "It's a great way to learn about the many ways Sandia exhibits its military-friendly values," Jody says.

more than 900 airmen. He previously was director of operations for the New Mexico Air National Guard, responsible for strategic planning and policy, and oversight and guidance for its missions.

"Science and the Air Force have both been very rewarding parts of my professional life," Clark says. "I've been fortunate to have such fantastic opportunities on both sides."

The 150th Fighter Wing, whose missions involve security police, logistics, and medical services, has been known since its days in Vietnam as the Tacos. The Tacos' F-16 fighter jets were transferred to other fighter wings in 2010 when the Pentagon opted to speed up retirement of its fourth-generation fighters in favor of fifth-generation stealth fighters.

Since then the 150th has taken on four new missions, including a merger with Kirtland's 58th Special Operations Wing, training crews on MC/HC-130 aircraft and two types of helicopters. The 150th also picked up a rapidly deployable engineering unit known as Red Horse and an Intelligence Target Production Center that does imagery and computer analysis for target planning.

Quantum information

Clark says he has long felt the pull of two professions. He graduated from the California Institute of Technology in 1989 with a bachelor's degree in applied physics. He was commissioned out of college by the University of Southern California ROTC program and served on active duty from 1990 to 2000. He first completed pilot training, but there weren't a lot of flying assignments at that time. He was assigned to use his physics degree in acquisition management at Los Angeles Air Force Base. He also did an internship in physics research with Aerospace Corp.

Clark was called back to fly and served from 1993 to 2000 as an F-16 pilot, mission commander, and instructor pilot. He left the Air Force to attend graduate school in New Mexico. "I had two very distinct interests," Clark says. "I was interested in flying and military service. I also wanted to pursue a science career. I thought the best mix for me was to continue doing the operational military role as a citizen airman in the Air National Guard. I could do that part time and pursue a scientific career on the civilian side. I also wanted to dedicate my technical work toward national security, so

New Mexico was a logical choice."

Clark joined the Guard in Albuquerque as a full-time instructor then went to traditional part-time status to begin graduate school. He earned a master's of science and a doctorate in physics from the University of New Mexico. He joined Sandia in 2004 as a student intern, followed by a postdoctoral fellowship. He became a full-time Sandia staff member in 2010.

"I have a pretty diverse background in physics," Clark says. He started graduate school in quantum information sciences and did his Sandia internship in solid-state physics examining high-frequency electronic properties of nanomaterials. At Sandia his research also has included ion trapping for quantum information science applications. He now does a mix of research and program management in a variety of technical areas.

Pave the way

Clark's post as 150th Fighter Wing commander is part time. "The traditional guardsman is the cornerstone of the National Guard," he says. "The central principle is the militia construct provided in the Constitution and realized in the National Guard."

Clark says his vision and motivation throughout his military career have been to take on challenges that reinforce the importance of the traditional Guard member in US society. "Taking on leadership roles and more challenges requires more effort, but I look to that to set an example of what a traditional guardsman can and should be," he says.

He says his role as Wing commander is the ultimate test of that. "Part of the challenge I was given was to pave the way, to show how it can be done," he says. "We haven't had a traditional commander in recent memory. Our New Mexico guardsmen are all highly dedicated, selfless, and professional airmen. The adjutant general has made the service of our traditional Guard members in particular a top priority. What better way to emphasize and realize that priority than to have a traditional guardsman as a commander?"

He says his dual path is possible because of the support of an excellent staff and vice commander, Col. Joel Harris, and the enthusiastic support of his Sandia management. "Sandia is exceptional in its support of the Guard and Reserves," he says. "I have been consistently supported throughout my Air National Guard service. Without that, I could not have done it."