terra

Oregon State University · Spring 2014

THE END OF PRIVACY

Digital surveillance imperils Americans' personal boundaries

Oregon State UNIVERSITY

terra

Volume 9 Number 3 // oregonstate.edu/terra // Spring 2014
Oregon's leading public research university

Loren Davis and his team recovered this projectile point, estimated to be more than 10,000 years old, at the Cooper's Ferry archaeological site along the lower Salmon River in Idaho. See "No Stone Unturned," Page 6.

FEATURES

DEPARTMENTS

President
Edward J. Ray

Vice President for University Relations and Marketing
Steven Clark

Vice President for Research
Richard Spinrad

Editor
Nicolas Houtman

Associate Editor
Lee Sherman

Contributing Writers
Sastry Pantula, David Stauth

Art Director
Amy Charron

Designers
Teresa Hall, Long Lam, Heather Miller

Photography
Chris Becerra, Jason Belport, Lanelle Connolly, Loren Davis, Adam Kent, Karl Maasdam, Kerry McPhail, Jessica Miller, Hannah O'Leary, Nikita Rolle, Brice Semmens, Lillian Tuttle

Illustration
Long Lam, Richard Mia, Tina Ullman

Oregon State is Oregon's leading public research university with more than $263 million in research funding in FY2013. Classified by the Carnegie Foundation for the Advancement of Teaching in its top category (very high research activity), Oregon State is one of only two American universities to hold the Land-, Sea-, Sun- and Space-Grant designations. OSU comprises 11 academic colleges with strengths in Earth systems, health, entrepreneurship and the arts and sciences.

Terra is published by University Relations and Marketing. It is printed by a Forest Stewardship Council certified printer with vegetable-based inks on paper with 55 percent recycled content (30 percent post-consumer).

Send address corrections to:
Ashley Fuszek, University Marketing
102 Adams Hall
Oregon State University,
Corvallis, OR 97331
ashley.fuszek@oregonstate.edu

Contact Nicolas Houtman at:
102 Adams Hall
Oregon State University
Corvallis, OR 97331
nick.houtman@oregonstate.edu
541.737.0783

Member
Member University Research Magazine Association

Follow *Terra* on Facebook and Twitter
facebook.com/terraOSU
twitter.com/terraOSU

On the cover: Illustration by Richard Mia

Oregon State UNIVERSITY

More than Science

As I was talking with a student for a story in this issue of *Terra*, he suddenly dropped his voice. "No one knows this," he said. "I was very glad to be in this lab because the people helped me through some difficult times. They are awesome.

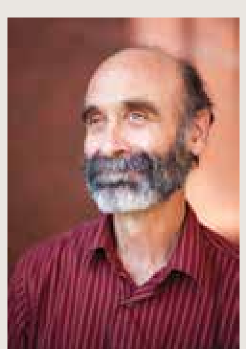
"A lot of students have this mid-college crisis," he continued. "When they are just getting out of high school, they think they know what they want to do. And then they realize that's not the case. That happened to me. But the people here kept me grounded. I could turn to them. It was something stable in my life that helped me tremendously."

I marvel at students' willingness to challenge themselves, to master subjects that take them way outside their comfort zones. But as I talk with them, it doesn't take long to realize they're not doing this work alone. Their mentors — scientists, lab managers and peers — support them much of the way. Sure, the science is front and center, but research team members often develop deep connections with each other. They become a family away from home.

For many students, such friendships are among the most valuable outcomes of doing research. College life and the complexity of the natural world can be intimidating. Skilled, caring mentors help students professionally and socially and enable them to gain confidence and trust in their own abilities.

In this issue of *Terra*, we take you through a diverse landscape: research diving from the Pacific to the South Atlantic, archaeological discovery in Idaho, growing threats to privacy, treatment for blood disease, an emerging nuclear partnership and the promise of new medicines from fungi. In every case, students are making real contributions and solving problems. Yes. Awesome.

Editor



Circle of Friends

Private investors bring diverse needs for research

BY RICK SPINRAD, VICE PRESIDENT FOR RESEARCH

In the 1960s, the Beatles sang about getting by with a little help from their friends. In the never-ending search for funding, scientists have sung the same tune, but their circle of acquaintances is expanding. They're partnering with a wider variety of organizations and accommodating more diverse needs. So, as a result, Oregon State's research enterprise is becoming more creative.

For the past half-century, researchers have relied largely on public funds from the federal government: the National Institutes of Health (NIH), Department of Defense (DoD), National Science Foundation (NSF) and U.S. Department of Agriculture (USDA), to name a few. Plans to double the budgets of several federal funding agencies have suffered from overall reductions and sequestration, with the result that nowadays, the catchphrase is, "Flat budgets are the new doubling."

These trends are likely to constrain public funding for the foreseeable future. For this and other reasons, Oregon State scientists are working more closely with private investors such as businesses and foundations. Because the goals of public and private organizations vary, we are becoming more flexible and responsive. That means moving at the speed of business instead of the speed of academia or government. It requires that we aim at multiple objectives, from basic science to commercial application. And we need to protect intellectual property rights, including the right to publish.

Private-sector organizations tend to be driven by commercial markets. The West Coast oyster industry, for example, needs confidence that production methods will meet the demand in restaurants and supermarkets. Wheat suppliers need grain with well-defined qualities for food processors. Flat-screen producers must maintain an edge in a highly competitive consumer-electronics market.

There are a lot of challenges to this new paradigm. Since so many private investors rely on the reputation of the researcher, it's often harder for a new scientist to "break in." And many foundations simply won't pay the overhead that supports research infrastructure (see "The Hidden Costs of Research" in *Terra*, fall 2013).

And, most challenging (while being quite exciting), we are just learning how to deal with the emerging trend in grassroots appeals — aka, crowdsourcing — to fund research projects. Seasoned researchers and graduate students are considering the use of websites such as kickstarter.com and gofundme.com to raise money for science. With a few clicks, individuals are donating money for hopeful ideas ranging from a free vaccine against HIV to the search for near-Earth asteroids. This cottage industry even has its own Twitter hashtag, #crowdsource. Groups such as the Association of Public and Land Grant Universities are helping to address this phenomenon.

In the future, the most successful research programs will be those that adapt to a rapidly developing environment but maintain the heart of a principled, value-driven enterprise. And yes, with a little help from a lot of new friends.

Editor's note: Rick Spinrad received the Oceanology International Lifetime Achievement Award in March for his accomplishments in marine science and policy.

Rick Spinrad to Take Chief Scientist Post at NOAA

In May, the White House announced the appointment of Rick Spinrad as the chief scientist for the National Oceanic and Atmospheric Administration (NOAA). Beginning in July, he will help drive policy and program direction for NOAA's science and technology priorities.

Spinrad, who came to Oregon State in 2010, will take a leave of absence from his position as a professor in OSU's College of Earth, Ocean, and Atmospheric Sciences.

"Rick Spinrad has provided exceptional leadership to the university's research enterprise," said OSU President Edward J. Ray. "He has successfully increased our research partnerships with industry, spearheaded the drive for a marine studies campus in Newport, and helped OSU secure a major grant to design and oversee the construction of as many as three new ships for the United States research fleet."

Finding Your Inner Einstein

In the lab, the field and the library archive, today's undergrads are "active scholars"

BY LEE SHERMAN | PHOTOS BY HANNAH O'LEARY

> *"We believe that undergraduate research is the pedagogy for the 21st century."*
>
> National Council on Undergraduate Research

Kevin Ahern's body language telegraphs his professional zeal. His arms akimbo, his eyes as round as moons, his swivel chair twisting this way and that, the director for Oregon State's undergraduate research extolls the virtues of active scholarship.

"I've seen phenomenal growth and output from undergraduate researchers," expounds Ahern, who teaches biochemistry and biophysics when he's not hooking students up with research opportunities.

Even his neckwear speaks of his commitment to jumpstarting students' college careers by bringing them into the research fold early and often. The face of Albert Einstein adorns his orange-and-black tie, a gift from a grateful student. "She told me it reminded her of me," he says, flipping it up to look at the fabled scientist with the wild hair. "I'm not sure if she meant my brains or my hair."

Tapping into each student's inner Einstein — that quester of cosmic secrets, that seeker of deeper insights, that finder of new truths — is what happens when undergrads do original research or scholarship under the wing of a professor or a post-doctoral researcher. It makes no difference whether they're studying physics or philosophy, forestry or fine arts. The act of creative delving, hand-in-hand with a caring mentor, is transformative.

"They go from being a consumer of knowledge to being a producer of knowledge," Ahern says. "They're often surprised that they, too, can participate in creating knowledge. It's extremely empowering."

Crockpots to Petri Plates

Ahern tells the story of one former student, Katie Lebold, a biochemistry major who was on his advisee rolls. "She struck me as extraordinarily bright," he recalls. "But her grades weren't that great." When he sat down to talk with her, he learned that she was working almost full-time at Bed Bath & Beyond in a neighboring town to pay for college. The grueling hours selling bathmats and crockpots, along with the grinding commute, were siphoning off her energy for school. Ahern went into action. He found her a paid position running experiments on vitamin E in the lab of OSU researcher Maret Traber.

"The transformation was remarkable," Ahern says. "She went from struggling to being top of her class. As an undergraduate, she co-authored three or four publications — that's almost unheard of for an undergrad. She published six more papers as a master's student. Now she's in the M.D./Ph.D. program at Oregon Health & Science University."

Students like Lebold are the beneficiaries of a heavy push toward inquiry-based learning that took hold in American universities a couple decades ago. Textbooks and lectures have their place. But passively soaking up facts fails to foster critical thinking, problem solving and creative visioning, advocates argue. Without systematic investigation and active scholarship, there can be no discovery, no innovation, no advancement, no matter what your field of study. In cetacean genetics, American history, ice-core chemistry, prehistoric art, ancient-forest ecology, breakthroughs happen only when scientists and scholars observe, explore, hypothesize, challenge assumptions, sample, experiment, analyze — in short, follow the evidence. Freshman year is not too soon to jump into this rigorous way of knowing, according to Ahern and other proponents of undergraduate research.

Just before the turn of the millennium, the Boyer Commission on Educating Undergraduates in the Research University made a call to action. "The freshman and sophomore years need to open intellectual avenues that will stimulate original thought and independent effort, and reveal the relationships among sciences, social sciences and humanities," wrote the commission, funded by the Carnegie Foundation.

At Oregon State, undergrads do research on amphibian declines, post-Cold War America, Weddell seal health, World War II censorship, threats to tropical reefs, radiation protection software and a host of other projects across multiple disciplines. About 2,500 undergraduate researchers participate yearly at OSU, some funded through the university's Research Office program called Undergraduate Research, Innovation, Scholarship, and Creativity (URISC) and others paid by professors, departments, scholarships and the OSU Foundation. Some students do research for credit. Others do it simply for the experience.

The numbers of students participating and the level of university funding for undergraduate research at OSU fall somewhere in the middle of the pack for land grant and public research universities, according to Ahern. A recent survey of peer institutions across the country found between 1,000 (Stony Brook) and 10,000 undergrads (Michigan State) doing research. University funding to pay undergraduate researchers started at $55,000 (UC Davis) and topped out at $450,000 (Florida State), with Oregon State coming in at $150,000.

Ahern is hoping for an infusion of dollars from two large undergrad research initiatives that are pending: $2 million from the Howard Hughes Medical Institute and $2 million from the National Science Foundation.

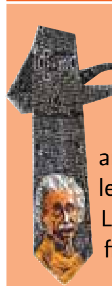
Keep on Truckin'

Since the Boyer Commission released its seminal report, studies have revealed that undergraduate research is a boon to students. Retention is one of the big benefits. African-American and other underserved students, in particular, are more likely to stay in college when they engage in research. Largely, that's because the cooperative nature of science enfolds students who might otherwise feel disconnected, research shows. It seems that team spirit imbues scientific and scholarly endeavors just as it does soccer matches and basketball games.

Undergraduate research heightens confidence, teaches patience, strengthens the work ethic, boosts achievement, raises aspirations, bolsters self-concept and fosters persistence. And it inoculates young scholars against the disappointments inherent in trial and error. "As a scientist, you have to learn that sometimes things just don't work," one student researcher at Xavier University remarked. "You have to pick up your boots and keep on truckin'."

In a nutshell, undergraduate research ignites what Grinnell College psychologist David Lopatto calls "a bright period of maturation." terra

FINDING YOUR INNER EINSTEIN



In the following pages, *Terra* highlights some of Oregon State's current undergraduate researchers and their central role in the culture of learning and creation of knowledge. Look for Kevin Ahern's Einstein tie to find their stories!

No Stone Unturned

Archaeologists on the trail of earliest Americans at Cooper's Ferry

BY NICK HOUTMAN

It may have been late afternoon after the sun had set below the canyon rim on a cloudless summer day. Or early morning, as dew still clung to grasses by the fast-flowing stream. At this place along the lower Salmon River thousands of years ago, someone laid four stone projectile points side by side in a shallow pit. It's likely that bones, stone tools and what archaeologists call "debitage" (stone chips and flakes) had been tossed in earlier. With hands probably calloused from a lifetime of pounding, carving and cutting with rock, this person covered the pit and topped it with round cobblestones to mark the spot.

We'll never know who left those precious points. Was it a man or a woman? An artisan skilled in making razor-sharp blades from local rocks? Maybe a young hunter who was heading up the canyon in search of deer to feed his family.

It's a good bet that someone planned to return and retrieve them. These people, whose ancestors may have migrated from Asia at the edge of an ice sheet or along a coastal waterway, needed such weapons to survive. Points made from local rocks —obsidian, chert, basalt — comprise the business end of darts most likely thrown with a device known as an "atlatl" (similar to the ball-throwing sticks some people use to exercise their dogs). But these four points, the result of hours of meticulous flaking and retouching, remained underground. Dust from the nearby plateau blew year by year through the steep-sided canyon and buried them ever deeper. Archaeologists think they remained there for more than 13,000 years until a graduate student dug them up in 1997. He found them at the bottom of a pit nearly 10 feet below the surface.

That student was Loren Davis, now an associate professor of anthropology at Oregon State University. With OSU students and other researchers, he has embarked on a journey to learn more about the people who made those artifacts.

Davis knows the trail is cold. "Archaeology is a gamble. You never know what's going to work out," he says. During his graduate school years he had considered working at prehistoric sites in Siberia and Baja California, Mexico. But for this Oregon native, the West held the strongest attraction. Five years into an ambitious exploration of a riverbank just above the

Deep in the lower Salmon River canyon, Cooper's Ferry has become a primary Western archaeological site, adding to findings from places such as Lind Coulee, Fort Rock Cave and Paisley Caves. The excavation site is covered by a black tarp. (Photo: Hayden Wilcox)

(Left) Alex Nyers holds the largest of 13 stemmed points found in a pit at Cooper's Ferry in 2013. (Right) Students conduct most of the excavations at the Cooper's Ferry Archaeological Field School. (Photos: Alex Nyers, left; Loren Davis)

lower Salmon, his roll of the dice is paying off. His team has already found the oldest examples of a type of stone tool that is unique to the Far West. And ancient artifacts continue to accumulate with each summer field season.

Ice-Age Hunters

In 1997, Davis was no stranger to the lower Salmon River canyon. As a master's student at Oregon State, before finding the points, he had worked as an archaeologist for the Bureau of Land Management, reviewing and inspecting cultural sites along the river. Later, while pursuing his Ph.D. at the University of Alberta, he combined archaeology with geology, particularly the last 2.5 million years, a period known as the Quaternary. It was an epoch of ice-age cycles. Now-extinct species of camels, horses, wooly mammoth, mastodon and bison roamed the steppes across Europe, Asia and North America. Whoever left those points along the lower Salmon probably hunted them.

That environment holds a key to the human story in North America, Davis says. "The world was so dramatically different at that time. There were ice sheets and giant lakes, and sea level was much lower. You have to have a geological outlook to make sense of a lot of it."

Now, every summer, he heads back to the lower Salmon, to its confluence with Graves Creek at a spot known as Cooper's Ferry, just south of the farm and ranch community of Cottonwood. Since 2009, he has led the Cooper's Ferry Archaeology Field School (see "Searching the Past," Page 13), where students from Oregon State and around the country learn to scrape and sift millimeter by millimeter through soil as they look for clues left by those ice-age hunters.

So far, working under the shade of a mesh tarp in temperatures often over 100 degrees, they have found, photographed, labeled and bagged more than 30,000 objects: stone tools, tool-making flakes, mussel shells, animal bones (fish, rodent, rabbit, deer) and projectile points.

In 2013, they discovered part of a wolverine skeleton buried in a pit with a stemmed dart point and, in another nearby pit, 13 other points lying next to each other. They have found soil burned red, heat-cracked rocks and charcoal from ancient cooking fires. Davis estimates they are about halfway through an excavation that will take the better part of 10 years.

"This is a huge responsibility," says Davis. "If you're going to open up a site that's this special, you have to be willing to do it at a very careful, slow pace. So in most years, we move downward only 40 to 50 centimeters (15 to 19 inches). We're trying to find everything the size of a dime or larger in place. We want to uncover it in the ground and record it.

"The goal is not just to find stuff. If that was it, we'd just get a front-end loader, dig it all out and screen it. But we wouldn't know how the artifacts go with each other, how the dates match with them and so on."

Clovis and More

It's the extraordinary care with which the work is being done, as well as the quality and the age of the artifacts, that make Cooper's Ferry a prime site for archaeologists. The results are adding new perspectives to discoveries made at other Pleistocene-age landmarks in the West. Organic remains at those sites — the famous sagebrush bark sandals recovered by Luther Cressman at Fort Rock Cave; animal bones, fabric and human wastes (known as coprolites) found by Dennis Jenkins at Paisley Caves — have shed light on how early people lived.

For much of the 20th century, the story of the earliest people in North America was known as "Clovis First." It proposes that all Native Americans descended from a single cultural group. In the 1930s, artifacts found near the New Mexico town of Clovis spurred a search for more such objects. Clovis culture became associated with a stone point that is fluted on both sides, meaning it features a concave channel running from the base toward the tip. Similar points, dating to more than 12,000 years ago, have been discovered across the continent.

However, in the Far West, the oldest points lack distinctive Clovis trademarks. They do not contain fluted channels and appear to have been made by a different method. They are about the same age as the oldest Clovis points but may have been made by another culture. Archaeologists call it the Western Stemmed Tradition.

"Cooper's Ferry contains a lot of information about the Western Stemmed Tradition. It's a series of technological patterns that extends from British Columbia to northwestern Mexico and seems to be an economic lifeway for food gathering and tool production," says Davis. "We think the Western Stemmed Tradition may represent a separate cultural pattern that's present in the Pleistocene before 10,000 years ago and may be a cultural manifestation of a totally different people than Clovis."

Digital Dig

As specialists in prehistory — human activity before the advent of written records — archaeologists wrestle with two major problems. First, their science is based on evidence embedded in an evolving landscape and deposited by people who left precious little else. The story is inherently uncertain and open to interpretation. Second, as they dig through layers of soil and remove objects, they destroy the actual record that accumulated as people came and went over thousands of years.

The solution for Davis and his colleagues lies with the latest information technologies. They have created what amounts to a virtual dig site that can be widely shared in great detail, right down to replicas of the artifacts themselves. The methods they are using at Cooper's Ferry are as far removed from the first studies at Clovis as modern people are from those early hunter-gatherers along the lower Salmon River.

Like detectives at a crime scene, Davis and his crew work hard to preserve evidence. As they remove soil by the bucketful and extract objects with surgical precision, they photograph every step of the way. They use a modern survey instrument known as a "total station laser transit" to pinpoint the location of every significant feature — debitage, mussel shells, bones, projectile points, soil layers, even rodent burrows. With a hand-held X-ray

(Above) In 2013, Loren Davis and his team found these 13 stemmed projectile points in a single pit at the bottom of the Cooper's Ferry site. (Right) These prismatic blades and core fragments show stages in the process of making stone points. (Photos: Loren Davis)

device, they analyze soil composition around the artifacts. And high in a shade-making tarp suspended over the dig site, cameras snap photos minute by minute. They produce about 9,000 images per day.

"These photos can be strung together in time-lapse movies," says Davis. "I can't be everywhere at the site, and if I have a question about an event, I can go back and watch the time-lapse and see what happened."

Then there's the Cooper's Ferry Wide Web. Through computers set up in a trailer at the site, this Intranet system allows researchers working simultaneously in a half-dozen small plots to record information about every object they find. As they work, each team logs in with a laptop, enters data and even prints unique labels for the artifacts they have collected.

"We find so many items, we would get bogged down with the analysis if we didn't develop these systems," says Davis. "When you do it the 15th century monk way, with a paper and pencil, you get repetition. With this system, you can have simultaneous users, and the server keeps it straight. It gives unique numbers to each person so you don't get overlap. We don't have to clean the data later. It saves a lot of time."

Knowing where artifacts accumulated over thousands of years is key to understanding how people lived at Cooper's Ferry. "We have a tremendous amount of spatial data. That's the majority of what we do when we're excavating," explains Davis. "Things are found in space longitudinally and in association with other objects."

Such detailed documentation enables the OSU researchers to share evidence with colleagues, students and the public. They have even employed a student to produce videos displayed on a Cooper's Ferry YouTube channel (youtube.com/user/CoopersFerrySite). "Archaeology is generally not all that transparent," Davis adds. "You either have to be there or you have to take my word for it. Or you can go see artifacts in a museum."

In addition to the photographs, soil chemistry and spatial data, Davis and his team benefit from the advent of 3-D printing. With a $100 digital scanner used by computer gamers, they scan artifacts in the field. They process the resulting images into files that can be sent to a 3-D printer for creating accurate physical replicas. Now, other scientists and students can learn, not just from reports and photos, but from their own hand-held inspection.

Reliable Resources

After Davis made his landmark find in 1997, it took him 12 more years to go back. It wasn't for lack of interest. He needed the support for what he expected to be a multi-year effort. That arrived in 2008 when Joseph Cramer, a retired oil geologist with a keen interest in North American archaeology, gave $1 million to Oregon State to establish the Keystone Archaeological Research Fund. Davis directs the fund and says it was key to starting work at Cooper's Ferry. It provided critical backup, for example, when BLM funds were cut in 2012 as a result of the federal budget deal known as sequestration.

In that same year, Davis and his students located a trench dug in the early 1960s by archaeologist B. Robert Butler of the Idaho Museum of Natural History. In re-opening it, they found pull-tab beer cans (Lucky, Buckhorn and Rainier) and other modern artifacts, but more importantly, they found that Butler had stopped short of the deepest, earliest archaeological deposits. Digging further, the Oregon State scientists found the wolverine skeleton and the nearby pit with 13 projectile points.

People with even longer ties to Cooper's Ferry are also uppermost in the minds of Davis and his colleagues. The Nez Perce (*Nee-Me-*

What Other Archaeologists Are Saying

Ken Ames, Professor Emeritus Portland State University

"This is an exceptional site and an exceptional excavation. I think it will be a flagship site for this time period … probably for the next generation, will be my bet."

David Ellis
Willamette Cultural Resources Associates

"What we're seeing here is opening an older chapter in early cultural development in the Columbia Plateau. There will probably always be a little controversy about the dates, but given the kind of features being found here and the dates of those features, it tells us there's something going on here that is unexpected … there's a level of intensive occupation."

Landmarks near Cooper's Ferry on the lower Salmon River could have guided early people through a post-ice-age landscape. (Photo: Loren Davis)

Poo) National Historic Trail crosses the lower Salmon River and marks the desperate flight in 1877 of 750 men, women and children from the U.S. Cavalry across some of the most difficult terrain in the West. It stretches for 1,170 miles through Oregon, Idaho, Wyoming and Montana.

Davis and his collaborator, archaeologist David Sisson of the BLM, also an Oregon State alumnus, have attended Nez Perce tribal council meetings to discuss their procedures and findings. "We try to keep them informed more than anybody," says Davis. "We get visits from tribal members. They're intrigued about what we're finding."

A West Coast Story

It's likely that occupation of Cooper's Ferry didn't start with the people who left the four points that Davis found by the river in 1997. Older sediment layers just below those points are waiting to be explored but have already yielded objects. "We may have a much deeper time span than we realized," he says. "It's a little like doing *Wheel of Fortune*. We've only turned one or two tiles, so it's hard to guess the whole thing. We just need to keep opening up more to figure things out."

Besides going deeper in time, the Cooper's Ferry research may expand the Western narrative about how early people came to North America and how they lived and reacted to a changing landscape. That's because the tools and points found there show links to people at other locations in the region, places such as Paisley Caves, Lind Coulee in Washington, and Baja California, Mexico. Western Stemmed Tradition points have been found in each.

Davis has focused part of his efforts on the Oregon coast. In a project that could point the way to future investigations in coastal waters, he created a map of what the near-shore environment would have looked like at the height of the last ice age, when sea levels were almost 300 feet lower than they are today. If early people occupied coastal sites, he says, much of what they left behind would now be underwater. Based on bathymetric surveys, he mapped likely river courses and locations where people might have lived. His maps already play a role in the U.S. Bureau of Ocean Energy Management's permitting process for near-shore development.

At Devil's Kitchen State Park near Bandon, Davis has found artifacts in buried deposits that range between 6,000 and 11,000 years old. The site is unusual because the land on which it sits is rising relative to sea level. "It's a preserved river valley that didn't get submerged. This is an example that is normally buried deep in sediment," he says.

If people from a non-Clovis culture walked from Asia to North America at the height of the last ice age, they would have run smack into an ice sheet that blocked their way east. It's possible that, as ice-free corridors opened later, they moved south along the long-submerged coastline and through inland river valleys.

It's unlikely that as such opportunities became available, Davis thinks, people would have sat in Alaska twiddling their thumbs until the ice sheet had fully collapsed. The Copper River valley, for example, opened early, and people could have walked from the Yukon to the ocean. "Is that what happened? I don't know," he adds. But he's walking down his own trail to find out.

FINDING YOUR INNER EINSTEIN

Searching the Past

Doing archaeology takes endurance and patience

Since 2009, students from Oregon State and around the country have come to the lower Salmon River canyon and lived in tents for eight hot summer weeks. When not cooling off in the river, they dig, sift, haul and record as they participate in the search for traces of some of the earliest human activity in the Northwest.

The Cooper's Ferry Archaeological Field School enables undergraduates and graduate students to become proficient in the latest techniques for digging into the past. Surrounded by steep canyon walls, they learn to excavate with hand-held masonry trowels, record data and create maps.

"My favorite part is learning about the people and their experiences through looking at the tools and the features we're finding," says Stef Solisti, a student in biocultural anthropology from Portland and a participant in the 2013 field school.

The field school will run this year from June 23 to August 15. See details online at oregonstate.edu/cla/anthropology/coopers-ferry.

Private Eyes

Americans' personal data are under scrutiny by government spy agencies, commercial search engines and a vast rabble of phishers, sniffers and black-hat hackers

BY LEE SHERMAN | ILLUSTRATION BY RICHARD MIA

Just about every child has lain in the grass, looked up at the clouds and traced the shapes of lambs, castles and pirate ships. But these days, there's a new kind of cloud, one made not of droplets but of data — one that conjures images far less benign than the "bows and flows of angel hair" Joni Mitchell sang about in a simpler age.

For this new cloud, the best imaginary shape might be a giant pair of eyes.

"In human history, there's never been more surveillance of individuals by the state and by private corporations than there is today," said Oregon State University historian Christopher McKnight Nichols in April when he appeared on National Public Radio's *Philosophy Talk*.

> *"If you look back at the forecasts of surveillance by George Orwell, it turns out that Orwell was an optimist."*
>
> **Mikko Hypponen, Cyber Security Expert**
> **"TED Radio Hour," January 2014**

Not so long ago, cloud computing — the collection, processing and storage by companies such as Amazon, Google and Microsoft of data generated by cellphone signals, computer searches and credit card sales — would have seemed as sci-fi as cryogenic revival, as out-there as lunar colonization. But now, Internet-based computing is as ubiquitous as blue jeans, as ordinary as PB&J. Within its very commonness lurks its insidiousness. Most Americans, completely comfy with their mobile phones, laptops, desktops, pads and GPS devices, go about their daily lives blithely unaware that their calls are being archived by the U.S. National Security Agency (NSA) in the war on terrorism, that their Web searches are being mined by marketers and that their movements are being tracked day and night by cell towers and satellites.

That's largely because the digital outputs of electronic devices flow invisibly among "virtual servers" that can send and receive data, unseen, from place to place, nation to nation, continent to continent. Just about anything in the digital universe's zettabyte of data (give or take a gigabyte) can be snatched (or purchased) by a government intelligence agent, a "black-hat hacker," a for-profit company, an email "phishing" scammer or a digital swindler "sniffing" for wireless signals in a coffee shop.

Since whistleblower Edward Snowden's recent revelations of government spying and large-scale data mining, journalists, pundits and scholars have ramped up their commentary about the intrusiveness of today's 24/7 surveillance. Some have gone so far as to invoke George Orwell's "Big Brother." *Philosophy Talk* played on that theme rather ominously in the title for its April taping at Oregon State, "The New Surveillance State: Big Brother Grows Up," where Nichols was the featured guest.

OSU business professor Nancy King, a nationally recognized scholar in the field of consumer privacy, echoes the sentiment. "The thing that pops to my mind is the extreme example of Orwell's *1984*, where everyone has a video screen inside their house that watches every move they make," she says. "We have Google doing something very much like that. We have government doing it, too. The extent of surveillance in our society is incredible."

What does this digital Big Brother mean for the privacy of Americans as consumers, citizens and human beings? That's the question Nichols, King and other faculty at OSU are digging into as they investigate the historical, contemporary and future concepts of privacy in the United States. Below are some observations distilled from interviews with five scholars: historians Ben Mutschler, Marisa Chappell and Christopher Nichols in the College of Liberal Arts; computer scientist Carlos Jensen in the College of Engineering; and consumer privacy expert Nancy King in the College of Business.

BEN MUTSCHLER
"Emergence of the self"

Secrecy and autonomy of correspondence, journals and even flesh-and-blood bodies have shifted in surprising ways as perceptions of privacy have evolved over the past three centuries. As he studies 18th-century American life, Ben Mutschler scrutinizes attitudes toward letters, diaries, body fluids — even bedfellows.

Back in those days, letters often were public performances, not unlike Facebook postings today, he notes. Recipients would read them aloud at social gatherings for amusement and discussion. Diaries, rather than records of inner musings — what Mutschler calls "intimate self-disclosures" — were matter-of-fact jottings about daily events and transactions. Bodily functions that Americans today regard as intensely private were routinely on public display. Young George Washington, for example, was instructed to urinate away from others and avoid spitting on the person beside him, two of the 100-plus rules listed in his boyhood handbook of etiquette. And in contrast to today's motel rooms with deadbolts and electronic key cards, a weary 18th-century traveler might awake in his lodgings to find a stranger sharing his bed.

"What we would take to be privacy issues might not have been construed in the same way in the 18th century," he says. "The social and cultural contexts were quite different. If the NSA were to come in today and take your diary, we'd say it's a real violation. But in the 18th century, diaries were often a register of social exchanges or bartering — who visited whom, when the eggs were delivered, that kind of thing."

In fact, the whole notion of "bodily integrity," of each human as a "self-activated person who can do his or her own thing," has emerged fairly recently in human history, according to Mutschler. "Historians date the emergence of the self — the whole discourse about a person being an individual with free agency — taking place over hundreds and hundreds of years."

MARISA CHAPPELL
"Not an enumerated right"

Like the concept of selfhood, privacy is a fairly recent notion, especially in American jurisprudence. Now, with the lines between the physical world and the virtual world as blurry as a dirty windshield in a blinding rain, incipient privacy rights are murkier still.

"Privacy is not an enumerated right," says Marisa Chappell, a scholar of 20th-century U.S. history. "It's a concept we create through law and sociocultural understandings."

Privacy, she points out, is not explicitly spelled out in the U.S. Constitution. The closest thing to a Constitutional guarantee to privacy is the Fourth Amendment, which protects Americans from warrantless government searches of their homes and seizures of their stuff. But the amendment was written well before anyone dreamed of valuable personal information floating around in the air instead of being locked in a vault or stashed under a mattress. Likewise, prohibitions against wiretaps seem quaint in a wireless world.

"Law has to constantly adapt to changing technology," says Chappell. "We're making it up as we go along."

In the 1973 landmark Roe v. Wade decision, for example, the U.S. Supreme Court invoked an implied right to privacy under the "penumbra" of the 14th Amendment guaranteeing due process in its opinion granting abortion rights to women. But state legislatures and lower courts are constantly challenging this fragile right.

FINDING YOUR INNER EINSTEIN

Delving Into Censorship

The news media were in a frenzy over the NSA surveillance story last fall when Pendleton history major Matthew Schuck was poring over documents about government surveillance during World War II. In the Valley Library Archives, he found a letter from Secretary of War Henry Stimson directing Carl Milam, executive secretary of the American Library Association, to place all books on "explosives, secret inks and cyphers" to restricted shelves. Patrons had to fill out a form to borrow such books. In 1943, OSU Assistant Librarian Lucia Haley forwarded at least one patron's name to FBI agent R.P. Kramer in Portland. "All the NSA stuff was coming to light when I was working on this project," says Schuck. "It was like the past was repeating itself."

"Privacy," says Chappell, "is a continual source of debate and negotiation, of weighing in on the boundaries. I don't think Americans are ready or willing to give up a private zone. But technologically, how can it be secured? I don't know. These are questions of law. They're questions of policy. They're questions of technology.

"I don't envision a dystopian future, myself. I'm not such a pessimist."

CHRISTOPHER McKNIGHT NICHOLS
"Abridging civil liberties"

Christopher Nichols echoes Chappell's point about the legal lag time. "Technology tends to outpace the law," he says. "Constitutional law hasn't caught up."

Rights to privacy, speech, due process — even physical liberty — often succumb in the face of enemies, real or imagined, observes Nichols, an historian of U.S. relations with the world. When people are afraid of terrorists, for example, many readily relinquish their privacy in exchange for the sense of greater safety.

"We often abridge civil liberties in wartime," he says. "You can look at conflict after conflict in American history, and you'll find abridgements of civil liberties that citizens willfully endorse. The Civil War is a great example. Lincoln suspended habeas corpus, the foundation of American civil law." The list goes on.

The American public's tepid outrage over Snowden's NSA leaks fits this pattern, he argues. People tend to be sanguine about government spying if they think it can stop another 9/11. But apathy about privacy is a slippery slope. What happens if today's existential threat becomes a threat without end?

Whether history judges Snowden as a patriotic hero or a dastardly traitor, his revelations have contributed to the transparency that keeps government accountable and safeguards individual privacy.

"These kinds of leaks are very important for open democracy," Nichols asserts. "Ideally, citizens should be informed directly by the government, in a proactive way, about surveillance activities. But that tends not to be the case. So these leaks help us to know more."

CARLOS JENSEN
"As if no one is eavesdropping"

Carlos Jensen is really glad Facebook wasn't around when he was growing up. Digital cameras, too. "Thank the Lord," he says, laughing.

"When you're putting your life out there, very few people think about the long-term consequences," notes Jensen, who studies online communications and communities. "In most likelihood, anything and everything you send over services like Google or, say, your employer's email is being logged, potentially forever, in a way that allows instant searching and instant correlation. Our thinking and our attitudes and the way we live our lives really haven't evolved to compensate for that. We still conduct business as if no one is eavesdropping on us."

For Jensen, even more troubling than NSA data mining, which he calls "a gross invasion of privacy," is corporate amassing of user information around the clock, seven days a week, no breaks for holidays.

"Honestly, what keeps me up at night is that all our laws and all our regulations are about what the government can and cannot do," says Jensen, who is working on browser privacy tools that are fast and easy to use. "But there's virtually no regulation that says what Google may or may not do."

Jensen teaches a class on computer ethics. One of the questions he poses to his students is this: "Who knows you the best?" After they ponder, he tells them: "Chances are, it's not your family. Chances are, it's not your friends. Chances are, it's Google."

NANCY KING
"The wild, wild West"

Nancy King, too, worries deeply about the unfettered access of governments and corporations to people's personal information. While she's quick to clarify that she's "quite pro-business," she rues the lack of a legal framework to reign in privacy abuses and tighten up security.

"I appreciate the business value of analyzing consumer data and creating targeted products and services for customers," she explains. "But there's almost no protection in the U.S. for consumers' privacy, particularly their information privacy. The technology is way out ahead of our ability to even understand what we need to do to protect ourselves from identity theft, unfair price discrimination and other harms."

What's urgently needed, King argues, is a baseline privacy law that tells businesses what they can and can't do with data. "Once we have a foundational law that establishes basic informational privacy rights," she says, "the more egregious privacy abuses likely will be reduced. But right now it's a free-for-all. It's the wild, wild West."

King also frets about Big Brother's crimping effect on creativity, innovation, spontaneity and originality — those most brilliant sparks of the human spirit, which flame freely only in an open society. "People don't develop the same way if they're constantly under surveillance by others," she warns. "If you're being watched by people, watched by cameras in the street, watched by computers that monitor your every keystroke and track your online behavior, that changes how you develop and act.

"It's the essence of being human to have some privacy about ourselves. Our laws need to reflect this fundamental truth."

Diving in an aggregation of spawning Nassau groupers on the west end of Little Cayman Island in the Caribbean Sea, OSU researcher Scott Heppell collects population data for an international study called Grouper Moon. (Photo: Jason Belport)

Total Immersion

Diving the world's waters in search of deeper knowledge

BY LEE SHERMAN

In her white coat, safety goggles and latex gloves, Kerry McPhail looks every inch the medicinal chemist at work in her Oregon State University lab. Amidst dozens of molecular diagrams taped to dun-colored walls, the College of Pharmacy researcher grows colonies of microbes in petri dishes and then runs their extracts through the super-conducting magnet of an NMR spectrometer — a key step in analyzing the structures of natural compounds with potentially curative powers.

But lab work is only half of this researcher's scientific persona. Before she can test them, she has to collect them.

That's why McPhail periodically undergoes a superhero-like transformation, trading her staid white lab coat for a sleek black wetsuit, strapping on a mask, a scuba tank and a pair of bright-yellow fins. Then, tucking a mesh collection bag and a supply of 1-gallon Ziploc bags into her dive belt, she splashes into some of the planet's most remote — and sometimes dangerous — waters to collect rare marine organisms. She once bloodied her knuckles on coral cliffs when currents pumped her through a cavernous reef in Panama. On another dive, this one off the coast of Saudi Arabia, she felt a rush of water pressure and glimpsed a big tail out of the corner of her eye. Breathing easy to relax, she was relieved to find herself staring into the curious eyes of a bottlenose dolphin ("like a dog wanting to play"). And in the surging seas of South Africa, she was horrified when she dropped a hard-won specimen.

Fisheries researcher Scott Heppell uses a "laser caliper" to measure Nassau groupers as part of a long-term study of the species, which is threatened by overfishing. (Photos: 2009 Brice Semmens, ©Grouper Moon Project)

Against all odds she managed to recover the rare organism from the rocky reef, still zipped tightly into its plastic bag. These and the other precious marine organisms she collects around the world may hold the secrets to curing a small child's brain cancer or a young mother's malaria.

For an elite handful of Oregon State researchers and students in pharmacy, biology, oceanography, zoology, fisheries, marine resources management — even maritime engineering — their other lab is underwater. They dive in the Cayman Islands and the Red Sea, in South Africa's Nelson Mandela Bay and Oregon's Yaquina Bay, in Central America, the Bahamas and Antarctica, in the Klamath River and the Virgin Islands. They dive to find chemical compounds for fighting aggressive cancers and deadly pathogens. They investigate the crashing of fisheries and the dying of corals. They track the spread of invasive lionfish in the Atlantic and Caribbean. They assess the impact of excess carbon beneath polar ice, study the life cycle of salmon parasites and monitor marine reserves and "dead zones" off the Pacific Coast.

In 2012, some 55 OSU faculty and students made nearly 2,000 official dives for science and training, logging close to 1,600 hours underwater.

Squirts and Sharks

In July, McPhail boarded an international flight at PDX en route to South Africa on a harrowing mission: to collect specimens of an extremely rare species of cancer-fighting "tunicate" (sedentary, sac-like marine organisms known colloquially as "sea squirts" for sucking in and squirting out seawater as they feed) in Algoa Bay, where waters surge wildly through narrow channels and hidden caverns.

"The water in the bay is pretty crazy," says McPhail. "The open ocean bumps this tabletop reef, smashes against the edge and rolls over it, creating massive surge. It's some of the trickiest diving in the world."

Pharmaceutical researchers worldwide have been excited about this tunicate's cancer-killing compounds ever since McPhail and fellow researchers from Rhodes University discovered the organism in 2004. Tunicates, which come in a rainbow of garish hues and a phantasmagoria of quirky shapes, ward off predators by manufacturing potent poisons. This new species of *Lissoclinum ascidian*, its white luminescence giving it a ghostly glow in the ocean, produces a compound that kills human lung cancer cells in test tubes. These bioactive chemicals are named "mandelalides" in tribute to the great South African leader Nelson Mandela.

By 2013, however, the collected specimens had been depleted. Scientists needed more tissue to continue characterizing the organism's extraordinarily complex natural-products chemistry. So McPhail and Shirley Parker-Nance, a tunicate taxonomist from Nelson Mandela Metropolitan University, met at the bay near Port Elizabeth to mount a hunt.

The challenges were steep. For one thing, the organism is super-scarce. It has been found only in this one spot on Earth, clinging to corals on a reef called White Sands. Second, powerful surges and treacherous currents rip through the reef, a maze of underwater cliffs and chasms at the intersection of the Indian and Atlantic oceans, a great mixing of big waters. And third, this tunicate dwells exclusively on the shadowy overhangs of deep, rocky ledges. Under those very ledges, in dark caverns and hidden crevices, skulks the ragged-tooth shark, *Carcharias taurusm*. Despite its extensive dentation, which resembles rows and rows of ivory ripsaws, these sharks are "surprisingly bashful," according to McPhail.

At Lee Stocking Island in the Bahamas, student researcher Darren Johnson (now an assistant professor at California State University, Long Beach) collects juvenile coral reef fish for Mark Hixon's lab at OSU in 2006. (Photo: Nikita Rolle)

Bumping into the odd shark, she concluded, is a chance worth taking for science. OSU's Office of Research Integrity aims to keep those risks as near to zero as humanly possible. That's where veteran diver Kevin Buch comes in. As the university's diving safety officer Buch (pronounced *Buuk*) runs the intensive training and ongoing oversight required to mitigate the inherent hazards of doing science underwater.

"If you compare it to other types of professional activities, scientific diving is statistically very safe," says Buch, who was recruited two years ago by famed reef ecologist Mark Hixon and now works to strengthen and expand OSU's scientific diving program. "Scientific diving accident rates are lower than they are in commercial diving. We haven't had any serious problems at OSU, but I've been on projects in the past where there were major injuries and fatalities. Fortunately, those kinds of things are very rare. But they can happen. So it's not anything you want to take lightly."

Unlike diving done just for fun, scientific diving requires complex multitasking. "When you're a scientific diver, you're considered a professional diver in the same realm as military divers, public safety divers, rescue divers, commercial divers," says Buch, who worked for the National Oceanic and Atmospheric Administration (NOAA) and then at Texas A&M before coming to Oregon State. "You're actually doing work underwater — identifying and counting animals and plants, measuring and laying grids, recording data, collecting samples, running experiments. You're task-loaded. So the diving itself has to be second-nature."

Safe scientific diving begins with a minimum of 100 hours of classroom instruction, pool practice and outdoor field experience. In places like Lake Woahink in Florence, Hood Canal in Washington state and the OSU pier at Newport, OSU divers in training hone their skills. Those who finish the program and pass the testing earn scientific diver certification by the American Academy of Underwater Sciences. Only then do they become eligible to dive with researchers in OSU's scientific diving program.

Last February, a dozen research divers clustered around Buch as he prepped them to conduct a mock reef census inside a pair of mega-aquariums — one called Orford Reef, the other Halibut Flats — that simulate real-life ecosystems along the Oregon coast. Under a contract signed last year by OSU and the Oregon Department of Fish and Wildlife, Buch oversees diver training for underwater monitoring in Oregon's five marine reserves. Conducted in collaboration with the Oregon Coast Aquarium, the training takes place in the aquarium's 26-foot-deep tanks, which each holds nearly a million gallons of triple-filtered seawater. They are ideal places to practice fish surveys and benthic transects (counting bottom-dwelling organisms inside a measured area) before actually plunging into the cold, murky waters of Redfish Rocks, Cascade Head and the other three reserves.

"It's great to train in a controlled environment — no current, no surf, and nobody can get lost," Buch observed, his voice mixing with a steady slosh of water, punctuated now and then by a splash from the "dump bucket," which filled and emptied, filled and emptied, to mimic ocean surge inside the tanks. As the divers gathered up their waterproof whiteboards and tape measures, they looked down and saw dozens of pouty rockfish — orange vermilions, yellow canaries, olive-brown coppers — suspended lazily in water that was bluer than blue. Between giant kelp fronds, a sturgeon cruised by, its shadow grazing the sandy bottom. A halibut popped up to look around. Buch double-checked his gear. Then, in a froth of bubbles, he slipped into the water with his trainees.

A Winter's Tale

A full moon rises over Little Cayman Island, casting a river of light across the deep-blue Caribbean and setting in motion an ancient pattern of procreation, the renewal of life growing ever more urgent for a once-abundant species, now endangered. As the silvery orb climbs high in the winter sky, thousands of Nassau groupers (*Epinephelus striatus*) suddenly feel evolution's tug. These big, striped fishes — which typically live solitary lives among widely scattered coral reefs — begin to swim in one direction, all destined for a single point, a promontory at the west end of the 12-mile-long island, where they will bring forth a new generation in frenzied releases of eggs and sperm.

For eons, Nassau groupers have gathered at this very promontory to spawn, always on the first full moon 30 days after the Winter Solstice, as regular as clockwork, explains OSU fisheries biologist and scientific diver Scott Heppell. This precision and predictability was a bonanza for a couple of local fishermen when they discovered the aggregation last decade. In 2001 and 2002, the two men, using nothing more than hand lines dropped over the side of a small boat, hauled in 4,000 groupers from the west-end aggregation. "These two guys caught two-thirds of Little Cayman Island's entire adult population in two seasons," laments Heppell. "For a fish seeking a mate, aggregation is a great adaptation. But for bipedal humans with big brains, the spawning grounds are easy pickings."

The decimation spurred the Cayman government's Marine Conservation Board to act. After placing an emergency ban on taking fish from aggregations, the government joined forces with an organization called the Reef Environmental Education Foundation (REEF) to study spawning groupers on Little Cayman Island. OSU's Heppell is one of eight divers on the international team for the project, poetically named Grouper Moon.

Laws of Conservation

When Heppell pinches his nose and drops backward off a research boat tethered to Little Cayman Island, he sinks into the liquid equivalent of, say, an Andean rainforest — except it's turned upside-down. Instead of ascending into thin air, the cliff faces here disappear into dark water 4,000 feet below. Marine organisms thrive at distinct levels, just as terrestrial organisms do. In shallow water suffused with light, soft corals, sea fans and small reef fish grow and drift and swim. Deeper on Little Cayman's famously beautiful vertical rock face called Bloody Bay Wall, those cravers of photosynthesis give way to organisms adapted to darker, colder places — big barrel sponges, lobsters, sea urchins, crabs. Cruising by are eagle rays and sea turtles, like birds in flight.

Every winter for 10 years, Heppell and his team have been diving into the groupers' sweet spot (90 to 110 feet deep) at their ancestral aggregation site off the western tip of Little Cayman. A place where two strong currents collide, the site is prone to big surf and swirling eddies. Diving there can be difficult and dangerous.

On Ghurab reef in the Red Sea off the coast of Saudi Arabia, Kerry McPhail's team collects cyanobacteria and sponges for natural-products drug discovery in collaboration with researchers at King Abdulaziz University. (Photo: Kerry McPhail)

"Everybody thinks, 'Oh, you're going to the tropics; you're going to be sitting on the beach sipping Mai Tai's,'" says Heppell, the chair of OSU's Diving Control Board, which monitors all scientific diving activities for the university. "But this is hardcore research diving. It's not to be trivialized."

Working with the Cayman Islands Department of Environment, the divers use lasers, underwater hydrophones and satellite telemetry to count, measure and track the fish, making three dives daily (including one night dive) over a 10-day period each winter. It adds up to hundreds of dives.

The results of the fishing ban have been dramatic, their studies show. From a low of 2,500 fish in 2003 when the ban was imposed, the population had rebounded to about 6,000 by 2013. In response to the clear evidence, the Cayman Parliament passed legislation in early 2014 — the Marine Conservation Law — which will protect grouper aggregations into perpetuity.

"Fishermen can still catch grouper. They just can't catch them when they're spawning," says Heppell. "We've gone from basic science all the way to new laws in just 10 years. The Cayman government has shown great leadership in smart, natural resource management and conservation in the Caribbean."

Dinner Is Served

It's the unusual dean's assistant who not only cooks a scientific team's dinner, but catches it, too. Last year, after each day's dive to collect sponges and cyanobacteria (a phylum of photosynthesizing bacteria formerly known as blue-green algae) in the Red Sea, Yousef Syamek of King Abdulaziz University would spear a string of *hareed* (parrotfish), grill them over a hibachi in his hotel room, and serve the hot, crispy fish with mounds of rice, tomatoes, cucumbers and fresh-baked Lebanese bread to Kerry McPhail, OSU graduate student Jeff Serrill and the Saudi Arabian scientists on her hungry team. Once sated, they would pile into a van and head out, motoring through the night toward the next morning's dive site while eating fresh dates for dessert.

At the end of the expedition, when it came time for McPhail and her collaborator on the project, medicinal chemist Diaa Youssef, to present their findings to scientists at King Abdulaziz University, she underwent yet another transformation in attire, this time donning a headscarf and an abayah, the full-length black robe worn by Muslim women in some Arabic countries. The targets of the trip were new species of cyanobacteria, including those in the genus *Symploca* and the genus *Leptolyngbya*, now undergoing analyses in Saudi Arabia for their cancer-fighting potential.

On the other side of the Earth, another novel cyanobacteria species belonging to a new genus still being described is in demand by the National Cancer Institute and scientists such as OSU pharmacologist Jane Ishmael. Their target is a potent compound called coibamide, discovered in 2008 and named for Panama's Coiba National Park, a UNESCO World Heritage Site in the Gulf of Chiriqui. Working with the National Institutes of Health-funded International Cooperative Biodiversity Group in Panama, McPhail — one of the species' discoverers — has made dozens of dives into the Pacific from the now-retired research vessel *Urraca* of the Smithsonian Tropical Research Institute. She collected samples of the purplish-red, hair-like organism, which has shown powerful effects against breast and colon cancers as well as glioblastoma, a very aggressive brain cancer for which there are currently few treatment options.

Despite the beauty of the tropical setting, getting these rare specimens is no small feat. "The water is really beautiful there — a very blue oceanic system, pristine," says McPhail. "You can see whale sharks there. The reef structure is beautiful, too — very high profile. But conditions are very rough. When I was there in July, there was a lot of runoff; it was violent and turbulent. The cyanobacteria grow in gullies or channels. The water comes ripping through. You get pumped down this chute. If you try to collect or hold on at the wrong moment, your knuckles get shredded."

Another Panamanian reef is known among divers as *Montana Rusa*, the Rollercoaster. "The open sea is hitting it constantly, creating all this swell and surge," McPhail says. "People get seasick 70 feet down."

Back on the boat, McPhail and her teammates transfer strands of the organism, a few at a time, into tissue-culture vials filled with 15 milliliters of water for transport to labs in Panama, Oregon and San Diego, where the scientists will continue investigating its remarkable cancer-killing powers. terra

Undergraduate Allison Stringer collects samples in the Bahamas for a study on invasive lionfish for Mark Hixon's lab while earning dual bachelor degrees in fisheries and biology. (Photo: Lillian Tuttle)

FINDING YOUR INNER EINSTEIN

Learning to Dive

OSU's scientific diving course opens underwater opportunities

It seemed that Kyle Neumann had a dream job: video broadcasting for the Portland Timbers. But something kept nagging at him. "For me, it just wasn't fulfilling a higher purpose," says the Oregon State University senior.

He wanted to use his video storytelling skills, he decided, not for professional sports but for Planet Earth. First, though, he needed to study science. So he enrolled in OSU's rigorous BioResource Research program, which requires undergrads to do original research and defend a thesis. Under the mentorship of professor Rick Colwell in the College of Earth, Ocean, and Atmospheric Sciences, Neumann has designed a device for remotely sampling water chemistry and studying microbial communities. The cylindrical pump, called an "osmosampler," promises to have wide applications, such as studying toxic compounds associated with hydraulic fracturing or investigating the greenhouse gas impacts of methane-munching microbes called methanotrophs.

Which brings us to Neumann's other passion: water. A competitive swimmer and surfer as a kid in California, he got to snorkel and free dive at Catalina Island for a high school oceanography class. The underwater life forms he saw entranced him. "It was so beautiful," he recalls. After Neumann left the Timbers and landed a gig with Oregon Public Broadcasting's *Oregon Field Guide*, videographer Michael Bendixen (formerly of Oregon Sea Grant at OSU) encouraged him to upgrade his scuba skills for underwater videography. So, after enrolling in OSU, he wasted no time signing up for recreational diving classes and then took the university's then brand-new scientific diving course, earning his credentials from the American Academy of Underwater Sciences. Neumann has been diving in Newport's Yaquina Bay with OSU scientific diver and researcher Andrew Thurber to sample microbes (read about Thurber's work in *Terra*, winter 2014).

Kevin Buch, OSU's diving safety officer, says OSU's scientific diving program is geared toward students, especially undergrads. "The goal is to expand opportunities for students," he says. "They not only earn professional credentials, but they also get real-world experience diving with scientists on actual research projects."

As he nears graduation, Neumann has begun applying for scientific diving jobs with marine labs in places like Panama, Florida and Alabama. But first he'll spend a month with Ocean Exploration Trust working under Robert Ballard of Titanic fame doing biological discovery and maritime archaeology (studying shipwrecks) on the Mesoamerican Reef in the Caribbean.

"At OSU, I've had access to world-renowned scientists doing real-world research — and I got funded to do it," says Neumann, whose microbial research has been supported by the U.S. Department of Energy.

Poison in the Blood

New treatment could reduce deaths from a hidden killer

BY DAVID STAUTH

They used to call it "blood poisoning," and the term is still descriptive, if outdated.

Like a poison, it's fast and often deadly. A modest infection suddenly turns into a whole-body inflammation complete with fever, flushed skin, swelling and hyperventilation. It can hit anyone from an infant to the elderly. It killed at least two U.S. presidents while they were still in office.

The modern term is "sepsis." That word was actually coined by Hippocrates around 400 B.C. and meant "the process of decay." As a syndrome leading to multiple organ failure, sepsis is clearly a type of decay. But it's a pretty quick process, where every hour of delay in administering an antibiotic can raise the mortality rate by another 6 percent. Even with aggressive treatment, 28 to 50 percent of the people diagnosed with sepsis die from it.

"Sepsis is a hidden killer, the one nobody really talks about," says Adam Higgins, a bioengineer at Oregon State University. "It kills more people in the U.S. every year than AIDS, prostate cancer and breast cancer combined, and you still don't hear much about it."

A group of researchers in the College of Engineering, however, are working with teams of undergraduate and graduate students on a project that may soon have the whole world talking about sepsis. Finally there may be a way to combat this syndrome with something other than antibiotics — which often don't work.

"A big part of the problem with sepsis is that it moves so rapidly," says Joe McGuire, professor and head of the OSU School of Chemical, Biological and Environmental Engineering. "By the time it's apparent what the problem is, it's often too late to treat it. What we have in mind is a way to process the blood and prevent sepsis, something that could be used at any time."

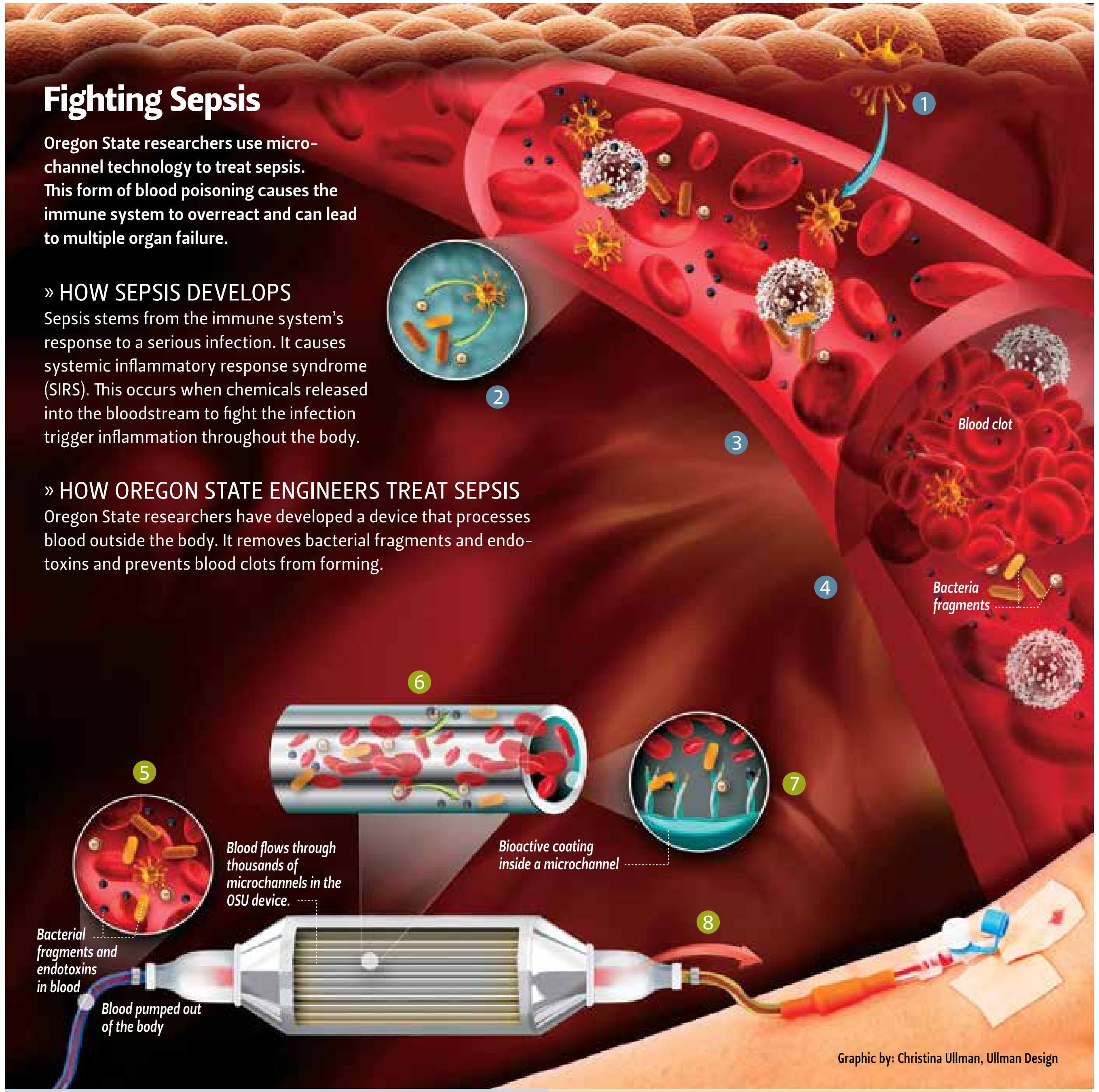
The underlying cause of sepsis is "endotoxins," molecules that are released from bacterial cell walls and lead to rapid, systemic inflammation. These pieces of bacteria can disrupt the immune response, cause it to overreact and to develop clots and other problems that lead to multiple organ failure.

"If given early enough, antibiotics and other treatments can sometimes, but not always, stop this process," McGuire adds. "Once these bacterial fragments are in the blood stream the antibiotics won't always work. You can have successfully eradicated the living bacteria even as you're dying."

The approach being developed at OSU is to move blood through a very small processor, about the size of a coffee mug, and literally grab the endotoxins and remove them. The concept is surprisingly simple and builds on some of the university's revolutionary work with microchannel technology.

By moving fluids through tubes the width of a human hair, microchannels accelerate chemical reactions and heat transfer. Applications are already being studied in heat exchangers, solar energy and chemical manufacturing. Microchannels can be produced in mass quantity at low cost, stamped onto a range of metals or plastics and used to process a large volume of liquid in a comparatively short time.

In this case, the liquid is blood, which may contain the endotoxins that cause sepsis. In the OSU system, blood can be pumped through thousands of microchannels that are coated with what researchers call "pendant polymer brushes," tiny strands equipped with chemicals that can grab endotoxin molecules like a fishing hook. On the business end of the strand is a peptide, a bioactive agent that binds tightly to the endotoxin and removes it from the blood,



1. Sepsis results from the immune system's response to bacterial infection.
2. In the blood stream, bacterial fragments and endotoxins continue to circulate.
3. In response to endotoxins, the immune response can overreact, leading to blood clots.
4. Antibiotics often don't work on bacterial fragments, which are not living cells.
5. Infected blood from the patient is pumped through the device.
6. As blood flows through microchannels, red blood cells migrate to the center of the channel while bacterial fragments and endotoxins are pushed toward the channel wall.
7. Tiny chemical strands attached to the channel walls snag bacteria and endotoxins and remove them from the blood.
8. The treated blood is transferred back into the patient.

which then goes directly back to the patient. To keep blood proteins and cells from sticking or coagulating in the channels, the strands also have been designed with repeating chains of carbon and oxygen atoms anchored on the surface.

"This doesn't just kill bacteria and leave floating fragments behind; it sticks to and removes the circulating bacteria and endotoxin particles that might help trigger a sepsis reaction," says Karl Schilke, the OSU Callahan Faculty Scholar in Chemical Engineering.

"We hope to emboss these out of low-cost polymers, so the device itself should be inexpensive enough that it can be used once and then discarded," Schilke adds. "The low cost would also allow treatment even before sepsis is apparent, a prophylaxis approach to prevent it, not just treat it after the fact. Anytime there's a concern about sepsis developing, due to an injury, a wound, an operation, an infection, you could get ahead of the problem."

The risk of sepsis is surprisingly common. It can develop after an injury from an automobile accident, from a dirty wound, during an extended operation in a hospital, or opportunistically when people with a weak or compromised immune system contract an infectious disease.

More development and a demonstration of feasibility are still needed, the researchers say. The National Institutes of Health, the Collins Medical Trust and the Oregon Medical Research Foundation are supporting ongoing research. Advances are also being made in microchannel structures that would increase the adsorption of the endotoxins. But the promise of such systems — and their value in medicine — could be enormous once the work is complete.

"When we first conceived of this approach to prevent sepsis, my initial reaction was, 'Wow!'" McGuire says. "Think of the number of deaths we could prevent. Think of the billions of dollars spent in intensive care that could be available for something else. Think of all the infants and young people who could have their whole lives given back to them."

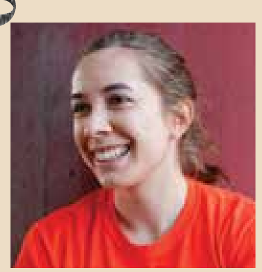
In the United States, one out of every four people in a hospital emergency room is there because of sepsis, and more than $20 billion was spent on this problem in 2011. It's the single most expensive cause of hospitalization. But as Higgins points out, it's still a hidden killer and doesn't always even make it onto the death certificate. Sometimes "cardiac arrest" or "kidney failure" is listed as cause of death instead of the real, underlying cause — sepsis.

Since the dawn of time, sepsis has killed infants. It's killed countless numbers of people wounded in battles. Millions of people around the world die from it every year. It killed Pope John Paul II.

But if the research at OSU succeeds within the next few years, much of that may become a problem of the past. terra

FINDING YOUR INNER EINSTEIN

Bioengineering Students Jump-start Their Careers



Marsha Lampi

A team effort to find a new way to treat sepsis has provided myriad hands-on opportunities for undergraduate and graduate bioengineering students at Oregon State. They've made vital contributions to the research and advanced their careers.

"This is such a large project that we've probably had a couple dozen or more students involved in recent years," says Joe McGuire, professor and head of the School of Chemical, Biological and Environmental Engineering.

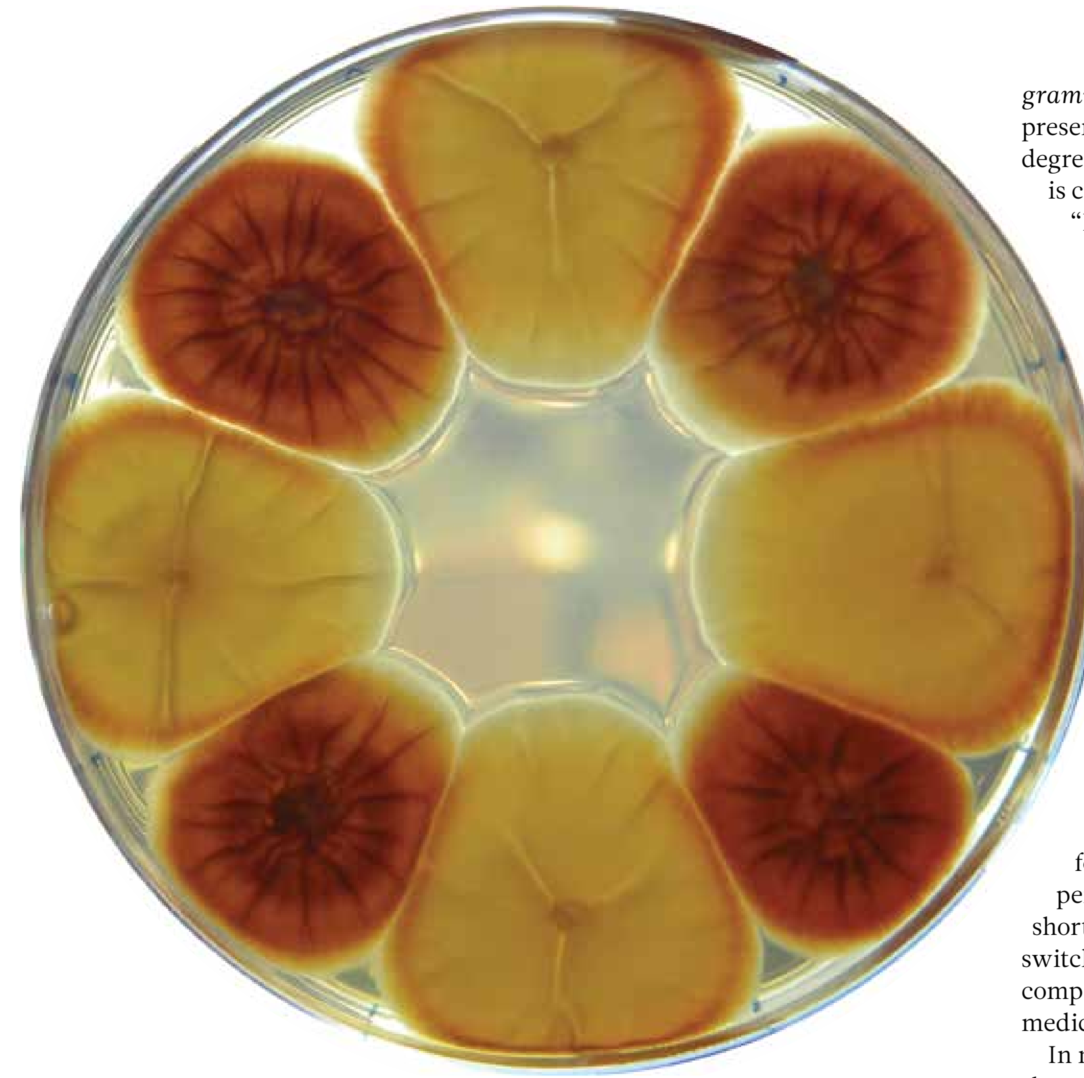
Research in McGuire's lab led a graduate student to a doctoral program at the University of Delaware and an undergraduate to a job with a biomedical company in Bend.

And it propelled Marsha Lampi, a Portland track star who received her OSU bachelor's degree in 2012, to a doctoral program in biomedical engineering at Cornell University.

"I was awarded fellowships from the National Science Foundation, the Ford Foundation and the Sloan Foundation," says Lampi. "My research with Dr. McGuire, particularly the opportunity to have a first-author publication from my undergraduate research, was pivotal in making me competitive for these fellowships."

At OSU, Lampi helped define how peptides can remove toxins from blood. At Cornell, she studies the effect of arterial stiffening, which occurs naturally with aging, on the formation of fatty deposits on artery walls.

She isn't sure yet where her career will end, but it's clear where it began.



Raising Spores

SCIENTISTS FIND FUNGAL TREASURE AND START THE HUNT FOR NEW ANTIBIOTICS

BY NICK HOUTMAN
PHOTOS BY LANELLE CONNOLLY
STUDENT PHOTOS BY HANNAH O'LEARY

In our homes and gardens, fungi are often unwelcome visitors, evidence of plant disease or rot and decay in damp places. They show up as black spots on tomato plants, discolored leaves on zucchinis and scabs on apples. Despite the benefits of these microorganisms — they are nature's master recyclers — we spray and prune to get rid of them.

But in Michael Freitag's lab, scientists work hard to grow fungi. Student researchers feed fungal spores — the microscopic seeds of a new generation — with nutritious meals, swirl them gently in Erlenmeyer flasks, propagate fungal colonies in petri dishes and watch hopefully as stunning colors and curious shapes emerge. Freitag's group has developed more than 400 strains of a species, *Fusarium graminearum*, that they keep preserved at a frosty minus 112 degrees Fahrenheit. Each strain is cataloged with a unique "FMF" number, shorthand for "Fusarium Michael Freitag," and logged in a database.

While known mostly as a pathogen of wheat, corn, barley and other cereal grains, this species turns out to be a treasure trove of potential new antibiotics and other natural compounds. In 2013, based on research conducted in part by undergraduates under the guidance of lab manager Lanelle Connolly, Freitag's team announced that they had unlocked nearly 1,500 *Fusarium* genes, accounting for a large part, nearly 14 percent, of its total genome. In short, they have discovered a master switch that opens the door to new compounds with potential use in medicine, agriculture and industry.

In nature, the genes that produce these compounds are normally inactive or "silent." They do little more than get carried from one individual to another in the act of reproduction. "It's likely," says Freitag, an associate professor in the Oregon State University Department of Biochemistry and Biophysics, "that they are activated only under special circumstances, like a secret weapon." They could help *Fusarium* to infect a plant host or to counter an attack by bacteria or other fungi. Until now, scientists have known almost nothing of the compounds that these genes produce.

Under Wraps

Despite their ubiquitous presence in the environment and even in our bodies, raising fungi takes extraordinary care. Connolly demonstrates the process by lifting a storage rack out of a freezer and, as vapors swirl about her head, she removes a sample smaller than a pea from a plastic microtube. She adds the sample to a broth of yeast extract, peptone (a protein mixture) and glucose (sugar) and places the liquid in a flask. On a shaker table — a platform that whirls flasks gently day and night — the fungus will multiply itself more than a million-fold. After several days, the flask holds more than 10 billion spores.

The fungal population isn't done growing. Student researchers filter the spores from the broth and inoculate them on a growth medium in petri dishes. For *Fusarium*, they often rely on carrots — organic, if you please. "You won't believe how many batches of non-organic carrots cannot support fungal growth because the carrots are somehow treated," says Freitag.

Contamination by other micro-organisms is a constant threat, so the students scrub countertops with bleach and sterilize their instruments with ethanol or steam and high pressure. After spending hours on developing their cells, it can be disappointing to find interlopers that spoil the broth.

Moreover, the scientific method can be notoriously fickle. "Getting something to work once doesn't mean it's going to work all the time," says Corinne Fargo, a member of Freitag's team and a junior in the Department of Biochemistry and Biophysics and the University Honors College. For example, in a recent experiment, she succeeded in getting all 36 of her colonies to grow in petri dishes. "I rocked it," she says.

She expected similar success with her second batch, only to find that it yielded one colony, and that one looked suspiciously like a case of contamination. "I need to work backwards and figure out what I did differently," she says. "We work very, very hard to keep things sterile."

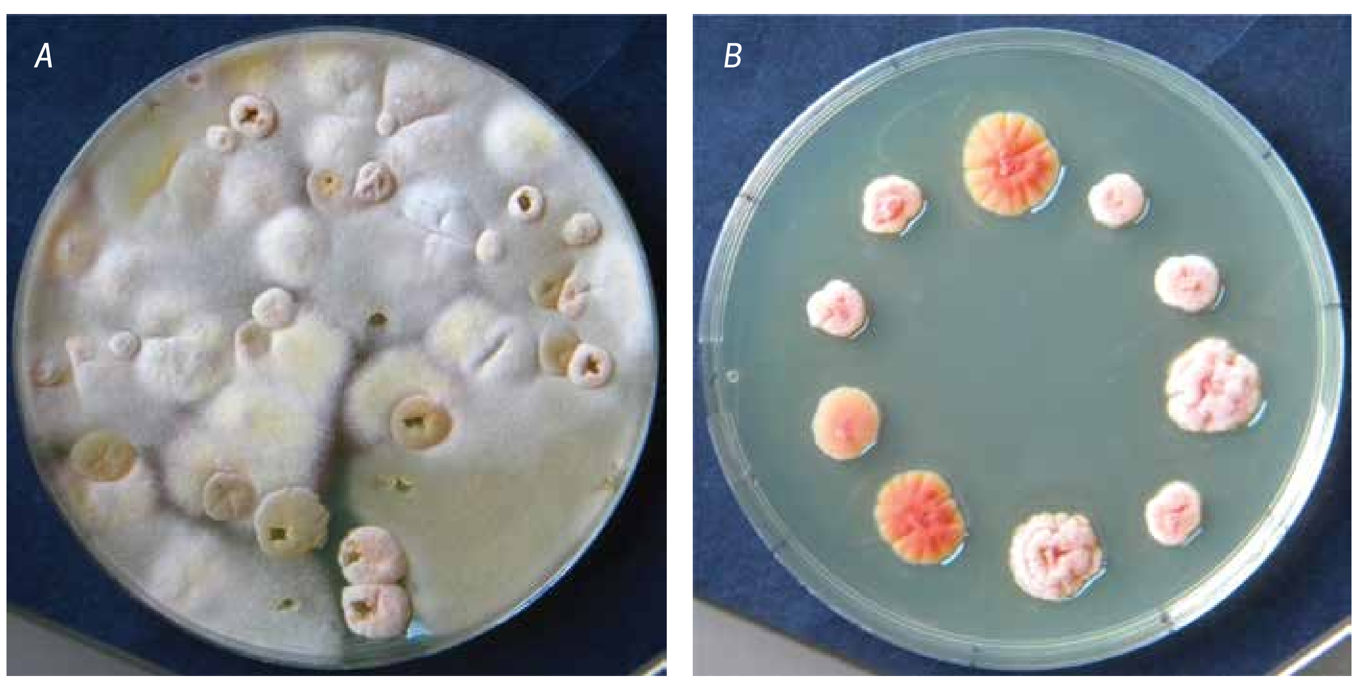
Biochemical Anarchy

With colonies growing in petri dishes, researchers are ready for the next step. At this stage, the fungi share a curious feature: Each colony carries a foreign gene, called "neo," that enables the fungus to detoxify two antibiotics — neomycin and an analog known as "G418." In a petri dish that contains these antibiotics, fungi with the neo gene can do just fine.

The scientists use neo to trick the fungi into making new compounds. They do that by swapping it for the master-switch gene that they discovered in 2013. That gene, known by the scientific shorthand "kmt6," is the same one that Connolly had shown to be responsible for controlling so much of the *Fusarium* genome.

By growing these fungal colonies in the presence of an antibiotic (G418), Freitag's group shows that neo is present and that kmt6 is indeed absent. However, without kmt6, a kind of biochemical anarchy prevails. Thousands of genes that were previously silent are now active, priming the cell's machinery to produce new proteins. And the researchers notice other changes as well. The mutant grows more slowly and exhibits orange, yellow and pink colors.

Analysis of Fusarium graminearum *gene silencing mutants. (A) Progeny from a cross of two strains are grown for 10 days, revealing several types. (B) Three different phenotypes can be distinguished after isolation of types.*



So the next challenge, says Freitag, is to begin sorting out the new order of gene regulation. And to do that, researchers rely on their own secret weapon: ultraviolet (UV) light. They expose the fungal colonies to a dose of UV that breaks DNA in unpredictable ways. To the casual observer, the device that delivers the dose — known as a "UV crosslinker" — looks just like a microwave oven. Unlike standard microwaves, UV damages DNA directly.

The hope is that UV will cause more mutated strains to arise. By comparing them to colonies that had not been exposed to UV, Freitag's team expects to begin unraveling the knot of new proteins and the genes responsible for making them.

"Now that we have this great mutant, we can let it all loose at the same time and find all sorts of new compounds," Freitag explains. "But that's not a scalpel. We really want to figure out which compound comes from which gene. We can mutagenize the fungus, check for better growth or other features and also see what's missing from the cocktail of products produced by kmt6. Then we can figure out where the new mutations occurred and repeat that many, many times."

Commitment

Freitag was surprised when his team discovered the kmt6 master switch, but the new findings show what can happen when students and laboratory scientists rub shoulders. Much of the current work is being done by Xiao Lan Chang and Phuong Pham, two Biochemistry and Biophysics undergraduates mentored by Connolly. Both students receive stipends to work in Freitag's lab.

"The best students are hard workers," Connolly says. "I'm always most impressed if they have a positive attitude, a good work ethic and are academically inclined. That's what we look for. And they do very well." Previous students who worked in Freitag's lab are now pursuing careers in medicine, biotechnology, government labs and academia.

Freitag's research program on the mechanisms of gene regulation is supported by the National Institutes of Health.

FINDING YOUR INNER EINSTEIN

Future Doctors

CORINNE FARGO

Junior in Biochemistry and Biophysics and the University Honors College from Woodinville, Washington

Accomplishment: She is developing standard laboratory *Fusarium* strains that are defective in specific genes. These strains will be used to aid in genetic analyses of *Fusarium* gene silencing mutants.

Career goal: To become a medical doctor

Most important thing she learned: "You have to think 10 steps ahead of your goal. I'm creating complete new genomes. No big deal. It's really exciting and fun."

XIAO LAN CHANG

Senior in Biochemistry and Biophysics from Portland

Accomplishment: Created transformed and mutant *Fusarium* strains in studying proteins that exert control over gene expression.

Career goal: To be a medical doctor

Most important thing she learned: "Retracing your steps and really understanding them. In class, things happen that you expect. In lab, surprises happen and you have to work backwards to figure them out."

PHUONG PHAM

Senior in Biochemistry and Biophysics from Portland

Accomplishment: He is testing the influence of the kmt6 protein complex on gene expression in *Fusarium*.

Career goal: To become a medical doctor and an Army medic

Most important thing he learned: Understanding how gene silencing helps us get new antibiotics and could help cure diseases. "I was very glad to get to work here. This lab helped me through difficult times. Michael is an awesome professor. I can't stress that enough."

A Nuclear Bond

A Polish university partners with Oregon State to build clean-energy capacity

BY LEE SHERMAN

Malwina Gradecka (right) and Izabela Gutowska, Ph.D. students from Warsaw University of Technology, prepare the core block for installation at OSU's High Temperature Test Facility. (Photo: Karl Maasdam)

Soon after the 1986 Chernobyl meltdown in Ukraine, nuclear energy in neighboring Poland ground to a halt. As the disaster and its aftermath fueled fears of fallout around the world, Poland's first nuclear plant, then half-built, was scrapped. For the next three decades, Poland remained wedded to coal.

Now, that's about to change.

In January, Poland revived its nuclear-energy ambitions when the government pledged to build two nuclear reactors, bringing the first one online as soon as 2024. Oregon State University is a partner in realizing Poland's new nuclear energy initiative. Since 2010, OSU's Department of Nuclear Engineering and the Warsaw University of Technology (WUT) have been exchanging faculty, students, computer power and expertise across the continents. A joint-degree program is in the works.

Scaling New Heights

Like an acrobat in a hardhat, a young woman nimbly scales a narrow ladder to the top of OSU's High Temperature Test Facility, an electrically powered reactor model for testing safety without using live nuclear fuel. "We're stacking the core," she explains as she steps out onto the scaffolding two stories above ground. At this construction site, her shiny blue hardhat is mandatory. Mandatory too, are the safety rope and harness she buckles herself into before venturing onto the towering platform where 1,000-pound ceramic plates, or "slices," are being lifted by a crane, one atop another, like a stack of pancakes. When she's not climbing up ladders or balancing on girders, she's driving a forklift, grinding metal rods or operating the crane that hefts the giant, custom-made plates into place.

Harnesses and hardhats are not every student's dream gear. But for Malwina Gradecka, an engineering student from WUT, working on the nuts and bolts of nuclear power was exactly what she was looking for when she first visited OSU with a delegation from her university, known for its deep expertise in mathematical modeling and computational problem solving. So when Gradecka laid eyes on OSU's scale-model, light-water test reactor, she knew Oregon State was the place for her doctoral work. "You can actually stand on top of the model reactor and look down," she marvels in fluent English. "Here in the U.S., students have this opportunity for hands-on experience. In Poland, this is not available to us."

Gradecka is among the first WUT students to earn a Ph.D. in Corvallis. Her studies in OSU's Radiation Center — where she spent a year not only "stacking the core" in professor Brian Woods' one-of-a-kind lab on high-temperature, gas-cooled nuclear technologies but also running computer simulations on fluid dynamics — now are being put to use in Warsaw. She's back home helping to rebuild her university's nuclear engineering program, mothballed in the 1980s along with Poland's half-built reactor.

Poland's historic strength in the field may not be instantly obvious, given its setback after Chernobyl. But it's useful to rewind the story to the late-1800s, when a newfound radioactive element was named for its discoverer's homeland, Poland. That discoverer of polonium — and also radium — grew up in Warsaw as

FINDING YOUR INNER EINSTEIN

Wanted: Strong Work Ethic

You might think the No. 1 quality professors seek in an undergraduate researcher is braininess. Yes, brains matter. But there's another valued trait, perhaps less obvious but at least as important: a strong work ethic. In the labs in Oregon State's Department of Nuclear Engineering and Radiation Health Physics, work ethic is often the deciding factor in hiring research assistants.

Take professor David Hamby, for example. He hired Andrew Child to work on projects funded by the U.S. Nuclear Regulatory Commission and other agencies. "He came to me after his sophomore year asking to work with me, and now I pay him quite well because he has shown what a good work ethic he has — as well as being very bright," says Hamby.

Assistant professor Wade Marcum echoes Hamby. "The students I seek to fill undergraduate research assistantships tend to have sound work ethics," says Marcum, who employs undergraduate students with funding from the Idaho National Laboratory, U.S. Department of Energy and other sponsors. "They are very reliable and provide feedback if they run into issues that may prevent timely progress on a project."

These highly motivated, dependable undergrads do basic science and tackle projects with advanced applications for nuclear energy technology. One of Andrew Child's projects, for example, was to design a "graphical user interface" for the Comprehensive Test Ban Treaty Organization's international data center. "The interface will ultimately display critical information on radiation monitoring systems from around the world," says Hamby.

Marcum's projects on fluid interactions employ students to run computer simulations and conduct experiments on properties such as convection and flow in nuclear power plants. These issues are important unknowns as nuclear technology moves away from active fluid pumping toward natural or "passive" convection.

"Undergraduates who are research assistants become insightfully knowledgeable about the subject they are researching," Marcum says. "They also gain an appreciation of the level of rigor required in a sound research study. Plus, they can better determine whether research aligns with their ambitions as they look ahead to graduate school and employment."

Marie Skłodowska before moving to Paris, marrying a French physicist, and becoming known to the world as Madame Curie. Curie is one of only four scientists ever to win two Nobel prizes. (A second member of that exclusive club is OSU's most famous alumnus, Linus Pauling.) Arguably, the field of nuclear energy was born of Polish DNA.

"Poland has a very rich history in the nuclear sciences," observes OSU's Kathryn Higley, chair of the nuclear engineering department. "After Chernobyl, that expertise emigrated to other places, like the UK. But now the Polish people want to develop their own nuclear energy capacity."

Renewables, Too

In a big white tent on the WUT campus, little kids in parkas and colorful wool hats crowd together in rapt clusters, their eyes barely clearing the display tables where university students demonstrate research projects in cool fields like aerospace. Just across a busy boulevard called Nowoweijska stands the university's Power Engineering School, where two faculty members sit at a small conference table recounting the history of their country's nuclear energy story and positing its future.

Konrad Swirski, the plenipotentiary for nuclear energy at WUT, was one of the last students in Warsaw to earn a Ph.D. in nuclear energy before Chernobyl. From where he sits, he has seen global attitudes about nuclear energy undergo an evolution. In the three decades since Chernobyl, he has seen fossil fuels muscle out radiation as the most cataclysmic threats to life on Earth. Wind, solar and hydropower are essential to a "balanced approach" to energy, he says. But nuclear, too, must be part of the mix.

"There is almost no sun in Poland," he says, gesturing toward the window where thick fog obscures the Warsaw skyline. "The wind is moderate, and we do not have big rivers. Looking toward the future, we have no choice than to diversify our power system and include nuclear power, which is a zero-emission technology."

The European Union, to which Poland belongs, has set ambitious goals for swapping wind, sun and other renewables for heavy CO_2 emitters like coal. Agreement on nuclear, however, has so far eluded the EU. France, for example, is 75 percent nuclear powered, while Germany is quickly phasing out its nuclear plants in reaction to Japan's 2011 Fukushima disaster. Swirski argues that nuclear, while not rated as a renewable in the EU, should indeed count if "zero emissions" is the gold standard. "The Europeans may argue about nuclear and renewables," Swirski says. "But everybody's against coal."

The second faculty member, Jan Alexander Blaszczyk, nods in agreement. The son of a Polish freedom fighter who sought asylum in the United States during the Solidarity movement, Blaszczyk grew up in Madison, Wisconsin. His comfort with America made him a natural to help spearhead the OSU-WUT partnership.

"A huge number of our coal plants are really old," says Blaszczyk, noting that nearly 90 percent of Polish power is coal-generated. "We need to have nuclear power plants as soon as possible."

Oregon State will be along for the transition. terra

Izabela Gutowska attaches a ceramic block to a crane during core installation. (Photo: Karl Maasdam)

"Here in the U.S., students have this opportunity for hands-on experience," says Polish engineering student Malwina Gradecka (right). (Photo: Karl Maasdam)

Konrad Swirski (left), plenipotentiary for nuclear energy at Warsaw University of Technology, and WUT faculty member Jan Alexander Blaszczyk are spearheading the OSU-WUT partnership (Photo: Lee Sherman)

The Oh! Zone • Far-out findings from science

Manufacturing advances will stem from shape-shifting materials, digital design and an energy storage device made from one of nature's most abundant compounds.

The Shining

New industrial materials are activated by light

New types of materials that change their shape when exposed to light could lead to advances in hydrogen storage, solar energy, carbon dioxide capture and other fields critical to the nation's economy. The W. M. Keck Foundation has awarded a $1 million research grant to OSU's School of Mechanical, Industrial, and Manufacturing Engineering and to Ohio University.

"We're excited about the possible applications of these materials," says Brady Gibbons, an associate professor of mechanical engineering. "They can absorb and store hydrogen like a sponge, but also squeeze themselves when light shines on them."

One application is the hydrogen fuel cell, one of the most promising technologies for automobiles of the future. It produces only water as a byproduct when it generates electricity, but hydrogen storage is a primary challenge in meeting auto industry requirements.

Other collaborators include OSU professors Rob Stone, Alex Greaney and Irem Tumer and professor Jeffrey Rack at Ohio University.

Designing Engineers

Rapid prototyping by computer could speed product development

What if the Wright Brothers had tested their flying machine on a computer before launching it on a North Carolina beach? They could have drastically shortened the time from idea to working prototype.

As part of a $320 million U.S. government initiative, researchers in Oregon State's Design Engineering Laboratory will apply the time-saving benefits of computer design and testing to new manufacturing products and processes.

"In design, the idea is to fail early and often, so that we succeed sooner," says Matt Campbell, professor of mechanical engineering and a leader in the initiative. "Our digital tools will predict performance and where failure will occur, and reduce or eliminate the need for costly prototypes. Then we'll use 3-D printers and other tools to automate and streamline actual manufacturing."

Advances have already been made at OSU in failure propagation analysis, verification tools, automated machining and assembly planning.

The initiative is led by UI Labs of Chicago. Industrial partners include General Electric, Rolls-Royce and Microsoft. Through the Oregon State University Advantage program, OSU will continue to apply results with companies such as PCC Structurals, Blount International, Daimler Trucks, Intel and HP.

Bio Boost for Supercapacitors

Cellulose shows promise for energy devices

Oregon State chemists have discovered an inexpensive and rapid process for turning cellulose into the components of supercapacitors. These high-power energy devices have a wide range of industrial applications, from electronics to automobiles.

Cellulose, the primary ingredient in paper, is one of the most abundant organic polymers. By heating it in the presence of ammonia, Xiulei (David) Ji, an assistant professor of chemistry, created an extraordinarily thin carbon membrane. "It's surprising that such a basic reaction was not reported before," says Ji. "Not only are there industrial applications, but this opens a whole new scientific area, studying reducing gas agents for carbon activation."

The high surface area of carbon membranes (three grams can cover a football field) makes them useful in supercapacitors, energy storage devices that can be recharged much faster than a battery. They help power computers and consumer electronics. In industry, they can power anything from a crane to a forklift.

New Treatment for Stubborn Illnesses

Dioxin study leads to new approach for autoimmune diseases

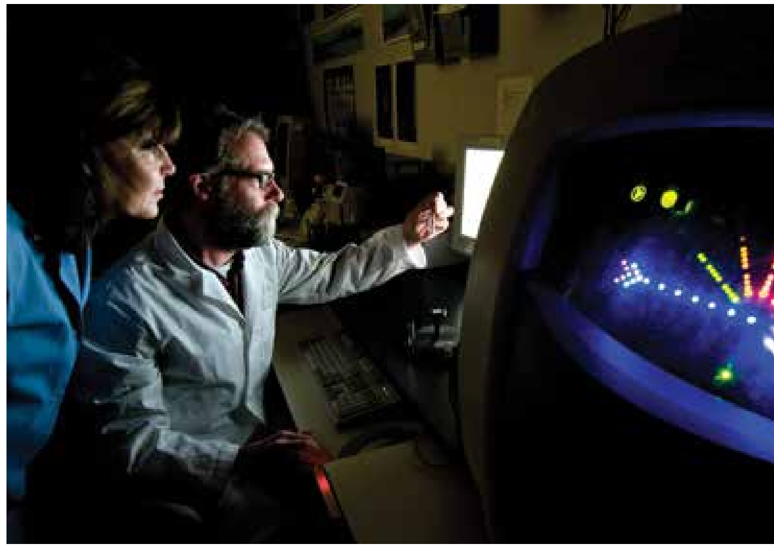
Autoimmune diseases (multiple sclerosis, Lou Gehrig's disease, rheumatoid arthritis and others) have caused suffering and stymied doctors and medical researchers for years. Corticosteroids and other toxic compounds are treatments of choice, but Oregon State scientists have discovered a possibly safer alternative.

Although studies must still be done in humans, the finding could bring hope to people suffering from conditions that occur when a person's immune system attacks his or her body.

Nancy Kerkvliet, Siva Kumar Kolluri and colleagues in OSU's Department of Environmental and Molecular Toxicology tested thousands of chemical compounds. One of them, known as 10-Cl-BBQ, showed the ability to shut down the immune response. The researchers tested 10-Cl-BBQ in mice that had graft-versus-host disease, a condition in which the immune system tries to eliminate foreign cells. The disease can occur in humans when they receive stem cell or bone marrow transplants. The scientists found that daily injections of 10-Cl-BBQ completely suppressed the disease.

At a cellular level, the chemical works like a type of dioxin, a notorious environmental contaminant. "We spent all these years studying dioxin because people have been concerned about its presence in the environment," Kerkvliet says. "Yet, look what we have now discovered from those basic toxicology studies."

The National Institute of Environmental Health Sciences funded the research.



Nancy Kerkvliet, an immunotoxicologist at Oregon State University, and research assistant Sam Bradford use a flow cytometer to analyze cells in their search for chemicals that suppress the immune system. (Photo: Lynn Ketchum).

Honors and Recognitions • Oregon State researchers earn international distinction

JANE LUBCHENCO
Distinguished University Professor, Adviser in Marine Studies, College of Science
AWARD: Frontiers of Knowledge Award in Ecology & Conservation Biology
ORGANIZATION: BBVA Foundation (Spain)

Her research established a scientific framework for defining the optimal locations, size and connectivity of marine reserve networks, effectively integrating her scientific expertise into science-based principles for public policy.

KATHRYN HIGLEY
Professor, College of Engineering
APPOINTMENT: Vice Chair of Committee 5 (Protection of the Environment)
ORGANIZATION: International Commission on Radiological Protection

Higley has studied radiation cleanup activities in the United States and Japan. Her research focuses on radiation dose assessment, neutron activation analysis and the transport of radionuclides in the environment.

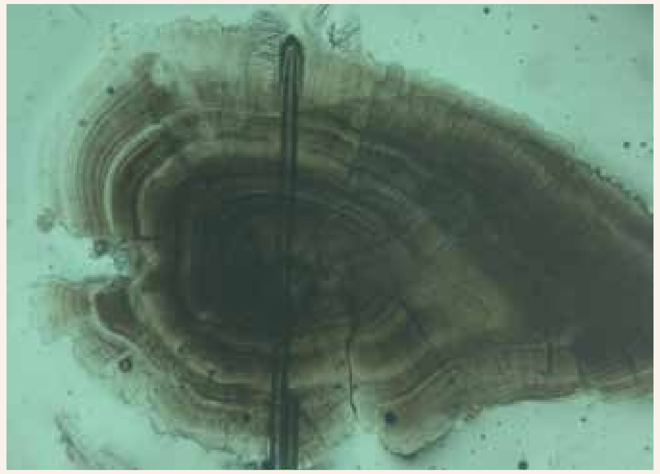
AARON WOLF
Professor, College of Earth, Ocean, and Atmospheric Sciences
AWARD: Il Monito del Giardino (The Warning from the Garden) Award
ORGANIZATION: Bardini and Peyron Monumental Parks Foundation (Italy)

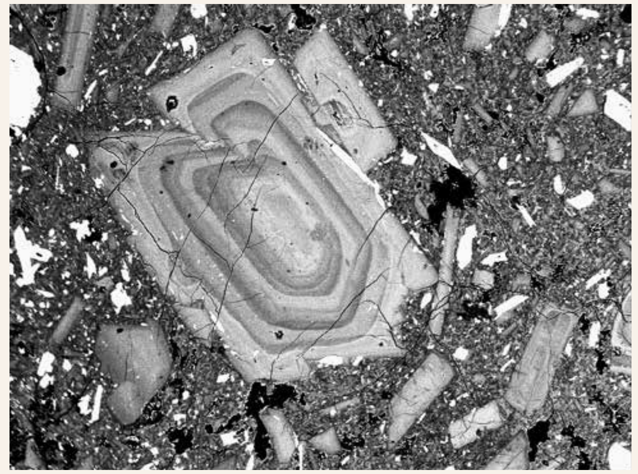
Wolf has traveled worldwide as a scientist and a mediator of water conflicts. He directs OSU's Program in Water Conflict Management and Transformation.

Trial by Fire

Cracking molecules in the W. M. Keck Collaboratory

BY NICK HOUTMAN





Plasma spectrometry enables scientists to analyze chemical composition in the otolith, or ear bone, of a Dolly Varden fish, a salmon relative (left), and a rock crystal from Mount Hood lava. The results reveal details about Dolly Varden migration patterns and volcanic eruptions. (Photos: otolith, Jessica Miller; rock crystal, Adam Kent)

Few places are as hot as 6,000 degrees Centigrade: the surface of the sun, the center of the Earth, the heart of a laboratory device at Oregon State University. In the lab, this is the temperature of a kind of flame produced when argon gas flows through an intense electromagnetic field. Appropriately, the part of the device that holds the flowing gas is called a "torch." As the gas ionizes — as it separates into positively and negatively charged particles — it becomes neither liquid nor solid nor gas. It becomes plasma, the fourth state of matter.

Welcome to the W. M. Keck Collaboratory for Plasma Spectrometry. Researchers from as far away as Estonia and as close as down the hall use the lab's analytical equipment — known in scientific jargon as an inductively coupled plasma mass spectrometer, or ICP-MS — to answer a variety of stubborn questions: Why do nerve cells die in the course of Lou Gehrig's disease? What causes volcanoes to erupt? How does the Earth's climate system operate? Where do fish spend their time as they navigate watersheds and the oceans?

The ICP-MS enables scientists to look for clues in the amounts and proportions of elements that are contained in river water, fish bones, ice cores, nanomaterials and cell cultures. With exquisite precision, the Keck Collaboratory identifies elements both rare (strontium, hafnium) and common (calcium, magnesium, copper) and enables scientists to find chemical patterns — what you might call elemental fingerprints — that point to answers.

DIY Science

As its name implies, the lab is about scientists working together. "We're not a service lab," says manager Andy Ungerer, who came to Oregon State in 1973 to do a master's degree with nuclear chemist Walter Loveland. "There are places where you can send samples, and they'll send back a spreadsheet. From the beginning, we've felt it is important for users to learn as much about the equipment as they could. You can only do that by running the samples yourself."

Ungerer and Gary Klinkhammer, emeritus professor and Keck lab founder, took this DIY approach when they received funding from the National Science Foundation (NSF) to install their first ICP-MS in 1992. With grants from the Keck Foundation in 2000 and from the NSF in 2011, the lab added more powerful mass spectrometers, the machines that separate and measure elements.

The analytical process can start when a liquid sample is sprayed into the torch. Or it can begin with a solid material, such as the fish otolith or rock crystal above. Scientists fire a laser beam at the material, and the collision sends molecules into the torch on a current of helium gas.

As molecules break apart in the plasma, the elements that comprise them are extracted and sent into a mass spectrometer that separates them by mass and ionic charge. Another device, an emission spectrometer, can add additional data based on the light emitted by the elements.

Plasma spectrometry is so sensitive that it can find one atom in a trillion — the equivalent of a drop of water in an Olympic swimming pool.

Over the last four years, more than 120 scientists and 50 Oregon State graduate students have used the lab for their research.

Cows Show Stress

Simulated wolf attacks produce trauma

The "ecology of fear" isn't limited to wild animals. Livestock that have encountered wolves experience stress that may affect their health and productivity.

In experiments at Oregon State's Eastern Oregon Agricultural Research Center (EOARC) in Burns, cows were exposed to the sounds of howling wolves and to German shepherds prowling outside an enclosure. Those cows that had previously encountered wolves on the range showed higher levels of stress than those that had not had such encounters.

"When wolves kill or injure livestock, ranchers can document the financial loss," says Reinaldo Cooke, an animal scientist in OSU's College of Agricultural Sciences. "But wolf attacks also create bad memories in the herd and cause a stress response known to result in decreased pregnancy rates, lighter calves and a greater likelihood of getting sick. It's much like post-traumatic stress disorder – PTSD – for cows."

David Bohnert, an expert in animal nutrition at the EOARC, says that stress affects ranchers' bottom line. "In a herd, if you are not raising calves, your cows are not making you money," he says. "A wolf attack can have negative financial ripple effects for some time." (For more on livestock well-being, see "Caring for Cows," *Terra*, winter 2013.)

Spirituality, Religion and Health

Benefits reflect prayer, meditation, church attendance

Religious practices and spiritual behaviors have distinct but complementary health benefits. That was the conclusion of a study led by Carolyn Aldwin, professor in the College of Public Health and Human Sciences. She and her colleagues (Crystal Park of the University of Connecticut and Yu-Jin Jeong and Ritwik Nath of OSU) reviewed previously published reports and evaluated evidence in the scientific literature.

Religiousness, including formal religious affiliation and service attendance, is associated with lower smoking rates and reduced alcohol consumption. Spirituality, including meditation and private prayer, helps regulate emotions, which aids physiological effects such as blood pressure.

"No one has ever reviewed all of the different models of how religion affects health. We're trying to impose a structure on a very messy field," says Aldwin, the Jo Anne Leonard endowed director of OSU's Center for Healthy Aging Research.

The John Templeton Foundation supported the research. (For more on Aldwin's research, see "The Stress Paradox," *Terra*, winter 2010.)

Wristbands for Health

Citizen scientists can propose projects

Pollutants can be undetectable to our senses, but an Oregon State researcher has come up with a simple way to monitor chemicals in the environment. A team led by Kim Anderson, professor in the College of Agricultural Sciences, has created a silicone wristband that absorbs chemicals in the air 24/7.

"The wristbands show us the broad range of chemicals we encounter but often don't know about and may be harming us," says Anderson. "Eventually, these bracelets may help us link possible health effects to chemicals in our environment."

In a recent study with 30 volunteers at Oregon State, wristbands picked up nearly 50 compounds, including flame retardants, pesticides and pet flea medicines as well as personal care products.

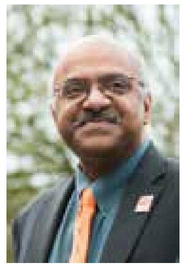
Anderson's lab is using the wristbands in a New York City study with pregnant women to measure chemical exposure in their last trimester and how that affects their children after birth.

Citizen scientists can propose projects to Anderson's lab at citizen.science.oregonstate.edu. (For more on Anderson's research, see "Down to the Gulf," *Terra*, winter 2011.)

Big Data Crunch

The demand for data analysts is exploding

BY SASTRY G. PANTULA, DEAN, COLLEGE OF SCIENCE



1.9 billion. That's the number of results turned up by a Google search on the term "big data."

However you measure it — in gigabytes, search results or truckloads — the data deluge is growing every minute. It comes at us nonstop in statistics, pictures, texts, videos, tweets, clicks and posts. Understanding what big data is, how it is transforming the world and what to do with it is essential for tomorrow's leaders. Those with expertise in analyzing large datasets will drive advances in productivity, innovation and global collaboration.

So what exactly is big data? The more accurate term might be "bigger data." We've been analyzing data for years. It's the speed, variety and volume that are novel. In our digital world, data are no longer contained in databases. They're generated instantly every time we make a purchase, click "like" on Facebook or make a phone call.

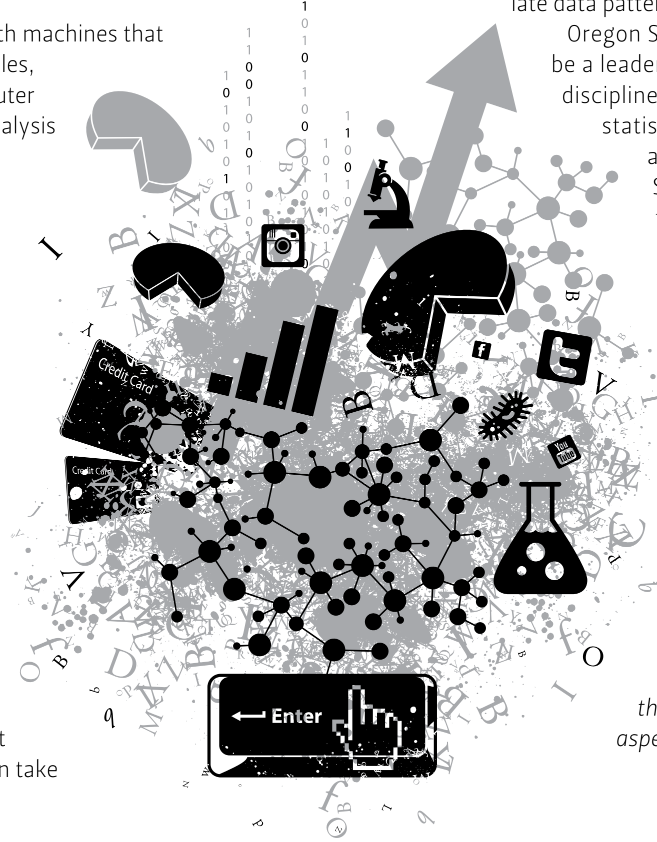
Researchers generate data with machines that sequence genes, analyze molecules, observe the Earth and run computer models. At Oregon State, data analysis yields insights into subjects from the environment and human health to the humanities and manufacturing.

I recently talked about the implications of big data with University Honors College students. They debated whether big data was good or bad but came to realize that it is not so clear cut. They were outraged at how business schools cheat by massaging data to improve rankings and by how companies buy and manipulate extensive personal data on their customers.

Students see that statistical analysis of big data can be like a knife. In the hands of a crook, it can be used to rob a bank or even take a life. In the hands of a surgeon, it can save a life. To maintain trust and integrity in science, we need to avoid the distortions that stem from unethical uses of data and separate the data "crooks" from the data scientists.

The sheer volume of big data is overwhelming. It is absolutely useless unless we convert it into practical knowledge in a timely fashion. A recent Bain & Company report of 400 large companies revealed that those that had already adopted an advanced data-analytics approach are outperforming competitors by wide margins. Proper uses of big data are helping to discover new drugs, mentor students, provide better services, help farmers, develop better public policies and advance security and sustainability.

What's next? People who can apply value and meaning to real-time data are in increasingly high demand. Tomorrow's leaders will need to analyze large datasets to generate insights and to apply them to predict behavior, trends and patterns. A recent McKinsey & Company study predicted a workforce gap of 1.5 million managers and analysts with the skills to decipher and translate data patterns for decision-making.



Oregon State University is well-positioned to be a leader in data science by blending diverse disciplines, including applied mathematics, statistics, computer science, genomics and business. And the College of Science is committed to preparing the next generation of leaders in data science and to creating a statistically literate public.

Editor's note: Before becoming dean of the Oregon State College of Science in 2013, Sastry Pantula served in leadership roles at the American Statistical Association and at the National Science Foundation. He contributed to the International Year of Statistics 2013 and is on the steering committee of its successor, the World of Statistics. It aims to increase public awareness of the power and impact of statistics on all aspects of society.

THE OREGON STATE UNIVERSITY ADVANTAGE

Connects business with faculty expertise, student talent and world-class facilities, and helps bring ideas to market and launch companies.

Active Ingredients

Chemists collaborate to form Valliscor

A good recipe depends on high-quality ingredients. That's as true in industry (electronics, food products, chemical manufacturing) as it is in our kitchens. So when two Willamette Valley chemists developed methods for producing industrial chemicals with exceptional purity, they saw a business opportunity. The result is a new company: Valliscor.

Co-founded in 2012 by Rich G. Carter, professor and chair of the Oregon State University Department of Chemistry, and industrial chemist Michael Standen, Valliscor produces organic building blocks for the pharmaceutical, electronics and biotech sectors. Its first product is a compound known as bromofluoromethane (BFM). BFM is a critical ingredient in the synthesis of fluticasone propionate, the active component in two popular medications: Flonase, a nasal spray; and Advair, an asthma inhaler.

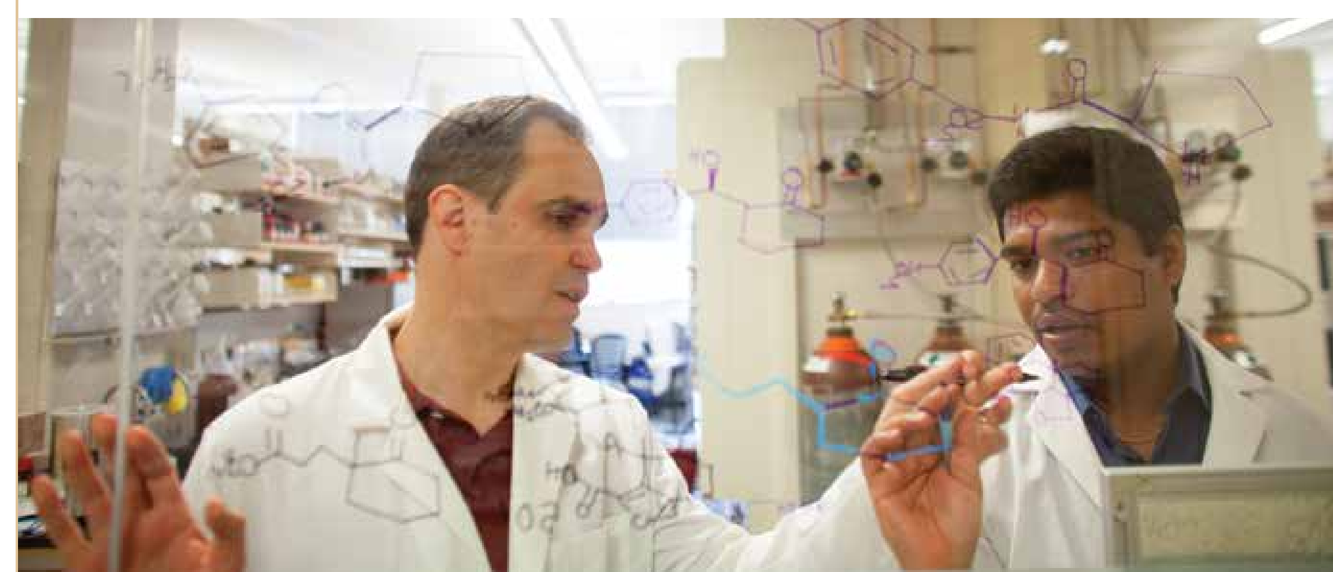
"The company was created to exploit the synergy between industrial know-how and academic innovation," says Carter. "Valliscor harnesses licensed technology from Oregon State and from industrial partners to provide unique and cost-effective solutions for producing high-value chemicals. We can provide ultra-high purity materials that are superior to those offered by our competitors."

Before founding Valliscor, Carter and Standen had collaborated on numerous projects over the past 10 years, including the commercialization of an "organocatalyst" called Hua Cat, an advance in environmentally friendly chemical manufacturing.

The OSU Research Office and the Advantage Accelerator program have been key to the company's growth, Carter adds. "We've had great mentorship and guidance from the Advantage Accelerator leadership: Mark Lieberman, John Turner and Betty Nickerson. When we get stuck on a problem, they are just a phone call away."

The Oregon Nanoscience and Microtechnologies Institute (ONAMI) supported the company in 2012 with proof-of-concept funding and guidance from commercialization specialists Jay Lindquist and Michael Tippie and from Skip Rung, ONAMI executive director.

Oregon State Professor Rich G. Carter, left, co-founder and CEO of Valliscor LLC, confers with Rajinikanth Lingampally, research associate at OSU. (Photo: Chris Becerra)



To discover what the **Oregon State University Advantage** and the **Advantage Accelerator program** can do for your business, contact Ron Adams, Executive Associate Vice President for Research, 541-737-7722. **oregonstate.edu/advantage**

Terra
416 Kerr Administration Building
Oregon State University
Corvallis, OR 97331

NON-PROFIT ORG
US POSTAGE
PAID
CORVALLIS OR
PERMIT NO. 200

Alexandra Davis, a Ph.D. student in Mark Hixon's lab, conducts a fish survey off Cape Eleuthera in the Bahamas in the summer of 2013. (Photo: Lillian Tuttle)