terra

A world of research & creativity at Oregon State University · Fall 2012

THE ETHIC OF CARE

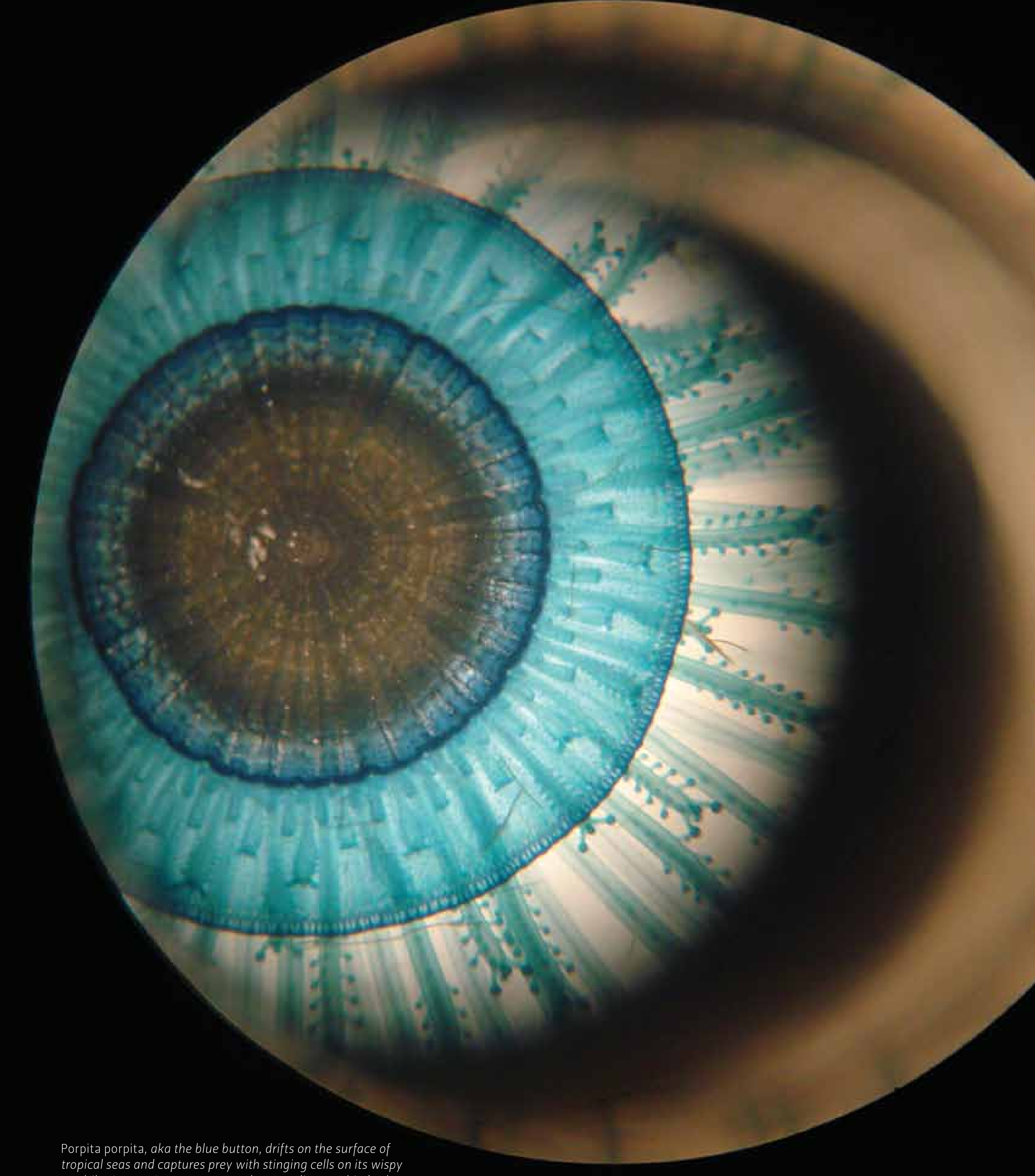
Scientists adhere to rigorous practices for research animals

terra

Volume 8 Number 1 // oregonstate.edu/terra // Fall 2012
Oregon's leading public research university

FEATURES

DEPARTMENTS



Porpita porpita, *aka the blue button, drifts on the surface of tropical seas and captures prey with stinging cells on its wispy tendrils. Oregon State oceanographer Angelicque White's photos of this and other plankton inspired Oregon artists who presented their work at The Arts Center in Corvallis.* *See "Forms from the Sea," Page 20.*

Oregon State is Oregon's leading public research university with more than $281 million in research funding in FY2012. Classified by the Carnegie Foundation for the Advancement of Teaching in its top category (very high research activity), OSU 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.

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Oregon State UNIVERSITY

TOUGH STORIES

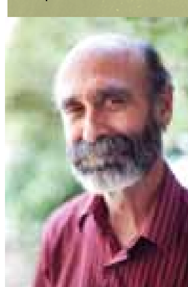
Some stories are harder to tell than others, but a magazine about university research has a duty to not shy away from the tough ones. Some topics invite debate because the public that pays for the work is divided. Nuclear power comes to mind. So do population growth and immigration. Telling these stories requires soul-searching and sensitivity on the part of writers, editors and designers. In this and the next two issues, we tackle another one: the use of animals in research.

Oregon State University doesn't use primates in research, a practice that has engendered controversy when cases of inhumane treatment and needless suffering have surfaced elsewhere (read Deborah Blum's classic *The Monkey Wars*). But Oregon State scientists use mice, rats, fish, snakes, horses, dogs and cows — about 400 species in all to study the complexities of biological processes. *Terra* has written about such work in the past: mice and bone development; dogs and cancer; wild horses and reproduction; zebrafish and embryonic development.

It's no exaggeration to note that millions of human lives have been saved by research based on animals. Polio vaccines and stroke treatments were developed through tests on monkeys. Insulin was discovered through work on dogs. At Oregon State, scientists have learned about immune system function through work on mice. Others have used zebrafish to demonstrate a connection between animal behavior and BPA, a chemical used in cans and plastic bottles.

Animals also benefit from the knowledge gained. Treatments for feline leukemia have arisen from work on HIV/AIDS. Surgical research has contributed to hip and heart-valve replacements for dogs.

No one is happy about having to euthanize animals, even for the greater good. Scientists are understandably nervous about public reaction to animal research, but in our experience, they are also highly committed to caring for the animals in their charge, making sure that the animals' health and social welfare are maintained to the highest standards. Oregon State's recent national accreditation for its practices in animal care underscores that commitment.

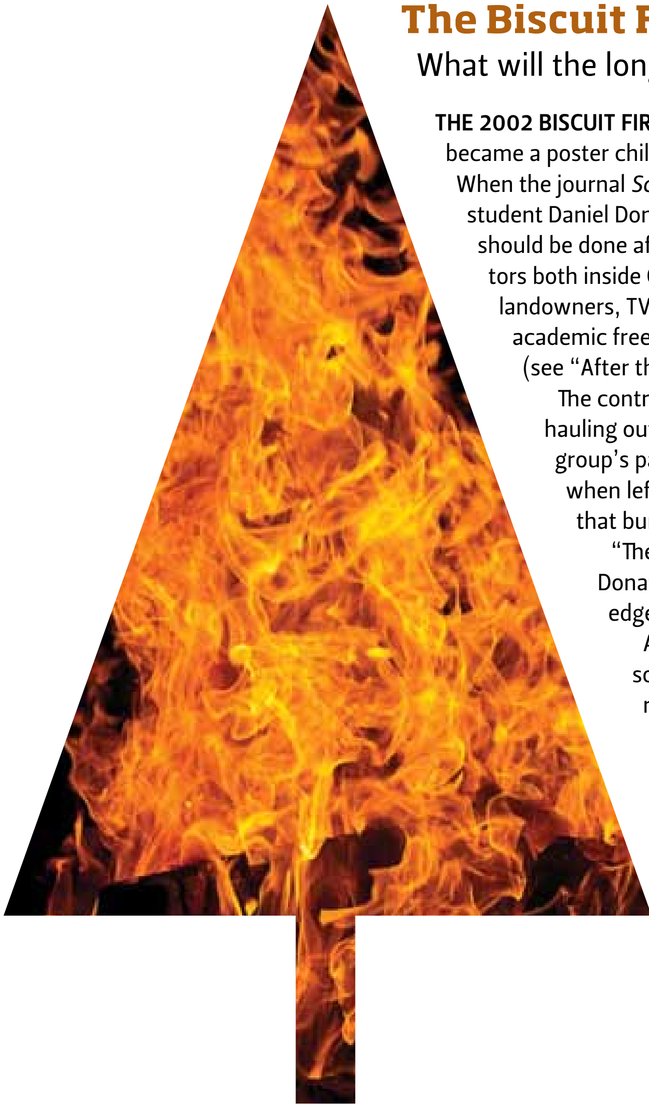


Nick Houtman

Editor

The Biscuit Fire 10 Years Later

What will the long-term data show?



THE 2002 BISCUIT FIRE not only torched a half-million acres in Southern Oregon, it became a poster child for the debate over post-fire management and forest recovery. When the journal *Science* accepted a paper on the fire's aftermath by then-graduate student Daniel Donato, it ignited a long-smoldering debate over what, if anything, should be done after fire scorches western forests. Stakeholders and commentators both inside OSU and beyond — scientists, lawmakers, local officials, loggers, landowners, TV crews and newspaper reporters — weighed in on both ecology and academic freedom as the debate swirled around the Donato group's work in 2006 (see "After the Fire," *Terra*, Summer 2006.)

The controversy centered on salvage logging — the longtime practice of hauling out dead trees to use in lumber or other wood products. The Donato group's paper suggested that burned-out stands might come back as strong when left alone to reseed naturally — a blow to the conventional wisdom that burnt forests regenerate best when logged and replanted.

"The Biscuit Fire has yielded several ecological surprises so far," says Donato. "It ranks near the 1988 Yellowstone fires in expanding our knowledge of post-fire vegetation succession."

A decade of new growth in the once-ravaged Siskiyou National Forest soon will generate more knowledge. Donato, now a post-doctoral researcher at Oregon State, is leading a follow-up study with funding from the Joint Fire Sciences Program (U.S. departments of Agriculture and Interior). The new study will look at the rates and patterns of post-fire vegetation growth, the effects of post-fire logging and the impact of subsequent burns.

"Large-scale fires are expected to become increasingly common throughout North America," Donato notes. "We need long-term, scientific data to inform post-fire management options and outcomes."

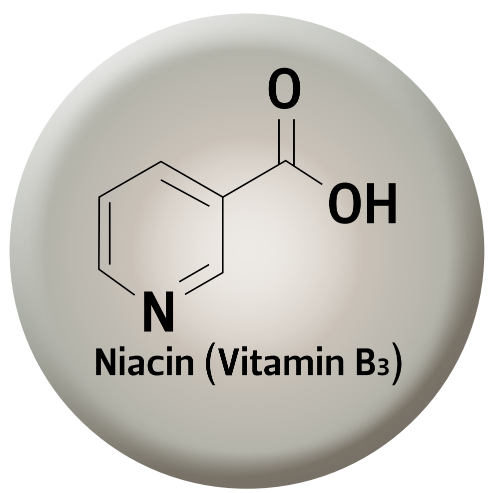
Staph Attack

Vitamin therapy shows promise in treating "superbug"

DEADLY STAPH INFECTIONS may have a potent new foe: Vitamin B3. Megadoses of the vitamin can help the immune system fight the superbug MRSA (methicillin-resistant *Staphylococcus aureus*), researchers at Cedars-Sinai Medical Center, OSU's Linus Pauling Institute and other institutions have found.

The findings could lead to new treatment options for health officials who have seen rates of bacterial skin infections spike in hospitals and nursing homes. In recent years, MRSA has made aggressive forays into the wider community as well, turning up in daycares, military barracks, gyms and other places where people have skin-to-skin contact.

"This is potentially very significant," says Oregon State researcher Adrian Gombart. "Antibiotics are wonder drugs, but they face increasing problems with resistance by various types of bacteria, especially *S. aureus*." However, Gombart warns against taking high doses of the vitamin, noting that the findings haven't yet been tested in humans.



The Oh! Zone • Far-out findings from science

NASA's quest for signs of life on Mars got a huge boost in August when Curiosity landed on the Red Planet. Oregon State University geologists, oceanographers and computer modelers are contributing to the mission.

A Home for Microbes?

Soil science on the Red Planet

WHEN MARTIN FISK TALKS about "looking at the scenery," he's not talking about the views from Cape Perpetua or Marys Peak. He's talking about surveying the terrain on Mars.

The Oregon State marine geologist is part of a NASA research team viewing the Martian landscape through the camera lens aboard Curiosity, the rover that landed on the remote planet in August. Examining the photos being sent back to Earth, Fisk and his colleagues are looking for signs that Mars may once have been (or may still be) habitable. They will design daily experiments for Curiosity to carry out with its array of equipment, including a mass spectrometer that can analyze soil samples collected by the rover's robotic arm.

Fisk already has discovered life in seemingly inhospitable places. In 1998, he and his team found evidence of rock-eating microbes living a mile beneath the ocean floor. If the basic elements of life are present (carbon, phosphorous and nitrogen), only water is needed. "Under those conditions," says Fisk, "microbes could live beneath any rocky planet."

Light Wind and a Balmy Minus 10

Mars lander had help from Oregon State scientists

LANDING A SPACECRAFT ON MARS may have little in common with basic aviation. But in one respect, at least, they're alike — their dependence on weather.

As any frequent flyer knows, even the most sophisticated aircraft is subject to changes in the atmosphere. So when NASA began planning explorations on Mars, the agency needed not only rocket scientists and engineers, but also experts in the Martian atmosphere.

Enter Oregon State's Jeffrey Barnes and Dan Tyler, researchers in the College of Earth, Ocean, and Atmospheric Sciences. Their computer model uses detailed calculations to predict winds, temperatures and atmospheric density on the Red Planet — factors that were critical to the safe landing of the rover Curiosity this summer.

On August 6, temperatures ranged from a frigid minus 110 to a slightly less frigid minus 10 degrees Fahrenheit at the landing site. Winds blew at 10 mph near the surface. But it was dust that most worried the scientists.

"If the orbiter observes a dust storm forming near Gale Crater, there could be last-minute modifications to the onboard program," Tyler said a few days before the touchdown. But no dust came, and the rover landed to raucous cheers in the NASA control room. Curiosity is roving. Hear Tyler interviewed on Oregon Public Broadcasting's "Think Out Loud," http://www.opb.org/thinkoutloud/shows/mars-landing/

Mars on Earth

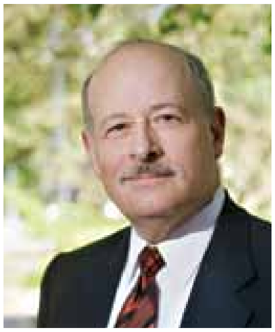
Argentina provides geologists with Martian analog

WHERE DO YOU GO when you want to study the wind-driven landforms of Mars? To South America, of course.

In Argentina's Puna region, Oregon State geologist Shan de Silva and a team of other researchers are looking for processes that parallel forces shaping the Red Planet. On the Puna Plateau, with its cold, dry, super-windy atmosphere, coarse gravel beds have been sculpted into vast, dune-like formations called "mega-ripples." How, exactly, did the region's howling winds shape those unique bedforms? With NASA funding, de Silva and colleagues at Johns Hopkins University and the Smithsonian Institution have been working with researchers in Argentina to find out. Field investigations of the mega-ripples and sediment sampling for laboratory analysis are being combined with wind-tunnel experiments.

The discoveries could deepen scientists' understanding of our most intriguing celestial neighbor. That's because the Argentine gravels, whose weights are equivalent to those at Meridiani Planum on Mars, make Puna a promising analog. Topography and bedrock at Puna are similar to the Red Planet's, as well.

"This science has direct relevance to the Mars Exploration Program that seeks to 'understand whether Mars was, is, or can be a habitable world,'" says de Silva. "In particular, it impacts Goal 3 — to understand 'how the relative roles of wind, water, volcanism, tectonics, cratering, and other processes have acted to modify the Martian surface.'"



Spinrad to Lead Ocean-Observing Group

Committee advises federal policymakers

OREGON STATE'S VICE PRESIDENT for research, Rick Spinrad, has been tapped to chair a federal committee on ocean observing systems. The 13 marine scientists, conservationists and industry stakeholders will advise the Integrated Ocean Observation System (IOOS), as well as the National Oceanic and Atmospheric Administration (NOAA), on data collection, management and technological innovation.

As a former research leader at NOAA and the U.S. Navy, Spinrad brings a unique perspective to the task. In addition, OSU's central role in the $386 million Ocean Observing Initiative funded by the National Science Foundation puts him on the frontlines of the mission. A fleet of undersea gliders and an array of moored observation platforms are being deployed by the College of Earth, Ocean, and Atmospheric Sciences.

"Most people are familiar with the value of weather observations — radar, rain gauges, and so on — in improving forecasts," Spinrad notes. "We have a need for a similarly robust set of ocean observations to support a broad range of needs including fisheries, shipping and transportation, national security and protection from natural hazards. This committee is a major step toward focusing federal efforts toward this goal."

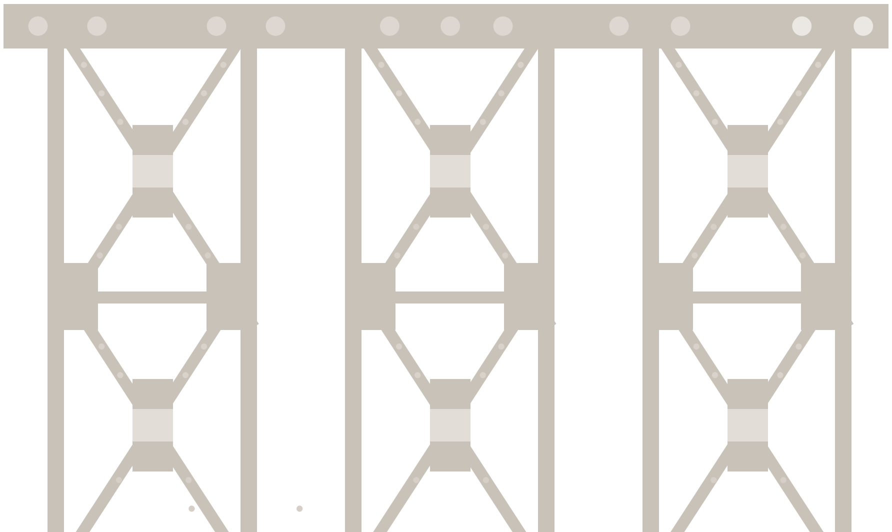
Eco-roofs and Earthquakes

Research will guide new structural standards

GROWING GREENERY ON ROOFS brings many benefits. Buildings stay cooler, saving energy. Roofs last longer, saving money and materials. Birds and insects find new habitat, helping ecosystems. And green roofs make urban spaces more aesthetically and spiritually pleasing, as well as reducing heat-island effects for city dwellers.

But there are some costs that need to be considered, too. "Eco-roofs carry higher gravity loads and must support more moisture for longer periods than traditional roofs," says Oregon State structural engineer Chris Higgins. "That changes the probabilities that need to be considered during design. In order to extract all the benefits of eco-roofs, we need to ensure their structural safety. That requires research."

One big question: Are green roofs safe during earthquakes? Led by Higgins, engineers in the School of Civil and Construction Engineering at OSU are undertaking the first comprehensive study of the seismic performance of eco-roofs with funding from the National Science Foundation. Using a full-scale simulated eco-roof, they will investigate drainage characteristics, load distribution of water-saturated soils, long-term service performance and the behavior of different planting materials during lateral shaking. Their findings will guide the development of standards for eco-roofs in seismic zones.



Bits & Pieces

News briefs from OSU

SEWER POWER. What's the next big thing in clean energy? Sewage wattage, predicts biological engineer Hong Liu. Her super-efficient microbial fuel cells — which generate electricity from waste-eating microbes — could revolutionize sewage treatment plants, making them energy producers instead of energy consumers. Someday, flushing a toilet could turn on a light.

CLASS ACTIONS. A tank full of fish or frogs might make for a lively science lesson. But what happens to the animals after class? Turns out, many get released into the wild by well-meaning teachers, says Sam Chan of Sea Grant Extension. Teachers need to know that such species as crayfish from Louisiana or red-eared sliders from Texas are invaders in Northwest ecosystems, Chan says.

FUTURE FERTILITY. Obese kids can add a new risk to their health challenges: problems reproducing in adulthood. Early puberty, common in obese children, can disrupt hormones and lead to reproductive cancers, diabetes, depression and infertility, says endocrinologist Patrick Chapell.

HOT AND HOTTER. As dry as North America has been, it's likely to get even drier. The chronic drought that singed the continent during the early 2000s may be the "new normal," says Beverly Law, who specializes in global-change biology. In fact, she says, we may look back on this period as the "wet old days" as climate change drives the thermometer ever higher.

After Fukushima

Nuclear power's future remains strong

BY KATHRYN HIGLEY, CHAIR, DEPARTMENT OF NUCLEAR ENGINEERING AND RADIATION HEALTH PHYSICS

AS CONCERN ABOUT CLIMATE CHANGE has grown, nuclear energy — long a polarizing subject — has gained increasing favorability. Its low carbon footprint, reliable power supply and strong safety record convinced many critics that nuclear power should be a bigger part of our energy mix.

That newfound favorability suffered a setback on March 11, 2011, when an earthquake struck off the coast of Japan. The resulting tsunami damaged the backup systems essential to the safe shutdown of the Fukushima Dai-ichi nuclear power station. Over the next several weeks, as the Japanese people struggled to limit the extent of the damage, a slow-motion accident unfolded. While the world watched, radioactive cesium, iodine and other nuclides were released to the air and surrounding ocean.

Suddenly, the nuclear power renaissance seemed very much in doubt.

For more than 50 years, Oregon State's Department of Nuclear Engineering and Radiation Health Physics (NERHP) has been engaged in nuclear power plant design and safety research. Lately, our department has been in the spotlight because of our focus on creating safer and simpler nuclear technology, such as the NuScale small modular reactor. But Fukushima brought attention to a lesser-known competence at OSU: radioecology.

Oregon State is one of the last U.S. academic institutions actively doing research in this unique, interdisciplinary field, which focuses on the movement of radioactive nuclides and their impact on humans and the environment. We travel to places like Johnston Atoll in the Pacific to evaluate radiological risk and find strategies to clean up Cold War-era contamination. We study radionuclide uptake by plants and animals — findings that have been incorporated into environmental protection standards for the U.S. Department of Energy, as well as guidance by the International Atomic Energy Agency and the International Commission on Radiological Protection.

After Fukushima, we answered hundreds of calls from the public and media. In June 2011, we participated in a Woods Hole Institution expedition to the Fukushima coast on the research vessel Ka'imikai-O-Kanaloa with funding from the Gordon and Betty Moore Foundation and the National Science Foundation. We designed and built a radiological sampling system for seawater and helped collect and analyze marine organisms for contamination. We studied mechanisms of radiological contamination of tea plants in Japan. With Corvallis-based Earthfort, we tested the company's proprietary compound for reducing the movement of radiocesium in soils in hopes that it might be used in Japan. And we joined the OSU Marine Council Action Coordination Team dealing with marine debris arriving on our coastline.

Our research has helped put Fukushima in perspective. The tragic accident caused a slowdown in nuclear power development worldwide. But today, scientists are reasonably confident that the radiation will have no measurable public health effects. And the best reasons for pursuing this energy technology remain: reliable power with minimal carbon emissions.

We will remain on the frontlines of reactor safety, radioecology and environmental protection. We will continue to advocate for more research and public education in radiation sciences so that as a society we can make informed choices about our energy mix.

Drug Test

Chemists' prototype fingers fake medicines

BY NICK HOUTMAN

IN 2005, A 23-YEAR-OLD MAN went to a rural Burmese hospital complaining of fever. The malaria diagnosis wasn't surprising. The disease is common in his district, but recent drug therapies have reduced death rates dramatically. The man took the prescribed medicine, artesunate supposedly made by Guilin Pharmaceutical in China. Doctors expected a full recovery.

Three days later, the patient went into a coma. Despite transfers to two other hospitals and injections of intravenous fluids and more artesunate, he died of cerebral malaria.

Analysis of the drug provided by the first hospital showed that it was a fake. Guilin makes authentic medications, but the active ingredient in the hospital's supply was acetaminophen. A small amount of artesunate was present, about 20 percent of a normal dose, enough to fool a simple test.

By some estimates, a third to half of the artesunate in some countries is counterfeit. The World Health Organization has called for faster, more accurate tests, and now a team of Oregon State University chemists has stepped up with an innovative approach. They have created an inexpensive paper-based assay that detects a range of artesunate concentrations by turning shades of yellow in the presence of the drug. In OSU's new Linus Pauling Science Center, this international team of scientists and students is also developing an affordable diagnostic device that can work with the paper test to pinpoint the amount of an active ingredient in a sample.

"We're trying to develop a simple, rapid and inexpensive method to detect these counterfeits," says Myra Koesdjojo, who received her Ph.D. in chemistry from Oregon State in 2009 and now manages OSU professor Vince Remcho's lab. The native of Indonesia knows what's at stake. Members of her family have had malaria, a disease that kills as many as 900,000 people a year, most of them children in Africa and south Asia.

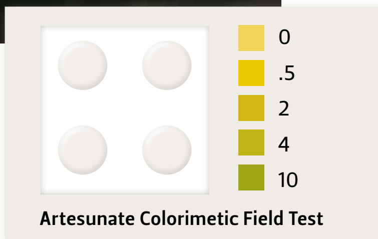
Fake drugs not only allow patients to die, they also promote antibiotic resistance. By exposing pathogens to ineffective doses of pharmaceuticals, counterfeits enable disease-causing germs to survive and spread, hastening the day when they can outwit front-line drugs.

Koesdjojo and her team envision a portable testing device the size of a cell phone. Health professionals would be able to test batches of drugs quickly and cheaply. The OSU researchers have already built a prototype using off-the-shelf electrical components and open-source software. In their plans is development of an iPhone app.

"We tried a color sensor with an existing iPhone app," says Koesdjojo. "It works pretty well. But it's not built for this purpose. We want to use the same idea and develop our own app."

The team has even greater ambitions: inexpensive, portable devices to detect environmental pollutants and blood-borne diseases. Koesdjojo says her brother would have benefitted. When he came down with malaria, doctors also treated him for dengue fever because the symptoms are similar and they were unable to perform a more precise test.

"Having these simple tools," she says, "will eliminate the guessing and enable doctors to treat for the right disease."



The real thing — or a fake? Oregon State chemists built this prototype (above) to separate authentic drugs from counterfeits. It precisely measures color on the paper-based test, right.

International Research Team

Koesdjojo's team includes students from Oregon and Asia

- **JAMY LEE**, a sophomore in chemistry from Tigard who received an OSU research grant to work in Koesdjojo's lab last summer
- **MICHAEL NEILSON**, a sophomore from Corvallis in physics
- **CHADD ARMSTRONG**, a senior in chemistry from Oregon who received scholarship support from a fund established by OSU alumna Gretchen Schuette (Ph.D., oceanography, '80)
- **ANUKUL BOONLOED (TONY)**, a Ph.D. student from Thailand who has received support from the Thai government for his research. He is helping to develop a collaboration with Chiang Mai University in Thailand.
- **YUANYUAN WU**, a Ph.D. student student from Dalian, China.

High school student

- **PARKS REMCHO**, Corvallis

"All who care for, use, or produce animals for research, testing or teaching must assume responsibility for their well-being."

The Ethic of Care

Respect for animals guides their treatment in teaching and research

BY LEE SHERMAN | PHOTOS BY FRANK MILLER

Rats receive pellets supplemented with cancer-fighting compounds.

National Research Council, *Guide for the Care and Use of Laboratory Animals*, 2011

The three rats snoozing in Cage 57 don't know it, but they could someday help save thousands of human lives.

Snuggled in their EcoFresh bedding, the rodents are digesting a meal that may hold clues to preventing colon cancer, the second-leading cause of cancer deaths in the United States. On their cage, equipped with HEPA air-purification filters and precision temperature controls, hangs a blue index card labeled "Special Diet," on which a researcher has scrawled "Bruss" in black felt pen. The scrawl is short for Brussels sprouts, those oft-disparaged veggies resembling tiny cabbages that are loaded with promising cancer-prevention compounds such as sulphoraphane.

To the rats, however, the pale-green pellets in their food tray (Mix AIN93 from Research Diets Inc., with sprouts added) are just dinner. That dichotomy — the rats' bodily, mental and social needs (rodents are housed with "buddies" for company and "crawl tunnels" for enrichment) versus the precise methods of science — requires researchers to walk a tightrope, always balancing the pressing questions of medicine, for example, against the welfare of animals. The results are key to curing devastating diseases like ALS or Alzheimer's.

Oregon State University, with 600,000 research and teaching animals (mostly fish and other aquatic species) at 30-plus sites across the state, is balancing those interests exceedingly well. That is the judgment of the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC), which in March gave a glowing report after an extensive accreditation study (see "High Grades for Animal Care," Page 10). Oregon State is the 19th among the nation's 71 land grant universities to earn full-campus AAALAC accreditation.

The snow-white, sprout-eating rats in OSU's state-of-the-art rodent facility are just one among 400 vertebrate species that populate the university's labs, barns, aquariums, ranches and hatcheries. Zebrafish, steelhead, beef cattle, garter snakes, rainbow trout, dairy cows, yellow- and red-legged frogs, copper and canary rockfish, lambs, koi, swine, salmon smolts and llamas are among the half-million-plus warm- and cold-blooded creatures that help educate OSU's students, improve health (both human and animal), protect ecosystems, guide resource management, bolster local economies and engage the public.

Every last one of these creatures, from the 2-inch trout fingerling to the 2,000-pound Hereford bull, is the responsibility of Dr. Helen Diggs. If you don't have an electronic key card, you must knock at a security door to gain admittance to her building on the west end of campus, the base from which Oregon State's attending veterinarian oversees her vast menagerie. With the welfare of thousands of animals on her mind, she is quick to question, slow to trust (or, as she likes to say, "I trust but verify"). It's a hyper-vigilance honed over 25 years in the field, some of those years at UC Berkeley where Diggs endured threats from animal-rights activists and had to be escorted to her car by security guards.

TACOS AND M&MS

"This is my morning health-status report," says Diggs, pointing to a spreadsheet on her computer monitor. "Every day, every animal-facility manager checks in with me. Here's Chad Mueller at the ag experiment station out in Union. Here's Rob Chitwood at the fish performance lab over by the golf course. Here's the Linus Pauling building. The Oregon hatchery. The Horse Center. Wherever I am, I can open up this online report and see what's happening."

So when a hamster is lethargic or a horse is lame, she's on it. But practices haven't always been so rigorous in the world of animal research. Diggs has been in the field long enough to have seen the transformation.

"In the decades before the 1980s, some universities were not caring for their animals as well as they should," says Diggs, who has overseen research animals since 1985. "The facilities smelled gnarly. There were wooden floors with urine stains, poor temperature control. Regulations weren't being enforced. No one was watching."

This laxity was not just a problem for the animals. It was also a problem for the science.

"Researchers weren't able to repeat their results. If I'm keeping my rats in a closet and feeding them oatmeal for breakfast, while your rats are getting leftover tacos or pancakes from the student lounge, we can't validate our findings."

Adds Steve Durkee, another of the university's leading research-animal watchdogs: "If rats in one study are getting cereal while those in a second study are getting oranges and M&Ms, you can't compare the results of the studies. By standardizing and harmonizing how animals are cared for, you create consistency across labs and institutions." In fact, he notes, prestigious academic journals publish only findings that document the highest standards of animal care.

That's why Diggs' job has teeth. Sharp ones.

"I can shut a program down," she says. "I've never had to do it here. But two times at other universities, I had to actually shut someone down and lock the door. If I have to go in and have a conversation with someone about their animal work, they'll listen to me. It's a big deal."

Even though the U.S. Public Health Service mandated in the early '70s that all animal research institutions hire an attending vet, the top docs didn't have any real enforcement power until the mid-'80s. That's when the National Institutes of Health and the U.S. Department of Agriculture cinched up the rules for labs getting federal research dollars.

"Attending vets had no real authority back in the early days," explains Diggs, who reports to Rick Spinrad, vice president of research at Oregon State. "Some didn't even have keys to the animal facilities. You need someone who's minding the store, not just a figurehead."

MINDING THE STORE

Bob Murray waves his key card in front of a laser-triggered security panel in the $62.5 million, 1-year-old Linus Pauling Science Center, which houses the Department of Chemistry as well as the Linus Pauling Institute. The elevator opens, and he steps inside. One floor down, he flashes his card again, clicking open an electronic steel door into a small anteroom, where he slips on a gauzy yellow "isolation gown" and a pair of puffy blue booties.

High Grades for Animal Care

In awarding full accreditation to Oregon State University in March, AAALAC offered the following remarks to Rick Spinrad, vice president for research. "The Council commends you and your staff for providing and maintaining an excellent program of laboratory animal care and use." Especially noteworthy, the council said, was the high level of administrative commitment to the animal care and use programs, evidenced by:

- The construction of the Linus Pauling building and the Livestock Pavilion
- The strong and effective program of veterinary care, evidenced by the excellent overall health status of the animals
- The engaged and effective IACUC, which was comprised of active and very knowledgeable members
- The excellent, detailed individual medical and production records maintained by the Dairy Barn
- The development of an electronic database to provide daily status reports to the attending veterinarian
- The excellent, well-documented training program

The Doctor at the Top

How lambs, preemies, "death cap" mushrooms and research pigs steered a stellar career

A human life can pivot on the quirkiest of convergences. In the life of Helen Diggs, it was the accidental nexus of five unfortunate hikers, a bagful of poisonous mushrooms and a few heroic pigs that set change in motion.

It all started early one morning in 1988 when Diggs, then a young veterinarian, heard an urgent knock at the door of the lab-animal surgery where she worked on Portland's Pill Hill. "Doctors! Come quickly! We've got some patients who need livers!" The two physicians Diggs was prepping for animal surgery peeled off their latex gloves and dashed out.

The timing couldn't have been more fortuitous for the poisoned hikers, who had eaten "death cap" mushrooms (*Amanita phalloides*) after mistaking them for the edible "paddy straw" species. Liver transplants were still rare in those days. But the two surgeons, one from Oregon Health & Science University and the other from the Oregon Veterans Administration, had spent the previous summer transplanting livers into research pigs with assistance from Diggs, who ran the animal O.R. So when four of the five hikers were raced to the hospital with critical organ failure, the surgeons were ready to perform the first human liver transplants ever done at OHSU.

All four patients survived. And Diggs had an epiphany.

"It was a really beautiful moment for all of us," she recalls. "Most of the time in animal sciences, we're working at the bottom of the research pyramid, trying to find answers at the level of basic discovery. It can seem remote from its eventual application in medicine. But this time, our work went straight to the operating room in a human hospital and saved four people's lives. I thought, 'Oh my gosh, we're right at the pinnacle.'"

Life-Saving Connection

Still, she expected research to be a stopover on the way to a more "warm, fuzzy" practice. When she graduated from Oregon State's College of Veterinary Medicine in 1985, she envisioned treating horses and cattle or, perhaps, cats and dogs. But with that urgent knock on the surgery door, the profound link between animal research and human health hit home. Her thinking began to shift.

"It makes you feel like a million bucks when you can be that close to a life-saving event," says Diggs, OSU's attending veterinarian for animal research.

Another convergence — this one involving lambs, preemies and high-tech blood-oxygenation pumps — clinched it for Diggs. She was pregnant with her first daughter when she and her animal techs at OHSU were testing new oxygen pumps on lambs to ensure that the life-saving machines could safely be hooked up to infants at the neonatal intensive-care unit at Portland's Emanuel Hospital. The "lambs were just adorable, frolicking and trying to nurse on your finger," she recalls. Having to euthanize the animals after the testing was "really hard" on the young vet. She questioned whether working with research animals was for her. Then one day while on maternity leave, she went to the hospital, her newborn bundled in her arms for a well-baby checkup. Still full of gratitude for the animal-tested technologies that had saved her own baby during a rough delivery, she bumped into a pediatric surgeon on the elevator. "Cute baby," he remarked, abstractedly. "Oh, by the way, we've saved 60 preemies with that pump you helped us test."

Her commitment to research was sealed.

After a 25-year career that included top leadership posts at the University of California, Berkeley; the University of Texas Southwestern Medical Center; and the American College of Laboratory Animal Medicine, she came home to Oregon State in 2009. "Extraordinary" is how Rick Spinrad, vice president for research, characterizes her leadership and national reputation. Announcing her appointment in 2011 as head vet and director of the Laboratory Animal Resources Center, he noted the astounding array of species under her care, "from tadpoles to swine."

For a third time, Murray brandishes his key card, unlocking yet another heavy door. He enters the inner sanctum of Oregon State's gleaming "vivarium" — the small-mammal equivalent of an aquarium or a terrarium — where hundreds of rats and thousands of mice live, as well as a few hamsters. Not one of these furry beings can get a sniffle or a sore toe without Murray knowing about it.

"The animals are checked at least twice a day, 24-7," says Murray, who clocked 35 years in the field, working at the New England Primate Center, Walter Reed Army Medical Center, Letterman Army Medical Center, UC Berkeley and Genentech before coming to OSU last year to manage the lab-animal facilities. "We watch for changes in gait or overall appearance — does the animal's coat look scruffy? How is the animal's appetite and hydration? We look for lethargy, weight loss, tumors. Any health problems we report immediately to Dr. Diggs and the researchers."

Murray's dad worked for the Society for Prevention of Cruelty to Animals in Boston for nearly 30 years. So worrying about animal welfare is practically in his genes. He takes pride in the life-saving research he has observed over the years, like the groundbreaking Herceptin research at Genentech that is being used to treat thousands of women with breast cancer and the malaria vaccine research at Walter Reed. Still, it's the health and comfort of the whiskered rodents that gets him out of bed every morning at 5 o'clock and keeps him running as he oversees his team of highly trained, certified animal technicians.

"I believe strongly in the value of the research we do here, but I'm not a researcher," Murray says, surveying his domain with the discerning gaze of a seasoned professional. "I'm into animal care."

If Murray were to take you through the 8,000-square-foot facility where researchers investigate the links between nutrients and human health, the first thing you would notice is an obsession with cleanliness. The giant Steris cage washer (which he calls "the heartbeat of the whole facility") sanitizes racks of cages in two cycles of 180-degree, pressurized water — and that's after the cages have been blasted with detergent and rinsed in acid. Everywhere you look, technicians and student workers are prepping cages for incoming animals or plying mops on floors that already look immaculate. Viruses and bacteria that could sicken the animals and compromise the research don't stand a chance.

The next thing you would notice is the attention to precision. Automated lighting simulates 12 hours of day, 12 hours of night. Electronic monitors maintain a 68- to 72-degree temperature range. An alarm alerts the staff if temperatures fall outside the range by even 1-degree Fahrenheit. There are ventilation tubes, fume hoods, stainless-steel work stations illuminated with stretchable spotlights. Every last facet of the facility is designed to protect the health and welfare of all its mammalian inhabitants, human as well as rodent.

Not until you reached the bosom of the vivarium would you come upon the rodents. The Brussels sprout-eating residents of the "rat room" were born and raised at an Indiana-

Technicians and researchers rely on rodents and other animals to unlock biological mysteries.

based research-animal supply company called Harlan Laboratories, arriving at OSU in ventilated crates via UPS. Firms like Harlan, along with Charles River Labs, Jackson Labs and dozens of others comprise a global mega-industry in the service of science. All must adhere to the same stringent federal requirements that guide OSU's animal-care personnel.

In the rat room where Rod Dashwood and other researchers in the LPI Cancer Chemoprotection Unit are looking for evidence that cruciferous vegetables like Brussels sprouts and broccoli sprouts can block the formation of colon tumors, dozens of clear-plastic cages are stacked, one above another, inside tall metal racks like high-rise condos. When you lean close and peer inside, you're likely to get a visual jolt. The cold, hard sterility of biomedical science is, you realize, wrapped around hundreds of breathing beings with whiskered snouts and beating hearts. They cuddle together for warmth and companionship. They look out at you with the pinkish eyes characteristic of albino Strain F344, understanding nothing about the scientific enterprise in which they play the leading role.

A FISH LIKE ME

So why do scientists work with animals? What can rats (*Rattus norvegicus*) or zebrafish (*Danio rerio*), seemingly so far from *Homo sapiens* on the tree of life, reveal about human health and disease? Turns out, many basic biological processes such as cell division, organ differentiation, gene mutation and disease formation play out similarly across species. That's why a rat or a mouse or a fish can act as a stand-in for a human in studies on micronutrients, obesity, aging, ALS, cancer, drug efficacy, infectious disease and any number of other biomedical questions under investigation at Oregon State.

When researchers use rats, mice or other species to study processes that mimic or parallel human biology, they call it a "model." One common model is a "knockout mouse." It works like this: To gauge how certain genes affect certain bodily functions or disease processes, researchers "knock out" or silence the targeted gene and then study what happens when the mice get, for instance, a high-fat diet or a hormonal supplement. Knockout mice are used at OSU to study bone growth, aging, obesity, immunodeficiency and many other intricate areas of human health.

But complex animals like mice and rats are used only when there's no other way to investigate the question at hand, Durkee stresses. Indeed, basic biomedical research begins with cells in a test tube. Only after experiments have shown great promise do scientists advance to animal work. And then, only after the animal studies achieve high rates of treatment success or cures — along with low risks for harm — do scientists go on to conduct experiments on humans. Steve Durkee's mother was a subject in one of those experiments, which researchers call "human" or "clinical" trials, when she was battling breast cancer (see "A Whole Lot of Seriousness," Page 14).

Durkee likes to direct people to the AAALAC website's long list of Nobel Prizes in medicine and physiology over the past 110 years. Without the use of lab animals, Frederick Banting and John McLeod wouldn't have discovered insulin and the mechanism for diabetes, winning the Nobel in 1923. Alexander Fleming, Ernst Chain and Howard Florey wouldn't have discovered penicillin and its curative powers. Typhoid and yellow fever would still be raging across the land.

But Banting and McLeod's methods with dogs, rabbits and fish probably would fail to pass muster with today's regulating agencies. It's not only federal regs that have changed — it's the moral

Ten Discoveries at Oregon State

With the help of animals, Oregon State scientists have made important discoveries in human health. "These findings would not have been possible relying only on cell cultures or experimenting with yeast and bacteria," says pharmacy researcher Mark Leid. His lab created and used genetically modified mice to discover important roles for the regulatory protein Ctip2 in several organ systems. Other findings include:

1. **ALS**. Genetic and chemical interactions are being revealed in patients with Lou Gehrig's disease. (Rats)
2. **Fetal Development**. Cancer-fighting nutrients taken in pregnancy protect fetuses from carcinogens. (Mice)
3. **Head and Neck Cancers**. These cancers contain a five-fold spike in the protein Ctip2, suggesting new tools for detection. (Mice)
4. **Melanoma**. A protein called RXR-alpha in some skin cells can protect pigment cells from damage. (Mice)
5. **Obesity**. A chemical in hops, xanthohumol, reduces body weight and lowers fasting plasma glucose. (Rats)
6. **Parasitic Infections**. A parasite called microsporidia, which can infect humans, can be transmitted via eggs. (Zebrafish)
7. **Spinal Cord Injury**. Vitamin E given intravenously within four hours of spinal cord injury increases survival and recovery. (Rats)
8. **Tooth Enamel**. Discovery of a tooth enamel-regulating protein could allow teeth to be grown in labs. (Mice)
9. **Toxicology**. The chemical BPA, used in plastic food containers, causes neurobehavioral changes. (Zebrafish)
10. **Tuberculosis**. Development of an oral therapy for TB and of an aerosol for treating bacterial lung diseases could lead to vaccines. (Mice)

philosophical and ethical sensibilities of Americans toward creatures of all kinds. Oregon State biomedical ethicist Courtney Campbell has seen a sea change over the past decade and a half.

"There's a generational change going on," says Campbell, who helped lead a series of national ethics workshops for land grant faculty in the 1990s. "The change isn't limited to animal research at universities — it's also about food and entertainment and sports. It's about the treatment of animals at zoos, circuses, aquariums, rodeos. "It's about our diets — how veganism and vegetarianism were way out in the 'fringy granola movement' not that long ago. "We haven't done a complete cultural 180, but there is definitely a new moral consciousness."

AT THE END OF THE DAY

In the rat room, the "Bruss" eaters live alongside the "brocc" eaters (broccoli sprouts) and the "fat" eaters (high lipids). There's a control group, too, which eats regular rat chow. That's so Dashwood can compare the health impacts of an ordinary diet against those of the special diets. At the study's start, all the animals were injected with the carcinogen found in charred meat — a known cancer-causing compound to which most Americans have been exposed in barbequed burgers or grilled steaks. Once the study is over, the animals will be euthanized, humanely, in strict accordance with the protocols set out by the American Veterinary Medical Association. The researchers will then compare the number and size of colon tumors among the four groups to find out whether eating sprouts made a difference.

When they talk about ending the lives of animals used in biomedical research, Diggs, Durkee and Murray all express a resigned sadness. None of them could do their jobs without a total conviction that scientific discovery justifies the animals' demise — that the death of a rat may someday save the life of a child. Still, it's unsettling. "Nobody likes it," muses Murray, his attempt at matter-of-factness not 100 percent convincing. "But it is what it is."

➡ *Editor's note: Read more about Oregon State's leadership in animal ethics in the Winter 2013 Terra.* terra

A Whole Lot of Seriousness

With lives on the line, there's no room for nonchalance

"Nothing is more important in an animal study than the animal itself," says Steve Durkee. His tone is reminiscent of Moses handing down the stone tablets. Just like Moses, Durkee is not kidding around.

The righteous idealism that fed Durkee's Greenpeace activism in his "younger, wilder days" still beats in his chest as administrator of OSU's Institutional Animal Care and Use Committee (IACUC) — a group of researchers, veterinarians, ethicists and laypeople who meet monthly to review each and every proposal for an animal-using project before it can go forward. His job is to make sure no animal is used needlessly, no animal suffers undue pain, no animal dies in vain.

"It's not a light topic," he says, sitting in his office amidst copies of *Lab Animal* magazine and photos of Murphy, his Goldendoodle. "Day in and day out, it's a whole lot of seriousness. To me, these animals are heroes. They're giving their life for the greater good."

Heroes, perhaps, but not volunteers. The rats nibbling on Brussels sprouts for a colon-cancer study in the Linus Pauling Science Center didn't choose to participate. And that, precisely, is why they need a surrogate. Durkee speaks for them. He puts himself in their shoes — rather, their paws: How would it feel to be one of those rats in Cage 57? Would he be stressed-out? Lonely? Would he be bored? Would he be too hot or too cold? Would he feel pain or anxiety?

The answers to these kinds of questions determine whether a research or teaching project gets an OK from the IACUC, which Durkee advises on regulations and national standards. Every iota of proper care — from lighting and companionship to noise, vibration, enrichment and surgical procedures — is detailed in the *Guide for the Care and Use of Laboratory Animals* published by the National Research Council of the National Academies. Moses had his stone tablets. Durkee has the eighth edition of the Guide.

"We have a really serious charge," he says, "to evaluate whether the benefits from a project justify animal life or involvement."

Care and Security

The benefits of animal research aren't just theoretical for Durkee. When his mom was battling breast cancer, her treatments had been tested on animals. She didn't survive the disease. But other women have beaten breast cancer thanks to the rats, mice and other creatures that participate in biomedical studies.

In return, Durkee says, humans have an obligation to feed, house and handle animals with the utmost care — even during dire emergencies. After a severe East Coast power outage cost nine rats' lives at his previous workplace, the University of Michigan, he wrote a comprehensive disaster-planning outline for animal facilities to follow during hurricanes, blackouts and other disasters. Coincidentally, as he was making final edits, Hurricane Katrina struck New Orleans. So he found a very receptive audience when he presented his outline at a national animal-care conference barely two months later.

Last winter, when floods washed out roads and power lines in Benton and Lincoln counties, plans derived from his outline kicked in to protect fish and other sea life at OSU's Hatfield Marine Science Center, as well as animals on campus. Because even when researchers are riding out the storm at home and staff are trapped by fallen trees or collapsed bridges, captive animals need food and fresh water, heating and cooling, bedding and medicine.

"Using animals is a privilege, not a right," Durkee insists. "We owe them gratitude and respect."

Under the Hood

Geologists reveal the steady personality of Oregon's signature peak

BY NICK HOUTMAN | PHOTOS BY JEFF BASINGER

Mount Hood last erupted more than 200 years ago, but at Crater Rock, not far from the summit, the signs of volcanic activity are unmistakable. Gas vents and hot springs emit sulfur fumes. Vapors rising from deep under the mountain carve snow caves, which can seem like sanctuaries for climbers but often hold deadly concentrations of CO_2 and other gasses. Rocks fall frequently from the steep unstable cliffs of the partially collapsed crater.

Odds are low that Oregon's tallest mountain will erupt any time soon, but when it does, scientists have a pretty good idea of what will happen. Driven by the grinding of tectonic plates deep in the planet's crust, hot magma will infuse cooler lava chambers closer to the surface (an event geologists call "recharge"). Pressure will build. Rocks will begin to crack.

In some volcanoes, not much happens after recharge. The lava chambers may be hotter and ready to burst, but the lid stays on, and the molten rock gradually cools. It takes quite a punch to force a mass the consistency of oatmeal up through miles of tortuous fractures.

Hood, however, is impatient. Within weeks of recharge, lava starts moving and gasses start bubbling out through the crater. Melting snow and ice generate debris flows down the mountain's flanks sweeping away forests and filling rivers with sand and rock. (In the distant past, such events have careened down the Hood River valley and across the Columbia River.) Eventually, lava emerges and snakes down the mountainsides, adding to Hood's bulk and remaking

Just east of Timberline Lodge are deposits from Mount Hood's most recent eruption, which occurred just before Lewis and Clark visited the region in 1805.

its classic profile.

That's been the story for more than a half-million years, says Adam Kent, Oregon State University geologist. When he first arrived in Oregon in 2003, the Australia native learned that while scientists from the U.S. Geological Survey's Cascade Volcano Observatory knew a lot about hazards posed by eruptions, Hood's underground plumbing remained largely a mystery.

Since then, Kent has analyzed the remnants of old lava flows to learn how the mountain behaves. He and post-doctoral researcher Alison Koleszar have climbed its slopes, brought samples back to their labs and squeezed clues from rocks. The chemical composition of Hood's lava flows has remained amazingly uniform over the centuries, and they have found that the mountain may represent an extreme end of volcanic systems. It may in fact be unique in

In September, Alison Koleszar, left, and Tyler Lomax, a junior from Albany, Oregon, collected rock samples from the 590,000-year-old Cloud Cap lava flow on the eastern side of Mount Hood. Composition of the rocks there is thought to reflect the original parent magma. Koleszar and Lomax also trekked through lava fields on the southern flank where flows are less than 30,000 years old.

the Cascades. Unlike Mount St. Helens, Mount Jefferson and others in this spectacular range, Hood doesn't explode; it oozes.

Crystal Visions

Kent keeps a piece of Mount Hood in his office. This flat gray rock looks like some kind of exotic concrete. It sparkles with crystals. Irregular, coffee-colored spots about the size of a quarter dot its surface. Dark flecks of hornblende are scattered across its surface like pepper on a fried egg.

"When this rock came to the surface," Kent says, "it was partly liquid. It records information about the last stage of the eruption. But if you want to know more about the long-term conditions in the crust where this magma was being stored, you need to look at the crystals."

Like tree rings, crystals grow from the inside out over time, says Kent. At their heart are the original minerals — formed out of common elements such as calcium, iron, silicon, magnesium and aluminum. As hot rock pulses up from below, crystals go through warming and cooling phases. Mineral layers form on the outside edges and create a record of temperature, pressure and chemistry. Each ring tells a story about a new pulse of melted rock that gives the crystal its unique character.

Crystals also trap tiny remnants of some of the original material, melted rock generated by tectonic forces. Analysis of these trapped particles — what geologists call "melt inclusions" — provides a picture of the minerals and volatile gasses (water, carbon dioxide, sulfur, chlorine and fluorine) that emerge from deep in the crust and can give a mountain shape and personality. When concentrations of those gasses are high, explosive eruptions are more likely.

To find out what distinguishes Hood from its neighbors, Kent, Koleszar and their team separate crystals from surrounding rock. In the Oregon State geology lab, they subject samples of the mountain to diamond-tipped saws, acids and devices that pound stones into dust or polish them to a fine sheen (Polishing can be pricey. Grinding pastes that contain diamond particles can cost upwards of $300 for half an ounce). They separate crystals further by exposing rock fragments to magnetic fields or dropping them in dense liquids.

"Some samples are crumbly and fall apart easily," says

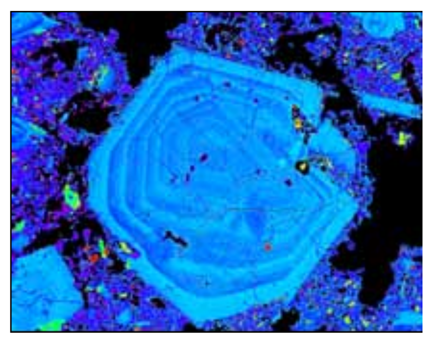
Tyler Lomax, a junior from Albany, Oregon, is starting a research project with Oregon State geologist Adam Kent to learn more about the 590,000-year-old Cloud Cap lava flow on Mount Hood.

Koleszar. “Those are harder to work with. Nice clean pure volcanic glass is great. It polishes like butter. It’s so soft compared with some of the minerals we use.”

Once separated, sliced and mounted on slides, crystals undergo analysis by electron beams that reveal fine structural details or laser and mass spectrometry that tell scientists what trace elements are present in each crystal ring. The result is an accumulation of evidence that allows geologists to explain Hood’s eruption process and compare the mountain to other volcanoes.

In a paper published in the *Journal of Volcanology and Geothermal Research* in 2012, Koleszar and co-authors Kent, William Scott of the USGS and Paul Wallace of the University of Oregon described their findings. They reported that Hood contains the ingredients for explosive eruptions: magma pumped regularly into the mountain from below, high levels of volatile gasses and a chemical profile similar to that of other explosive volcanoes. However, rather than explode, Hood’s gasses tend to escape readily like fizz from an open can of soda. That’s because a 100-degree increase in temperature — an increase that happens as hot rock flows into magma chambers under the mountain — makes the flowing rock five to 10 times runnier than it was before.

“Imagine you are blowing into a straw in a milkshake,” says Koleszar. “It’s so thick that the bubbles don’t come out right away, but when they do, they burst and throw stuff up



Produced by Oregon State’s electron microprobe lab, this false-color image of a plagioclase crystal shows growth rings that are generated by repeated heating and cooling of magma. Geologists analyze the composition of each ring to understand the depth, temperature and other conditions in which the crystal grew. The electron microprobe facility, operated by the College of Earth, Ocean, and Atmospheric Sciences, is used by geologists from Oregon and around the country to analyze mineral structures.

As rocks weather, olivine crystals break down. Alison Koleszar looks for rock samples that have clean, unaltered crystals of olivine, the most abundant mineral in the Earth's mantle. Since they trap "melt inclusions" (bits of ancient magma), they provide geologists with a window on past eruptions.

in the air. Compare that to blowing into a straw in a glass of milk. Bubbles just come easily to the surface. That's more like what we see at Mount Hood."

Mount Hood may be unique in the Cascades, but it joins a select group of volcanoes worldwide (Mount Unzen in Japan, Soufriére Hills Volcano in Montserrat, Mount Dutton in Alaska) that tend to ooze instead of explode. Nevertheless, volcanoes can also demonstrate both types of behavior, and there's no guarantee that Hood will always operate as it has in the past. Two well-known explosive volcanoes — Mount Pelee in the Caribbean and Mount Pinatubo in the Philippines — have exhibited both types of eruptions. Moreover, geologists know that pulses of hot magma, which occur at Mount Hood, can cause explosions such as the 1980 Mount St. Helens eruption.

"We're still trying to figure out why Hood only erupts right after a recharge event," says Koleszar. "It may be that it just doesn't have the oomph to erupt at other times.

"It seems like such a boring volcano," she adds. "It erupts the same thing all the time; it doesn't seem to do anything interesting. It's an icon, it's a beautiful volcano and it's Oregon's volcano. But when you start to tease things apart a little bit, it does get interesting, exactly because it is so boring." terra

RESEARCHER PROFILES

Adam Kent

A native of Australia, Adam Kent is an associate professor in the College of Earth, Ocean, and Atmospheric Sciences. He has studied volcanoes in Greenland, Japan and North America and has climbed mountains (Mount Shasta in California, the Three Sisters in Oregon). Now that he has a child, he says, his climbing days are behind him. His research has been supported by the National Science Foundation.

Alison Koleszar

As an undergraduate at Colgate University, Alison Koleszar wanted to study astronomy and physics, but her first geology course turned her toward planetary sciences and geology. Eventually, she decided to focus on her home planet. Now a post-doctoral scientist, she came to Oregon State in 2007 and regularly uses the laser ablation lab in OSU's Keck Colaboratory to study trace elements in volcanic systems.

Forms from the Sea

Artists reveal hidden worlds in plankton science

BY NICK HOUTMAN

During a Pacific Ocean research cruise, Angel White peers into her microscope. The ship rides gentle swells and sways side to side. In her field of view, organisms the size of dust motes rise and fall through their own watery world. "It can be disorienting and enthralling at the same time. The microbes are dying as I look at them, and it doesn't always make for the best photos," she says.

White studies plankton, the microorganisms that power the marine food chain, pump oxygen into the atmosphere and regulate global chemical cycles. In the course of her research, she has recorded an astonishing diversity of living shapes, forms, colors and patterns: spiny Radiolarians, fat copepods, football-shaped ostracods and coiled threads of Trichodesmium that coalesce into filamentous balls. Under fluorescent light, her photos reveal organisms within organisms, glowing constellations that rival images from the best space telescopes.

White's science is strictly down to Earth. She aims to reveal how plankton consume and release nutrients such as nitrogen and phosphorus and how, in turn, these abundant organisms respond to variations in temperature and water chemistry. Her tools run the gamut from high-tech instruments to old-school nets towed behind a ship. In the lab, her camera has become invaluable in her exploration of a world that is largely invisible to the naked eye.

"Photography is a wonderful outlet for creativity and discovery," she adds. "Plankton show an amazing array of different adaptations to their environment. If you concentrate them in a drop of ocean water and look through the microscope, you will see organisms feeding, swimming, gliding, tumbling and floating. There are blues and reds, jaws and antennae — whole alien worlds."

In 2012, 35 Oregon artists took up a call from The Arts Center of Corvallis for works based on White's plankton images. Submissions came from painters, fabric and glass artists, sculptors, potters and an expert in the ancient Japanese art of stencil dyeing. They comprised a show, "The Art of Plankton, Form Follows Function."

The range of art gave White a new view of a world that she has explored through her research. "I've been fortunate over the years to look through a microscope and be thrilled with the familiar and the mysterious," she says. "And now to have a whole range of creative people re-envision what I saw the first time is very cool. The natural world can be astonishingly beautiful.

"The general view is that scientists pick it apart and explain it through cold and methodical equations. It is easy to get lost in the details and lose a sense of wonder. This collaboration — merging the perspectives and talents of artists with science — is refreshing. It reminds me what it was like that first time at sea, the first time I realized that, 'Oh no, really, the ocean teems with life, glorious tiny life.' That sense of discovery is what I felt talking to the artists."

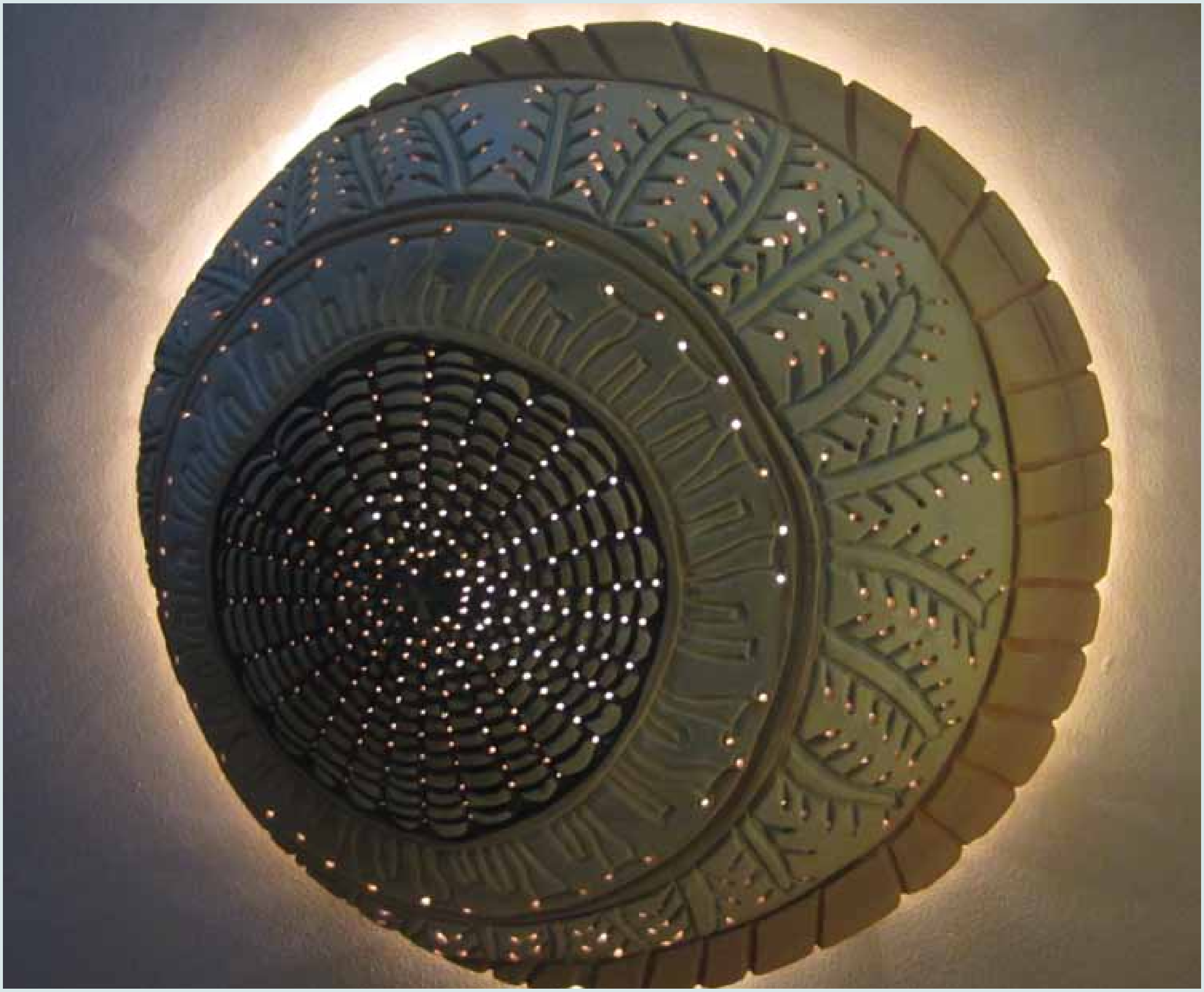
ANGELICQUE WHITE | SCIENTIST, PHOTOGRAPHER

From left: Harpactacoid copepod embedded in a Trichodesmium colony; dinoflagellate Ceratium with star-shaped Acantharians in the background; three isopods clutching one another; composite of cyanobacteria, protozoans and metazoans.

JERRI BARTHOLOMEW | CORVALLIS

TITLE: BENTHOS | MEDIA: GLASS

I am not a formally trained artist. Instead, my education is in science, having received degrees in fisheries and microbiology at Oregon State. This background informs and influences my art. I enjoy the anticipation of opening the kiln and seeing how my idea transforms. It is also why this show was so exciting for me, as the images of plankton are very similar to images of the parasites I study. (On the Web, see those images at http://microbiology.science.oregonstate.edu/barthol_lab_atkinson)



SANDRA SCHOCK-HOUTMAN | CORVALLIS

TITLE: BLUE BUTTON
MEDIA: PORCELAIN PAPER CLAY

There are infinite possibilities when one uses the Earth and its progeny as sparks for creativity. I found Angelicque White's photographs of plankton engaging at first sight. My illuminated pieces in the Art of Plankton show are wheel-thrown porcelain paper clay (dried trimmings from my functional pottery mixed with scraps of paper) that has been stained with underglazes, sprayed with a light coat of clay and finally highlighted with a small amount of acrylic paint.

SARA MCCORMICK | PORTLAND

TITLE: DRIFTERS
MEDIA: FRACTAL GICLEE PRINT

My work is a form of digital art known as fractals: mathematical and natural forms that exhibit what's known as self-similarity. Using a computer, I render mathematical formulas into art of infinite depth and detail. More than anything else for me, my work represents a real, tangible connection to nature. The patterns I work with are the same patterns that make up the universe. When I create, I know that I am creating something that is both a part of myself, my physical body and the world as a whole.

ELLA RHOADES | CORVALLIS

TITLE: *EMILIANIA COCCOLITHOPHORE* — EUKARYOTIC ALGAE ENCASED IN CALCIUM CARBONATE
MEDIA: MOSAIC USING OCEANOGRAPHIC OPTICAL FILTERS, CHRYSOCALLA STONES AND BEADS

I went literal in my interpretation of Angelicque White's photographs. The imagery of life beneath the microscope lends itself so beautifully to mosaic form. Optical filters are remnants from the oceanographic industry and generated the color palette for this piece. Aqua blues and greens feel right for such studies from the sea.

SIDNEE SNELL | CORVALLIS

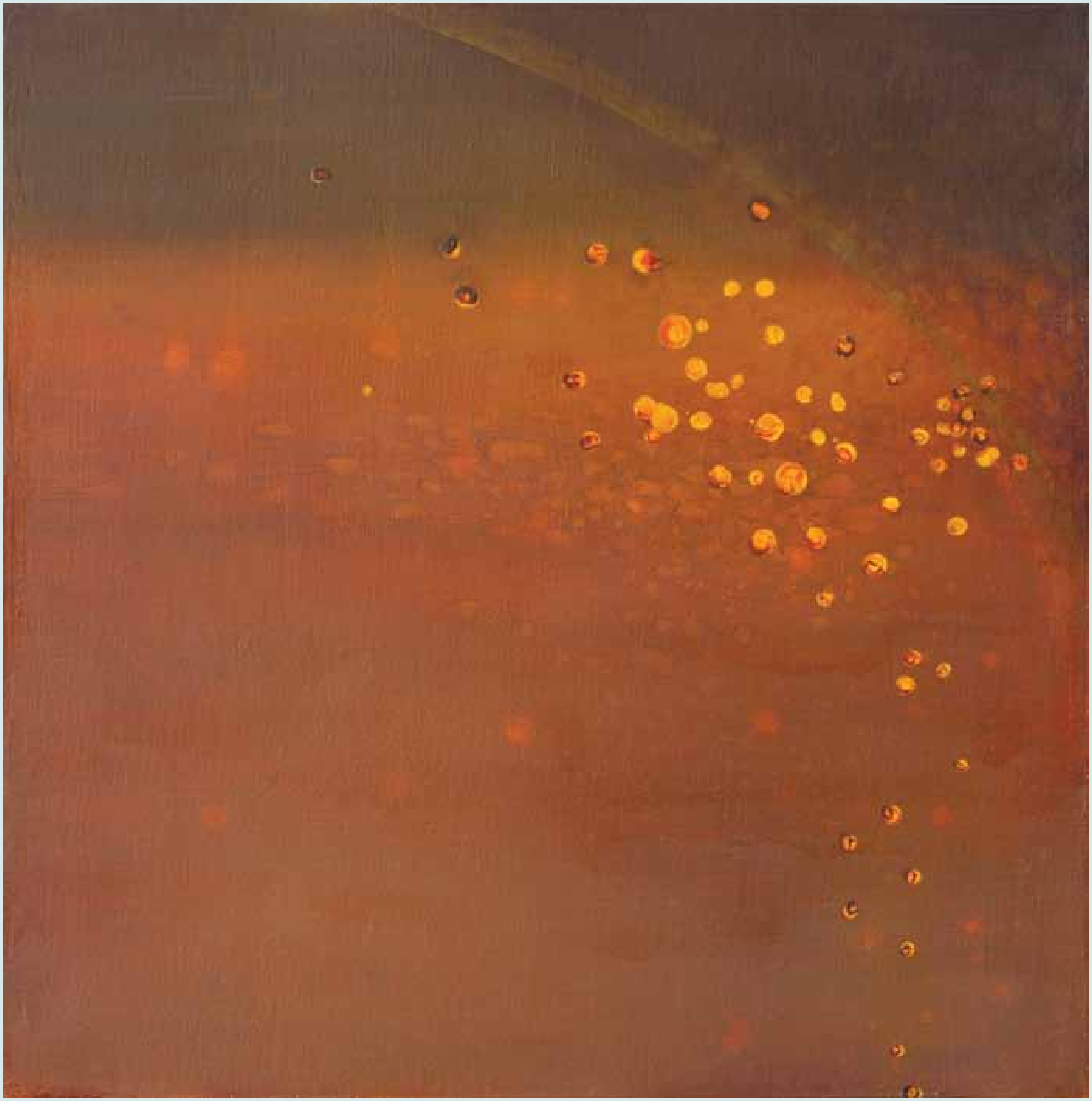
TITLE: PARUM AQUA FLORA
MEDIA: FIBER

I was originally attracted to the lacy quality of sections of Angelicque White's photograph. However, as I began to work with it, a floral image began to appear. Although I have no idea whether the plankton should be considered flora or fauna, I decided to follow that theme. The result is *Parum Aqua Flora*.

RAKAR WEST | EUGENE

TITLE: LEVIATHAN
MEDIA: OIL AND WAX ON CANVAS

All of Angelicque White's images of plankton are very beautiful and interesting to me. The one I chose as my main inspiration is the composite image of the cyanobacteria, protozoans and metazoans. My painting, *Leviathan*, refers to the food chain (or web), but is not a literal depiction. The word leviathan has come to mean any large sea creature, such as a whale. Both the whale (the large center shape) and plankton are part of the food web.



LEAH WILSON | EUGENE

TITLE: DRIFTERS I
MEDIA: OIL ON WOOD PANEL

My paintings are created in the intersections of science, philosophy and art. With these paintings, I am using Angelicque White's images of phytoplankton (marine cyanobacteria) as a starting point and anchor. I chose images of marine cyanobacteria for their simplicity and ambiguity. They are expansive images, opening possibilities of meaning beyond the realm of the sea.

Far and

Oregon State students make discoveries from French Polynesia to the African savannah

BY LEE SHERMAN

When you play fetch with a killer whale, it makes an impression. When you play fetch with a killer whale and you're only 6 years old, it can change your life. For Renee Albertson, the change was a long time in the making. But as she tried first one career and then another, she never forgot how it felt to look into that whale's eyes one rainy day in Vancouver, B.C. — a species-to-species connection that eventually led her to Oregon State's Marine Mammal Institute and expeditions to study whales and dolphins around the world. Her summer on the turquoise seas of French Polynesia was just her most recent research adventure.

Meanwhile, other Oregon State students were at work in equally exotic places around the planet, from Kenya to New Zealand to the countryside of France. They worked on projects as diverse as engineering water systems and experimenting with emulsifiers in ice cream. Here's a sampling of stories from these intrepid student researchers around the globe. For more profiles, visit *Terra* online at oregonstate.edu/terra.

Away

Pumped Up

Zachary Dunn helps bring clean water to Kenyan farmers

How far would you go to help someone get a glass of clean water? Zachary Dunn knows exactly how far he'd go: 9,000 miles. And that's just one trip, one way. By summer's end, Dunn and fellow Oregon State University students had traveled almost 36,000 miles — greater than the Earth's circumference — to help bring drinkable water to Lela, a tiny farming community in Kenya.

So why would engineering students fly halfway around the planet from bucolic Oregon to struggling East Africa, not once but twice? Why would Dunn say that contracting malaria on his first trip was a "small price to pay"? Why would he shrug off a State Department travel warning about terrorism and piracy in the region?

"In Lela, women and children walk up to three miles a day carrying 40-pound buckets of water," explains Dunn, who grew up in Albany, Oregon. "I've seen kids as young as 5 with buckets on their heads. It's a feat. They don't complain. But the loss to productivity and education is huge."

It's not despite the chasm between the Kenyan village (where waterborne disease is common) and his Oregon hometown (where pure water flows from faucets and fountains at the twist of a wrist) but *because* of it that Dunn joined the Oregon State project in 2010 to survey water sources, test water quality and commission a groundwater survey. He went back in July to help drill a well and install a rainwater catchment system.

"We all have a common fate," says Dunn. "These kinds of projects can help shape the future of the world. It benefits all of us. It's a win-win."

That all-embracing, planetary vision is what led to Dunn's participation in OSU's chapter of Engineers Without Borders USA (EWB-USA), which is dedicated to the vision of a world in which all communities have the capacity to meet their basic human needs. And

Oregon State students Jordan Machtelinckx and Jessica Cawley (top) pump Lela's new well for the first time. (Right) Zachary Dunn gives a lift to Fosten, son of the fundi (Swahili for technician), who built the rainwater catchment system at Lela Primary School. (Left) Residents gather for a community event. (Photos above and left: Justin Smith; bottom photo couretsy of Zachary Dunn)

it's that vision that steered him to the ecological engineering program for his undergraduate work. The program, he says, is based on "systems theory," the notion that everything is connected and, thus, solutions must be holistic.

"I'm interested in redefining the relationship between humans and the planet," says Dunn, who describes himself as a "born tinkerer," always tilting toward problem solving even in childhood.

The Lela Women's Water Committee linked up with EWB-USA when they were looking for a partner on their quest for a better life. "We only partner with communities that have identified a need and have asked for help," says Dunn, who started graduate studies in public policy this fall.

The other EWB-USA requirement: The project must be sustainable. "A huge number of wells in Africa are in disrepair," Dunn notes. "Many communities do not have the capacity to maintain them."

That's why EWB-OSU's team of six (five students and one professional mentor) recommended a hand pump for Lela's new well. Other power-source options, such as diesel or solar, cost too much to maintain or are targets for theft. With guidance from faculty and a groundwater expert from the engineering firm CH2M Hill, the students have researched everything from the compressive strength of concrete (for the foundations under rainwater storage tanks) to the reliability and availability of pumps.

In Kenya, Dunn and his team stay in a "simba," a house made of wood and mud with a corrugated metal roof, on the land owned by village elder Charles Olang'o (photo below). The elder's son Paul is the translator for the Oregon State engineers. A fast friendship has formed among the Kenyans and the students.

"We have a really special bond with Lela," Dunn says. "Charles calls me his son; Paul calls me his brother. They are very gracious people."

Freeing Lela's women from carrying water long distances has been a dream for Penina, a member of the Lela Women's Water Committee. The house (below) belongs to Charles Olang'o, the elected village elder of Lela who has hosted all EWB-OSU travel teams. (Photos: Justin Smith)

Legacy of a Whale

Renee Albertson's childhood encounter led her, decades later, to French Polynesia

On the island of Hao in French Polynesia, Renee Albertson holds a jawbone from a sperm whale (top left), which she sampled for genetic analysis. Albertson and colleague Marc Oremus (top right) are studying dolphin genetics. Hector's dolphins (bottom) show off in Cloudy Bay, New Zealand. (Top photos courtesy of Renee Albertson. Bottom photo: Anjanette Baker)

Rain was pouring hard the day Renee Albertson first connected, face-to-face, with a marine mammal. She was a 6-year-old visiting British Columbia's Sealand aquarium (Canada's now-defunct answer to California's SeaWorld) with her mom and dad. The daily show had been cancelled because of the downpour. The usual crowds were absent. As the soggy trio from Portland stood looking into a small tank, the resident killer whale surfaced. The young killer whale — a rescue named Miracle — was balancing a plastic ring on her nose. And she was looking straight at little Renee. Again and again, Renee tossed the ring. Again and again, Miracle brought it back, always to Renee.

"There was just a low fence around the tank, and you could literally reach over and throw the ring," recalls Albertson, a Ph.D. student in Oregon State's Marine Mammal Institute. "She kept coming back to me. It was a neat connection. It really made an impact on me."

That encounter fed Albertson's ever-deepening fascination with marine science — a fascination that led her, eventually, to join the international research team of OSU cetacean scientist Scott Baker. "Increasingly, I knew I wanted to help conserve these intelligent animals," she says. "I just didn't know how." But with stubborn single-mindedness punctuated by moments of pure serendipity, she found her way into an elite circle of researchers who follow cetaceans (whales, dolphins and porpoises) to the farthest reaches of the Earth.

Albertson always loved biology. But the notion of making a living helping whales seemed unrealistic and out-of-reach. Chemistry — now there was a practical path to a career, she decided. After earning a bachelor's in chemistry at Portland State University, Albertson took a job analyzing water and soil samples. But lab work was, for her, too solitary. So she got a master's in education at Pacific University and taught chemistry at David Douglas High School for 10 years. She loved teaching. But in the recesses of her mind, the eyes of the captive killer whale were still on her.

Then one day she heard about renowned whale researcher Michael Poole from a friend who had taken one of Poole's whale-watching trips in French Polynesia. The friend encouraged Albertson to meet him. She emailed Poole, offering to assist in his research during summer break. "I never heard back," she recalls. "I emailed and emailed and emailed."

Finally, she sent one last message. She told him she was coming, regardless, and that if he didn't need her, she joked, she guessed she would just have to spend the summer drinking martinis while writing lesson plans on the beach. Two days later, Poole's name popped up in her inbox. His Ph.D. student wouldn't be coming to collect samples that year, he explained, and it was humpback whale season. He offered her an unpaid internship.

When she got to the island of Moorea, Poole handed her not a lifejacket but a notebook. Inside the fat binder was a photographic catalog of humpback whales' tails. Poole tasked her with comparing the tails of recently sighted whales with those of previous years. "If you still like biology when you finish this, I'll take you out in the boat," Poole said. For two weeks Albertson "sat in a little beach cabana with a little magnifying glass, matching whale tails." Soon after, she was on the boat helping Poole collect photos and skin samples from breaching whales for eventual mitochondrial DNA analysis as part of her master's research.

The work led her to the University of Auckland, where Baker had just accepted a new position as assistant director of the Marine Mammal Institute located in (how ironic is this?) Albertson's home state of Oregon. Since joining Baker's Cetacean Conservation and Genomics Lab, she has studied humpbacks in Polynesia and Antarctica, rough-toothed dolphins from Hawaii and the South Pacific, and multiple species of dolphins and whales in the Marquesas archipelago.

➡ ***Visit Albertson's blog at http://blogs.oregonstate.edu/marquesas/.***

The quirky phenomenon of mud volcanoes captured WeiLi Hong's scientific interest in Taiwan. Falling in (above) is one of the occupational hazards of studying mud volcanoes. His research has turned to another manifestation of methane seepage, gas hydrates. (Photos courtesy of WeiLi Hong)

The Earth Burps and Burns

WeiLi Hong measures methane emissions on land and at sea

When the Earth burps, WeiLi Hong listens. Whether Earth's gaseous emissions bubble up from "mud volcanoes" on the planet's surface or seep out of fissures on the ocean floor, the Oregon State University Ph.D. student has his monitoring gear to the ground.

And sometimes, he's actually in the ground.

"I fell in twice," Hong admits, describing the hazards of surveying mud volcanoes in his home country of Taiwan. "I was trapped in thick mud up to my waist. There was nothing solid to grab onto. I had to kind of roll across the surface of the mud until I could pull myself out."

Which brings up a couple of questions: What is a mud volcano, anyway? And why would anyone risk life and limb traipsing around these oddities of nature?

The answer is methane — millions and millions of tons of it trapped in ancient sediments. Under pressure from the bumping and grinding of tectonic plates, the gas migrates upward through Earth's crust, seeking the atmosphere. Certain countries, such as Taiwan, Indonesia, Pakistan and Azerbaijan, are "burping gas like overfed infants," to borrow a metaphor from one *New York Times* writer on the subject of methane emissions. As the methane escapes, creating a slurry of fluids and dissolved solids, volcano-like mud domes mound up across the landscape. They can be as small as a toddler's backyard swimming pool and as big as several city blocks.

But that's not the only way methane migrates. It comes up through the bottom of the ocean, too. On the seafloor, where it's super-cold, seeping methane gets locked into ice-like structures called "hydrates," Hong explains. Studying methane emissions on land, despite the pitfalls, is a walk in the park compared to studying them 2,000 feet beneath the sea.

"With mud volcanoes, we're looking at how much methane is emitted to the atmosphere," says Hong, who specializes in chemical oceanography in the College of Earth, Ocean, and Atmospheric Sciences. "With cold seeps, we're looking at how much methane is emitted to the water column. To do that, we need a vessel with the ability to drill."

The discomforts of being at sea for two months didn't deter Hong two summers ago when, along with Oregon State researcher Marta Torres, he joined an exploratory expedition to Korea's East Sea hunting for hydrates aboard the research ship Fugro Synergy. His job was to analyze the physical properties of sediment samples taken from the depths.

For scientists and engineers, this trapped methane presents both threats and opportunities. On one hand, Hong says, melting hydrates could trigger Earth-warming greenhouse-gas emissions and tsunami-causing landslides. On the other hand, methane could be an energy bonanza — if it could be safely harnessed. That's why the Korean government and the U.S. Department of Energy cosponsored the 2010 Ulleung Basin Gas Hydrate expedition.

"We were looking at porosity, permeability, texture, composition," he says. "We used an X-ray machine to get 3-D images of the cores." Opening his laptop, he clicks on a grainy gray image from the bathysphere. As he toggles the image this way and that, he points out traces of long-dead organisms in the long-buried layers. "On the computer," he notes, "you can rotate the sediment column to see how the geosphere, hydrosphere and biosphere interact."

The Milky Way

Rachel Miller puts French ice cream to the taste and texture test

When Rachel Miller was shadowing a pie scientist in her hometown of Spokane, Washington, no one — not her teachers, not her parents, and certainly not she herself — could have predicted that her high-school job shadow would lead to possibly the coolest summer internship in the universe: tasting ice cream in France.

OK, so let's back up a minute. A pie scientist? Really? The year was 2008, and transfats were the newest boogeyman in the food industry. The scientist Miller shadowed at Cyrus O'Leary's Pies was reformulating recipes, replacing shortening with healthier palm oil. Sugar, too, was on the food industry's hit list as Americans' waistlines swelled and their blood sugar spiked. Enter low-sugar pies and yet another reformulation.

Miller admits that her teenage choice of a job shadow had more to do with her sweet tooth than with any carefully thought-out career goal. Nonetheless, a career path began to unfold for this child of a meteorologist dad and a veterinarian mom (who worked with bomb-sniffing dogs during a military tour in Kuwait). After a senior-year visit to Oregon State University, Miller set her sights on the Department of Food Science and Technology. Studying food appealed to her practical nature.

"Food science is so applicable to everyday life," she says. "It's not one of those sciences where you have to work in a lab. Your kitchen can be your lab."

A part-time freshman gig crunching data for Oregon State cheese researcher Lisbeth Goddik introduced Miller to the chemistry, microbiology and artistry of curds and whey. So a logical spot for her first summer internship was Oregon's famous Tillamook Cheese Factory, where she chemically analyzed milk samples and inspected incoming ingredients like sugar and salt. The next summer, she worked at the Darigold plant back home in Spokane.

Finally, her professional life looped back to its origins: that sweet tooth. At the end of her senior year at OSU, Miller was accepted as a summer intern at ENILBIO, the National School of Dairy Industry and Biotechnology. Tucked away in the picturesque French town of Poligny, the school resides in one of the world's finest cheese-making regions. The school also researches ice cream.

Miller's delighted grin seems to say, "Can you believe it?" as she explains her summer job testing the texture of ice cream made without chemical emulsifiers — compounds like polysorbate 80, monoglycerides and diglycerides — that give ice cream its smoothness, free of gritty ice crystals.

"It's all about mouth feel," she says, sounding very much like a vintner after swishing, sipping and spitting a pinot noir. "Consumers want a creamy, pleasant mouthfeel, but they don't want the substances that create that pleasant texture. It's a Catch 22."

In France, she investigated what happens to ice cream texture without those multisyllabic emulsifiers. It's all part of an international trend, Miller says. More and more, consumers avoid foods listing unpronounceable additives and unrecognizable terminology on their packages. "There's a big push to clean up the labels on food products, to limit the number of ingredients and to use only natural ones," she says.

Rachel Miller's dairy food research took her to France, where she spent the summer investigating how emulsifiers affect the texture of ice cream. (Photos courtesy of Rachel Miller) Bottom right: Miller, shown here in OSU's food science lab, is now doing graduate work at Cornell.

Behind the Screens

Oregon State and the University of Oregon partner in sustainability center

BY NICK HOUTMAN

"Your TV-picture screen in 1964 may be so thin that it can be hung like a painting on the wall or mounted like a vanity mirror in a table model."

Popular Mechanics, January 1954

Popular Mechanics' prediction took considerably more than 10 years to come true, but today's flat-panel screens have gone well beyond that early vision. Some of them are nearly as big as a living room wall. They bring us unimaginably sharp detail, from spots on butterfly wings to grimaces on a linebacker's face.

This technology — whether hooked up to your cable feed, DVD player, wi-fi or computer — is also becoming integral to daily life. It increasingly provides the platforms on which we shop, share photos, read books, keep up with friends, play games, manage finances and work. In 2011, the global flat-panel screen industry shipped more than $120 billion worth of products, enough to cover nearly 16,000 football fields.

However, our love of flashy high-res has a dark side. Manufacturing the semiconductors behind these electronic systems produces waste, lots of it. "The electronics and solar industries build devices where the materials input is very high relative to what ends up in the product. There's tremendous amounts of waste and very high energy input," says Doug Keszler, Oregon State University chemist.

Keszler and a team of scientists and engineers at Oregon State and the University of Oregon are leading a national consortium (see "Partners in Science") bent on greening the flat-panel display industry. In their future, windows, mirrors, walls and counters could display messages and harvest solar energy. "We're trying to turn this industry into a truly zero-waste proposition while improving performance," says Keszler, a principal scientist in the Center for Sustainable Materials Chemistry (CSMC). "We'd like to do electronics the size of a wall. The question is: How do you do that efficiently without producing even more waste?"

New materials and water-based manufacturing may be key to reducing waste in the semiconductor industry, says Doug Keszler. (Photo: Jeff Basinger)

Startups provide jobs

The CSMC has already produced significant results: a metal-insulator-metal diode (a kind of electronic switch) that outperforms the fastest silicon-based semiconductors; water-based manufacturing techniques that reduce waste and improve productivity; high-resolution fabrication processes that forge thinner electronic components. With research roots going back more than a decade at OSU and UO, the center has spun off two startup companies, generated more than a dozen U.S. patents and developed an educational partnership to inspire more Oregon high-school students to attend college. It also helps graduates to create their own careers. In cooperation with the National Collegiate Inventors and Innovators Alliance, CSMC students join business leaders in the chemical and electronics industries to identify commercial opportunities stemming from research.

"About two-thirds of all Ph.D. graduates in the physical sciences now find their first job in a startup company," says Keszler. "There is very little education to prepare students for that career path. We train them to recognize market value in their research, so they can work effectively with entrepreneurs and business development people."

Two startups have already hired the center's graduates. Amorphyx (www.amorphyx.com) is commercializing a new electronics manufacturing process that limits the production of unwanted industrial byproducts. Moreover, it trims a six-part process to two steps, offering the possibility of tripling production capacity in an existing facility.

In collaboration with another spinoff, Inpria (www.inpria.com), the center has broken a barrier in high-resolution circuitry, going below the 20-nanometer scale and enabling computer chips to accommodate more functions at higher speeds.

These achievements reflect gains reported by Oregon State engineer John Wager, physicist Janet Tate, graduate student Randy Hoffman and other researchers as early as 2003. They noted that transparent thin-film transistors made of zinc oxide could lead to new kinds of liquid crystal displays, the dominant type of flat-panel screen. In 2006, HP licensed the technology and has been developing applications in collaboration with OSU.

At UO in 2003, researchers in Darren Johnson's chemistry lab discovered a solution-based process for making nanoclusters, leading to the possibility that new semiconductors could be made without hazardous chemicals. Jason Gatlin, the UO graduate student who discovered the process, instigated a new UO-OSU collaboration when he shared his findings at a conference sponsored by the Oregon Nanoscience and Microtechnologies Institute.

"We're pushing the boundaries of science and seeing things no one has ever seen before," says Keszler. "There's a lot of joy in the intellectual exchanges in such a diverse group."

To attract more young scientists to their journey, CSMC students will begin working with Hermiston High School teacher Lisa Frye and her chemistry classes this fall. They will provide support, advanced instruction and resources to inspire high-school students to consider careers in science.

"What we're after over the next 10 years," says Keszler, "is to put the (industrial) ecosystem together that allows you to print electronics on flexible glass. They will be high-performance, durable, and include applications such as solar collectors."

We've come a long way from the futuristic idea of hanging TV screens like paintings on the walls of our homes. terra

PARTNERS IN SCIENCE

The Center for Sustainable Materials Chemistry has been created through a collaboration of state, federal and private-sector partners.

FUNDING

- National Science Foundation
- Oregon Nanoscience and Microtechnologies Institute (ONAMI)
- Hewlett Packard
- Corning

FEDERAL LABS AND AGENCIES

- Los Alamos National Laboratory
- Argonne National Laboratory
- Lawrence Berkeley National Laboratory
- National Institute of Standards and Technology

UNIVERSITIES

- Oregon State University
- University of Oregon
- Eastern Oregon University
- University of California, Berkeley
- University of California, Davis
- Washington University
- Rutgers
- Clemson
- Central Washington University

BUSINESS AND INDUSTRY

- Hewlett Packard
- Corning
- Intel
- Boeing
- Sigma-Aldrich
- IBM
- General Electric
- Inpria
- Amorphyx

Science Without Borders

Want to do science today? Make sure your passport is up-to-date.

BY RICK SPINRAD, VICE PRESIDENT FOR RESEARCH

WHEN LAND GRANT UNIVERSITIES were created 150 years ago, science was already an international activity. Well before the signing of the Morrill Act in 1862, American scientists aboard six U.S. Navy vessels had circumnavigated the globe, collected thousands of plant and animal specimens and mapped parts of the Pacific Ocean from the Columbia River to Antarctica. In 1859, Charles Darwin published his theory of evolution partly on the basis of a worldwide voyage aboard the *HMS Beagle*. The world's first international scientific conference was held in 1860, two years before President Abraham Lincoln set the land grant research and education engine in motion.

These universities — the people's colleges as they were called then — are a singular American innovation. They put a college education and the world's collected knowledge within the reach of everyday people and focused their energies on such practical endeavors as agriculture and engineering. And they have made global impacts (think the Green Revolution or the computer). They have also made global opportunities available to the sons and daughters of every state, regardless of income or social class.

My own career as an ocean scientist, begun through connections made at Oregon State, has taken me to South America, Africa, the Mediterranean and more than a few unlikely places, such as a cattle-hauling freighter in the Congo River. By its very nature, oceanography is an international endeavor. Ocean currents and ecosystems have no respect for political boundaries.

While we are committed to this state — its people, governments and businesses — international collaborations are also crucial to our mission. Our researchers, faculty members and students alike, work on transdisciplinary projects on every continent. In *Terra*, you can read about students building water systems in Africa, studying dolphins in the South Pacific and food science in France. Our anthropologists and agronomists are at work in India and China. Our geologists are studying the Himalayas and the Andes. Our chemists work with colleagues in Scandinavia, Germany and France. Water resources scientists advise the United Nations and national governments. Public health researchers work in Africa, Mexico and Taiwan.

In the Oregon State Research Office, we regularly review proposals from faculty members who are being recruited for international projects, but their work pays off for Oregon. It gives them a rich perspective on the world and enables them to train our students with the latest knowledge. And our graduates help Oregon businesses (farmers, equipment manufacturers, apparel design companies) compete in the global marketplace.

There are still important challenges to address in managing this far-flung enterprise. The volatility of the global economy means that 3-month-old financial agreements might need to be renegotiated. Concerns about protecting national commercial interests raise regulatory compliance issues, which dictate careful, sometimes complicated considerations about access to equipment and materials. And, despite translation apps and cultural competency training, the Tower of Babel is still standing (How do you say "earned value management principles" in Farsi?).

Just as technology links the world economy and events echo within minutes across the globe, researchers collaborate across international boundaries in ways unimaginable only a generation ago.

Wheat for the West

Land grant research catapulted wheat farming into an economic power that feeds the world

BY NICK HOUTMAN

Wheat made the West. Pioneers brought seeds in practically every wagon on the Oregon Trail. It fed farm families in the Willamette Valley and miners in the John Day and California gold-rush towns. It was currency and foreign exchange. Today, the partnership between scientists and farmers — envisioned by the creators of the land grant university system — has more than doubled yields, held diseases at bay and generated revenue for Northwest economies. Here are some of the milestones.

1833: FIRST RECEIPT

Robert Ball records the first sale of wheat in the Willamette Valley.

1862: PEOPLE'S UNIVERSITIES

Abraham Lincoln signs the Morrill Act to establish land grant universities.

1910: BETTER WHEAT

In Sherman County, Oregon Agricultural College opens the first Agricultural Experiment Station focused on wheat variety selection.

1948: BREEDING CHAMPIONS

Oregon State University begins its wheat-breeding program under the direction of Wilson Foote.

1961: LEGENDARY HIRE

Warren Kronstad directs the wheat-breeding program.

1975: GLOBAL IMPACT

Oregon State's Eastern Oregon research in dryland wheat production is shared through international training programs. Kronstad partners with about 200 programs worldwide.

1978: TOP VARIETY

Oregon State releases Stephens, which quickly becomes one of the most successful varieties in the Northwest. It increased wheat revenues about $25 million per year between 1981 and 1984.

2001: BANG FOR THE BUCK

Oregon State Crop and Soil Science researchers developed a new nitrogen mineralization test to help wheat growers reduce fertilizer applications and save money.

2003: HERBICIDE RESISTANT

Clearfield wheat, released by Oregon State in cooperation with the German chemical company BASF, becomes Oregon's most widely planted variety.

2010: REVENUES FOR RESEARCH

Clearfield wheat royalties to Oregon State top $1 million, providing additional support for wheat research. The Port of Portland leads the nation in wheat exports.

2011: NEW LEADER

Robert Zemetra arrives at Oregon State as Kronstad Wheat Research Endowed Chair.

2011: SETTING THE BAR

Oregon farmers produce a record-breaking 80.5 million bushels, earning $521 million in farmgate revenues. Yield per acre (81 bushels) was double that achieved in 1977.

Business Partnerships

Private support, technology licenses lead increase in Oregon State research revenues

Oregon State University recorded its second-best year ever in research funding in the last fiscal year, which ended June 30, hitting new milestones in research support from the private sector and in technology licensing.

Oregon State research totaled almost $281 million last year, just shy of OSU's top research record in 2010. Meanwhile, private-sector financing reached nearly $35 million, a 42 percent increase in two years.

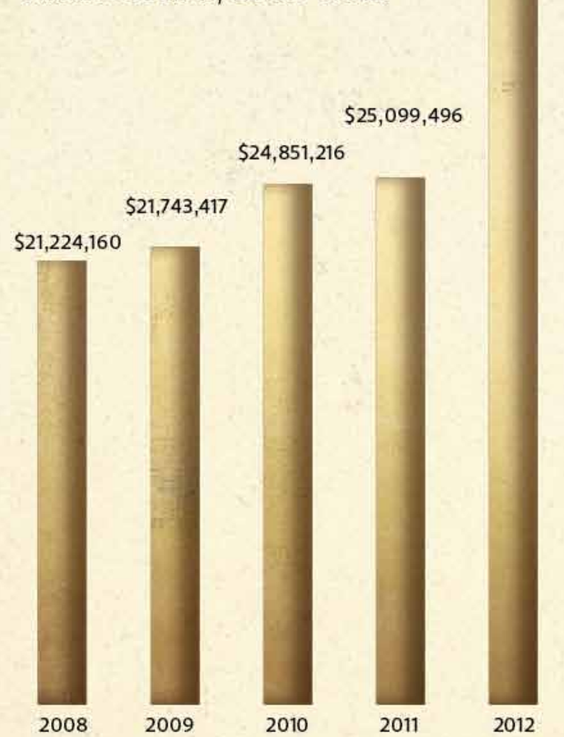
"Research produces revenues for practically every sector of Oregon's economy. It's our best bet for moving the state forward," says Rick Spinrad, vice president for research at Oregon State.

Industry funding included testing services, environmental analysis, prototype development and licensing fees for the use of OSU-developed intellectual property. Businesses partnering with the university ranged from global corporations (HP, Intel and British Petroleum) to Oregon companies (NuScale Power, Voxtel, Precision Castparts and Benchmade Knives).

Among companies signing licenses with Oregon State were three new startups: Applied Exergy (energy storage), Microflow CVO (chemical mixing) and CLJV (forest products). Since 2006, OSU has spun off 11 companies that have attracted more than $180 million in capital investment.

OSU signed 108 new licenses, a 277 percent increase, with companies in fields from biotechnology and forest products to agriculture, healthy aging and manufacturing.

Industry supports Oregon State research, 2008-2012



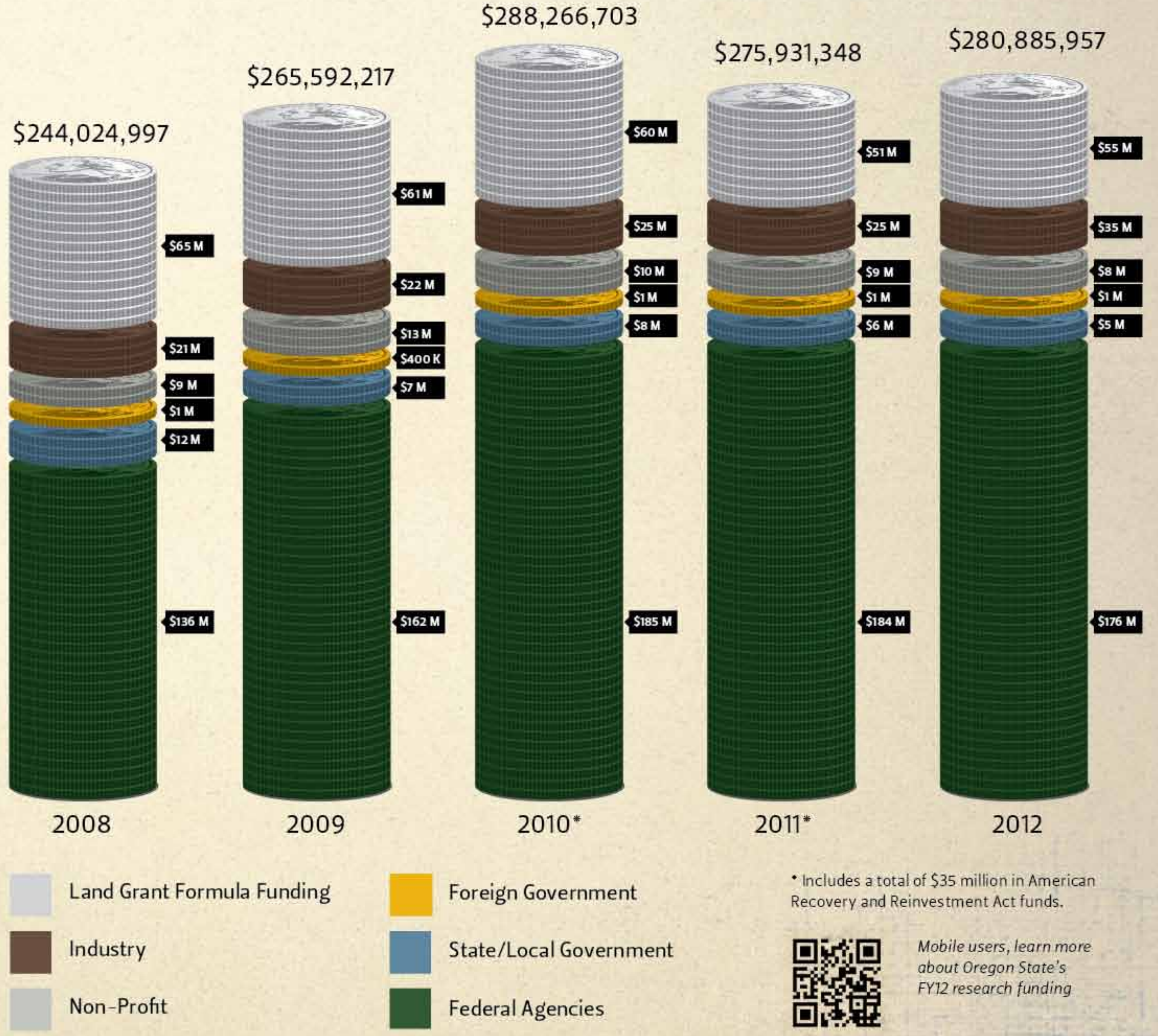
OREGON STATE'S LARGEST GRANTS IN FY12 CAME FROM FEDERAL AND STATE AGENCIES. EXAMPLES INCLUDE:

- **$12 MILLION** for the sustainable materials chemistry center (National Science Foundation) See "Behind the Screens," Page 32.
- **$7 MILLION** for nutrition research and assistance (Oregon Department of Human Services)
- **$3.9 MILLION** for research to address the growing threat of childhood obesity (U.S. Department of Agriculture)
- **$3.7 MILLION** for research in support of coastal communities (National Oceanic and Atmospheric Administration)
- **$3.4 MILLION** for a multi-agency ocean research program housed at OSU's Hatfield Marine Science Center in Newport (National Oceanic and Atmospheric Administration)
- **$2.9 MILLION** for the study of diet in cancer prevention (National Institutes of Health)
- **$2.8 MILLION** for new ways to monitor air and water pollution by polycyclic aromatic hydrocarbons (PAHs) and to protect human health (U.S. Public Health Service)
- **$1.9 MILLION** to support ocean research through ship operations (National Science Foundation)
- **$1.9 MILLION** to study methods for producing biofuels from woody debris (U.S. Department of Agriculture)
- **$1.9 MILLION** for development of aquaculture methods in developing countries (U.S. Agency for International Development)

Lead Research Growth

"It's about more than just the economy. Research also saves lives. It guides policies that protect public health and reduce the impact of natural hazards in our communities."
Rick Spinrad, Vice President for Research

Sources of Oregon State research funding



* Includes a total of $35 million in American Recovery and Reinvestment Act funds.

Mobile users, learn more about Oregon State's FY12 research funding

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Zachary Dunn dances with a Kenyan woman named Penina and other members of the Lela Women's Water Committee. See "Far and Away," Page 28. (Photo: Justin Smith)