

terra

DISCOVERY | CREATIVITY | INNOVATION • Fall 2017

COME AND GET IT!

Krill set the table for penguins, whales and their kin.
Will the banquet end?

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Oregon State
University

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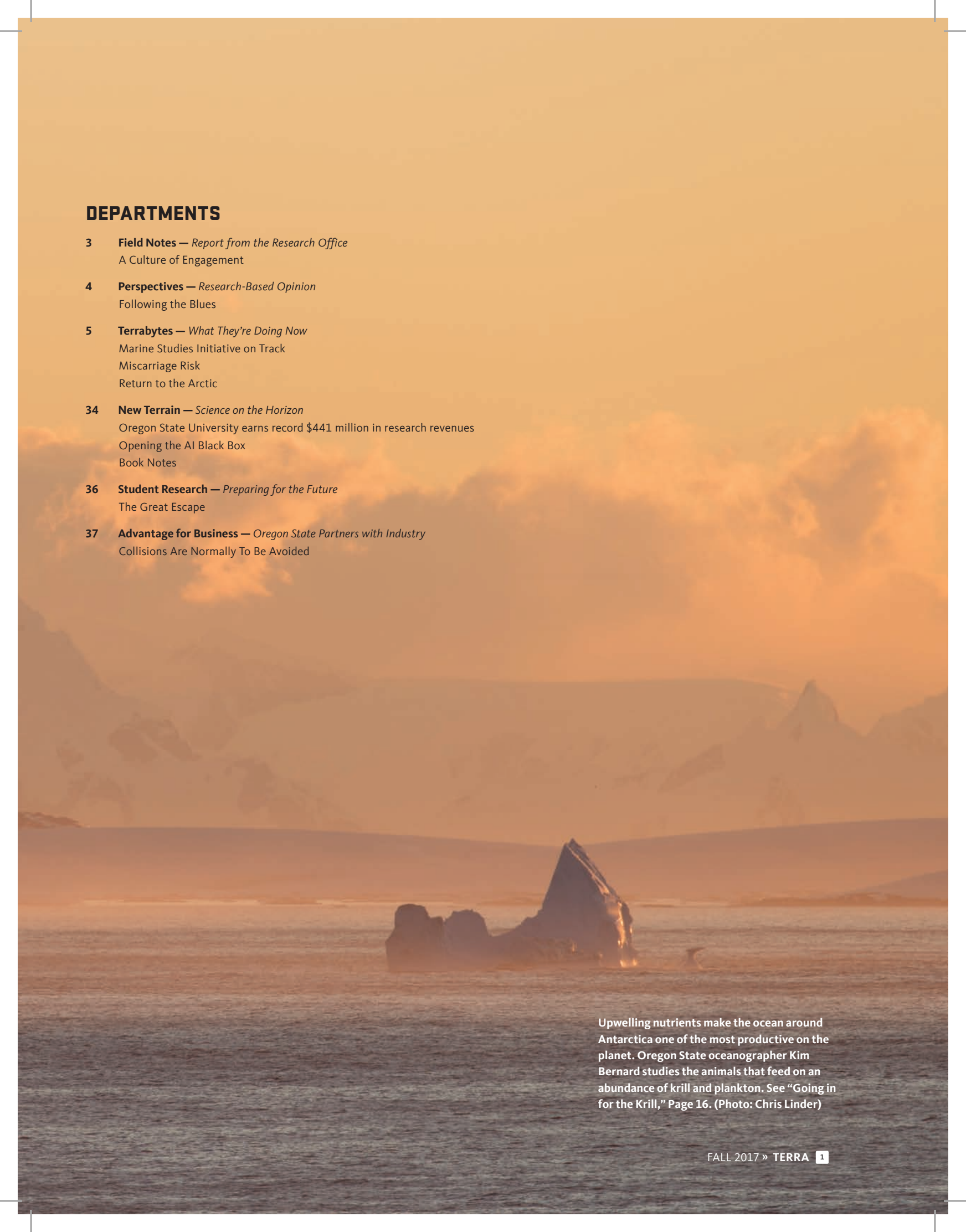
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The liberal arts are at the heart of the land grant university mission. For 150 years, Oregon State scholars have been celebrating the human experience.



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Upwelling nutrients make the ocean around Antarctica one of the most productive on the planet. Oregon State oceanographer Kim Bernard studies the animals that feed on an abundance of krill and plankton. See “Going in for the Krill,” Page 16. (Photo: Chris Linder)

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Oregon State is Oregon's leading public research university with more than \$441 million in research funding in FY2017. 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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Photo by Chris Linder.



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SCIENCE WITH A HUMAN FACE

When I was a boy, I cared more about Willie Mays and the San Francisco Giants than just about anything else. My grandfather, a chemical engineer, had other ideas. He bought me a chemistry set. The metal case opened to show rows of small bottles filled with powders and solutions. There were test tubes for concocting mixtures and a kind of cookbook to guide me through the wonders of chemical reactions.

One year, Opa (as Dutch kids call their grandfather) gave me a 4-inch-thick edition of Van Nostrand's Scientific Encyclopedia. He sprinkled iron filings on a piece of paper to show me how magnets work. However, despite his best efforts to inspire another scientist in the family, I followed a different path. I was attracted to ideas and events with a human face: history, politics, language — in short, the humanities.

So I pursued journalism and economics in college and worked as a reporter for a local newspaper in rural Wisconsin. I wrote stories about education and the struggling farm economy. But I was also drawn to questions about how things work: a farmer's computerized milking system, pesticide contamination in local wells, an inventor's claim of a perpetual motion machine.

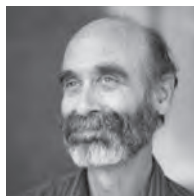
I enjoy stories that connect people with science. I learned why the inventor's machine would eventually stop and how a pesticide might wind up in someone's drinking water. But while physical principles illuminate a process, it's the human story that brings them to life.

Such stories are central to the liberal arts. In recognition of OSU150, the celebration of Oregon State's land grant designation, this issue of *Terra* looks at the arts and humanities at OSU (see "From the Margins to the Center," Page 26). Gordon Gilkey was a leading figure in the drama. He led the transformation of the liberal arts from "lower division" standing to a full and equal partnership with other colleges. I expect he'd be thrilled to see OSU's ongoing efforts to integrate the arts and humanities with science and engineering, especially plans to create the "great hall" for education and the performing arts that he envisioned.

Opa once told me that the chemists who worked for him knew their science but often lacked the writing skills to share their knowledge. Research needs to be communicated so that people can understand and appreciate the benefits. The liberal arts and the sciences need each other.



1940s Gilbert chemistry set. (Photo: Joe Mabel)



Nick Houtman

Editor



A CULTURE OF ENGAGEMENT

Vital work in a 21st century land grant university

BY CYNTHIA SAGERS, VICE PRESIDENT FOR RESEARCH



The shouts of children echo through the halls, gym and swimming pool of the Women's Building on campus. It's IMPACT day, a typical Friday in the College of Public Health and Human Sciences. These kids with special needs are developing new skills, and the Oregon State students who guide them are getting an invaluable educational experience.

Beyond the campus, Latino high school students and their families are meeting in weekly workshops, after-school clubs and summer camps. They are also visiting college campuses. The program called Juntos (meaning "together" in Spanish) is raising graduation rates and academic achievement. It is offered by OSU Extension in more than 20 school districts across Oregon.

In coastal communities from Port Orford and Newport to Astoria, OSU is partnering with community colleges and other local organizations to expand educational opportunities and ensure the resilience of our ocean-based economy. The Marine Studies Initiative builds on the university's longstanding commitment to the coast. The MSI draws strength from an oceanography research community ranked No. 3 in the world on the basis of scientific publications.

I could cite many more examples that underscore Oregon State's "Community Engagement" classification by the Carnegie Foundation for the Advancement of Teaching. OSU is the only Oregon university to hold both that distinction and the foundation's ranking for "very high research activity."

These two recognitions go hand in hand. OSU students benefit from the experiential opportunities and research that stem from the communities in which they live and work. This kind of education doesn't happen in a bubble. It reflects the practical issues and needs that shape our neighborhoods, state and nation. It is informed by the daily lives of people who make their living from the land and sea and strive for a better future for our children.

As a 21st century land grant university, OSU research combines this commitment to practical application with support for basic, curiosity-driven work. This strategy emerged from lessons learned by the "greatest generation," our predecessors who struggled through the Depression and World War II. The advances in science and technology they unleashed led to America's global leadership in innovation. This reputation attracts students from around the world to Oregon State and other American universities.

In this issue of *Terra*, we share some of that work. We explore what's known about brain injury and athletics, a growing concern for coaches, athletes and parents. We consider how hunting by indigenous people affects wildlife populations, how solar electricity can succeed in some of the world's most remote corners and how rising seas might spur future migration across the country.

As we embark on OSU's yearlong 150th anniversary celebration, we share our research journeys and welcome citizens into the day-to-day work. It is in the shouts of the children, the accomplishments of our students and the solutions to difficult problems where we find the real value of what it means to carry out the land grant mission, "to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life," as the Morrill Act of 1862 directed us to do.

Top: IMPACT day in the College of Public Health and Human Sciences. Middle: Sampling estuary water. (Photo courtesy of Oregon Sea Grant Marine Education Program) Bottom: A remotely powered radar station in the Antarctic. (Photo: Chris Linder)





FOLLOWING THE BLUES

Science in service to whale recovery

BY BRUCE MATE, DIRECTOR, OSU MARINE MAMMAL INSTITUTE



Nothing prepared me for snorkeling with a sperm whale. I felt the pressure of its acoustic probing in my chest. I trusted its sonogram would reveal my bones, so the whale would know I wasn't a squid, its normal food. But there was that moment of doubt at 20 feet away that brought me face-to-face with my mortality.

That experience only deepened my sense of respect, scale and awe for the magnificent animals we call "whales." You may get the feeling of size and other-worldliness by watching gray whales spouting off Depoe Bay or humpbacks breaching near Cannon Beach. Regrettably, not all whales have recovered from commercial whaling. While the grays have done very well, others are still struggling. In the vast Antarctic, whalers killed 366,000 blue whales from 1900 to 1950, taking them close to extinction. With 50 years of full protection, blues have made modest gains, but the Antarctic population is just 2,000, less than 1 percent of what whalers killed. The eastern North Pacific (ENP) has about 1,700, perhaps 30 percent of the worldwide population.

Oregon State scientist Kim Bernard's discovery of an enormous Antarctic krill patch (see "Going in for the Krill," Page 16) is good news for blues there, which dine almost exclusively on these shrimp-like crustaceans. Marine Mammal Institute (MMI) scientist Leigh Torres uses drones to study the energy demands and resources of New Zealand blues that forage on surface krill. The MMI Telemetry Group tags whales with sensors to describe their feeding during deep dives in the eastern North Pacific. Researchers know the fate of blue whales is tied to krill.

Unfortunately, since 2014, two Pacific Ocean warm-water "blobs" and an El Nino have been unfavorable for krill. Blues normally stay in coastal waters off California, Oregon and Washington during the

summer and fall because krill are usually abundant. However, when krill are scarce, the whales just keep moving, trying to find dense krill patches. MMI scientists found that 50 to 80 percent of the blues they approached off California were too skinny to tag, and few calves were seen.

Our recent studies have shown that some blue whales swim south to reproductive areas two months earlier than usual. We suspect they are finding less abundant but possibly more dependable feeding opportunities. Something is better than almost nothing.

We are committed to understanding what changing ocean conditions mean for blue whales and other marine life. Fortunately, OSU is up to the task because of extraordinary support from donors who share our passion for the ocean. The institute will occupy part of the new marine studies building being constructed at the Hatfield Marine Science Center in Newport. MMI scientists hope to be mentoring OSU undergrads with the latest research findings on whale ecology.

MMI doesn't do this work for its own sake. We want our findings to improve conservation and management practices. Tracking tells us about where, when and how whales migrate between reproductive and feeding areas. By determining seasonal habitats and behaviors that put whales at risk, we can help reduce unintentional human impacts. We've already helped reduce the number of whales hit by ships.

When it comes to environmental change, we know that there will be winners and losers. We want to identify the issues that determine how whales adapt and rebound so our children's children can see healthy populations of whales and experience the deep feelings of respect and awe these whales instill in us today.

(Photo: Flip Nicklin)





MARINE STUDIES INITIATIVE ON TRACK

Fisheries, ocean acidification on the research agenda

The chemistry of Oregon's coastal waters and the health and productivity of fisheries have become high priorities for Oregon State University's Marine Studies Initiative. The MSI links research, a new academic program and coastwide collaboration, says Jack Barth, executive director of the MSI and a professor in the College of Earth, Ocean, and Atmospheric Sciences.

"The MSI brings the liberal arts and sciences together to address challenges facing our coastal communities and the oceans," says Barth. "The Port Orford Field Station and the new facility due to be built in Newport add to the great network we already have through the Experiment Station, Extension and Oregon Sea Grant."

Groundbreaking for the new \$50 million MSI building is anticipated next spring with completion in 2019.

Private support launched the MSI effort and has continued to be key. In the last year, research on the biology of Oregon's largest fishery, Dungeness crab, has received a boost from Bob Eder and Michelle Longo Eder, leaders in the coastal fishing community. "They see the MSI as the connector to get this work done," says Barth. Previously, The Schmidt Family Foundation contributed to the ongoing effort to study ocean acidification and to develop courses based on the latest research.

The College of Liberal Arts will be the home for a marine studies degree program, which is making its way through the academic review process. New classes, Barth notes, will have a cross-disciplinary emphasis.

See more about the MSI in the spring 2016 issue of *Terra*.

MISCARRIAGE RISK

Vitamin E deficiency linked to embryo damage, death

Researchers for the first time have explained how deficient levels of vitamin E can cause neurologic damage to an embryo, failure to normally develop and death – a process that in women can be a cause of miscarriage.

The research answers some questions about vitamin E that have been debated since 1922, when this essential micronutrient was first discovered in part for its role in preventing embryonic mortality.

"In the growing embryo, vitamin E plays a major role in protecting essential fats," says Maret Traber, the Helen P. Rumbel Professor for Micronutrient Research in the College of Public Health and Human Sciences. She is also affiliated with the Linus Pauling Institute at Oregon State.

"Loss and oxidation of these fats can begin a chain reaction that involves glucose, depletes the cell of other antioxidants such as vitamin C, robs the cell of energy and ultimately has a lethal outcome."

To learn more about Traber's work, see "To Conquer Vitamin E" in the summer 2006 *Terra*.



RETURN TO THE ARCTIC

OSU oceanographers on the R/V Sikuliaq

A science team led by Oregon State oceanographer Laurie Juranek returned to the Arctic Ocean last summer to gather data on trends in plankton growth. They targeted areas northwest of Alaska that had been covered with ice during their first trip to the region in 2016.

As the summer ice pack continues to diminish in thickness and extent, researchers want to know how phytoplankton and other organisms at the base of the food chain are responding. With funding from the National Science Foundation, scientists are analyzing ocean chemistry and other signs of changing food webs.

This year, they also added a new wrinkle: the concentration of tiny bits of plastic in ocean sediments.

See "Altered Arctic" in the winter 2016 *Terra* and science writer (and Oregon State alumna) Kim Kenny's blog at thedynamicarctic.com.



The Matsigenka people of the Peruvian Amazon lived in relative isolation from Western influences until the 1960s. In 2004, OSU ecologist Taal Levi lived with the Matsigenka and studied their hunting practices.

HUNTERS AND THEIR PREY

Taal Levi wants humans and wild animals to coexist

BY DANIELLE JARKOWSKY | PHOTOS COURTESY OF TAAL LEVI

The Matsigenka people of the Peruvian Amazon hunt with surefooted agility. They can scale a tree without low branches in seconds and cross a ravine on a narrow log without hesitation.

They didn't think Taal Levi was up to the challenge. It takes skill and stealth to hunt monkeys, among other animals, with a bow and arrow. And then there are the herds of wild pigs, aka peccaries, which are known to use their tusks to attack anything that threatens them.

So in 2004, when Levi asked to join a Matsigenka hunting party, the hunters were reluctant. He grew up in Los Angeles and had just completed a bachelor's double degree at UC Berkeley in physics and biology. As a field technician on a crew from the University of East Anglia, he was studying the impact of hunting on the animals that the Matsigenka depend on for survival. Despite the hunters' fears, they let Levi join monkey and peccary hunts near their settlement in Manu National Park in the Amazonian rainforest.

The Matsigenka have been hunting sensitive species such as tapirs and woolly and spider monkeys with bows and arrows for thousands of years, but there was growing pressure to remove indigenous settlements from the park. Levi and his colleagues weren't so sure that native hunters threatened the sustainability of wildlife.

The results of the study helped to settle the argument, at least for the time being. Publishing in *Conservation Biology* in 2007, the researchers showed that traditional bow-and-arrow hunting had not significantly depleted woolly and spider monkey populations.

Two years later, in a follow up study in the *Journal of Applied Ecology*, Levi and his colleagues used mathematical models to apply the same data to a future scenario. Under current conditions, the scientists projected that hunters would not appreciably reduce spider monkey populations over the next 50 years, even if the human population were to grow and spread out.

However, the use of guns would change the picture dramatically. "If they switch to guns," says Levi, "you need to restrict where humans can live with zoning or by providing infrastructure that people want — or the monkeys are toast."

These studies helped to shift the discussion. Hunting with bows and arrows was no longer seen as incompatible with conservation. Officials permitted organizations to bring clean-water systems and other improvements to indigenous villages in Manu.

Science for Life

Just as Levi's research laid the foundation for a new relationship with native people, it helped launch his scientific career. Today, he is a wildlife ecologist and assistant professor in Oregon State University's Department of Fisheries and Wildlife. He uses mathematical modeling to explore questions about how humans and wildlife can coexist. The issues are cultural and biological, relevant to people everywhere who hunt and fish to survive. The topics in the Amazon would be familiar to hunting and fishing communities across the West: the ability of local people to maintain their livelihood, the conservation of animal species, the relationship between science and traditional knowledge.

Levi hopes his contributions will allow community-based programs and science-led conservation to inform decisions about managing natural resources for the benefit of nature and people.

Hunting is not his only interest. For him, the relationship between humans and wild animals turns in many directions: the



Matsigenka men make arrowheads designed for hunting small birds. With a large rock-like cone and a sharp point, even if the point doesn't strike the bird, the cone can still mortally wound the bird.

spread of Lyme disease, low carnivore abundance in North America, sustainable salmon practices in Alaska and the impact of disease-carrying insects on human health in South America.

According to Jennifer Allen, environmental genetics lab manager in the Levi lab at OSU and Levi's life partner, he has a photographic memory and one-track mind for science. "He is full of ideas and has his foot in many doors. He is social, collaborative and wants to be inclusive of everyone. If the project is cool, he wants to do it."

This future wasn't apparent to Levi during his youth. His parents didn't go to college, but his curiosity and love for solving puzzles guided his choice to study physics. During summer breaks, helped by his ability to speak Spanish, he traveled in Central and South America, volunteering with indigenous rights nonprofit groups and studying tropical ecology.

He enjoyed being outside, experiencing life first-hand rather than being in a lab studying physics, so in his fourth year he added biology as a second major. "Physics is good prep for biology," he says. "I see

a biological problem and think how to characterize the system."

People Versus Parks

The 2004 study was motivated by an assertion from one of the world's leading tropical ecologists, John Terborgh. In his 1999 book, *Requiem for Nature*, the member of the National Academy of Sciences argued that hunting should be banned in national parks. Terborgh first went to Manu in 1973 and helped run the Cocha Cashu Biological Station there for about 30 years. Reflecting on the mission of parks in the United States, he also wrote that people should not live in parks. Expanding human populations, he said, would threaten the purposes for which parks were established.

In response, Levi collaborated with ethnobotanist and anthropologist Glenn Shepard from the Goeldi Museum in Brazil and with tropical ecologists Douglas W. Yu and Carlos A. Peres, both at the University of East Anglia. They wanted to determine if Terborgh's assertions were justified. Terborgh questioned the right of the Matsigenka — whose population

in the park has about quadrupled since Terborgh first went to Manu — and other indigenous people to live, hunt and farm on parklands.

As he prepared to immerse himself in the yearlong project, Levi learned to speak Matsigenka by studying a dictionary created by missionaries who had tried to convert the tribe to Christianity. "On my first expedition into Manu, I was with Glenn (Shepard) who is a linguistic genius," Levi says. "He knows a bunch of indigenous languages; he can read and write French, German, English, Spanish and Portuguese. He helped me become proficient in Matsigenka."

The scientists focused on bow-and-arrow hunting of some of the most harvest-sensitive species, the large primates. As part of the project, Levi's job was to teach the Matsigenka hunters to record their activities in detail: what animals they killed, how much the animals weighed, the animals' gender and reproductive status.

During post-hunt interviews, Levi gathered as much information as possible to learn where and how bow hunting happens: How far from the house did they go? What time of day? Which weapon was used? What animals did they see, pursue, shoot, hit and retrieve?

At first, the Matsigenka were reluctant to allow Levi to participate on the hunts, but speaking the language helped him gain



This Matsigenka woman is making a traditional cushma garment, a striped tunic, on a backstrap loom. Cotton is a native plant, and women spend long hours making thread with a drop spindle made of palm wood and clay.

their trust. “The major insights happened because I attended a bunch of hunts,” Levi says. “I realized just how bloody hard it is to kill a smart, agile spider monkey with a palmwood bow and a bamboo-tipped arrow.”

Career Epiphany

When Levi returned to the United States, he reflected on his year with Manu National Park’s animals, plants and people. He admired the Matsigenka’s connection with nature, the simplicity of having their needs met by the natural world. He had immersed himself in their community and culture and formed strong relationships. He had even become the godfather to a child, despite a priest’s initial objections due to Levi’s disdain for religion.

“I was assessing the moral landscape and my values. I thought, if we want monkeys and gorillas as species to exist, we need to find solutions to human-induced wildlife extinction,” Levi says. “I believe a species has a right to exist. I recognize that humans need to have good lives as well. I wondered, ‘How can we make these two goals compatible?’”

For Levi, it was a realization that integrated the mathematical modeling he had learned in physics with his biology background. By combining both fields,

he envisioned becoming a quantitative ecologist, a scientist who uses math and statistics to interpret ecological data.

He became excited by the notion that he could use a mathematical model like a surgeon’s scalpel to dissect relationships between humans and wildlife. Models could answer deep questions about the impact of future human population growth in Manu and elsewhere.

Levi’s path led to graduate school at UC Santa Cruz where he created models to project hunting impacts into the future and over large areas. His work enables wildlife managers and scientists to estimate hunting’s impact through a network of factors such as the number of hunters, wildlife population sizes, distances from settlements, types of weapons used and time into the future.

“I believe a species has a right to exist.”

—Taal Levi

policy and create strategies to get ahead of problems. He’s turned the models into a Windows-based software package for scientists and nonprofit organizations and is working on an app for smart phones. When there is no government-enforced wildlife management, indigenous communities could use it to create their own hunting regulations.

An App for Wildlife

Levi hopes these and other models can continue to help inform



As a graduate student, Taal Levi learned to hunt with a palmwood bow and arrows designed for killing monkeys. His bag was woven by men using rope made from the bark of a cecropia tree. His bracelet was a present made by cutting a ribbon of skin from an iguana.



As she nurses her own baby, a Matsigenka mother feeds manioc root to a young white-lipped peccary. These animals roam in herds of hundreds and are key granivores (animals that predominantly eat seeds) in tropical forests. They are often one of the most important wild meat items for humans.

With Levi's models, local communities can project the likely impact of hunting over a given area to determine how much land to designate as reserves and where to put them. The approach has drawn the interest of conservation groups such as the International Union for the Conservation of Nature. Outside of national parks, says the IUCN, sustainable-use tropical forest reserves "conserve ecosystems and habitat, together with cultural values and traditional natural resource management." The hope is that industrial development can be kept out of such areas. Otherwise, forests could be lost to oil and gas drilling, mining, ranching and agriculture.

After their work in Peru, Levi and Peres continued to collaborate on other aspects of tropical ecology. In 2013, they showed that large primates play a uniquely important role in dispersing seeds and maintaining the composition of tropical forests.

In 2016, Peres asked Levi to collaborate on another project, this time in Brazil's western Amazon basin. As Peres and co-author João Vitor Campos-Silva reported in the journal *Nature Scientific Reports*, communities had been overharvesting arapaima fish. The fishery had collapsed, and, after communities agreed to a management plan — counting fish and harvesting no more than 20 percent — fish populations rebounded dramatically.

Levi is using data from Peres and others to create models to help the locals set sustainable harvest limits. As with the Matsigenka, the goal is both biodiversity and food security. True to form, Levi is learning Portuguese.

And despite their differing views, Terborgh and Levi are now collaborating on a study of tree ecology and seed

dispersal. Terborgh admires Levi's applied approach to science, his ability to immerse himself within a community's customs and culture. "Taal is a rare individual with rare powerful quantitative skills, and he has a muddy-boots lifestyle," says Terborgh. "People with quantitative gifts usually live in imaginary worlds."

Nevertheless, Terborgh remains convinced that the expanding Matsigenka community threatens the park. "The Matsigenka population is doubling every 20 years," Terborgh says. "Nothing is sustainable in the context of a demographic explosion. What might be 'sustainable' today won't be tomorrow."

Levi doesn't view the Amazon as a novel laboratory. Rather, he cares deeply for its biodiversity and indigenous peoples. He values how nature's many attributes intertwine with human cultures. He brings an unpretentious confidence to the task of figuring out how the pieces fit together. This propels him to collaborate, to challenge conventional theories and study ecology through the lens of human well-being.

In his view, it will take science-based wildlife management to balance that well-being with nature. "Many conservation biologists have a mentality of preservation but not of management," he says. "I think that mentality of preservation is going to be very ineffective because so much of the land is occupied by people, and it's always going to be occupied by people, and you're never going to preserve it." **terra**

Editor's note: Danielle Jarkoswky is the internship coordinator for the Department of Fisheries and Wildlife.

Top right: This spider monkey was obtained as a baby after its mother was killed. Monkey hunting with bow and arrow is very challenging and typically requires isolating one individual for an extended chase that can last many hours. Mothers burdened with young are often slower, making them easier prey.

Below: A Matsigenka man makes barbed arrows designed for killing large game birds. He has ornamented the arrows with toucan feathers, and the fetching (the feathers that guide the arrow) is made from the feathers of a raptor.



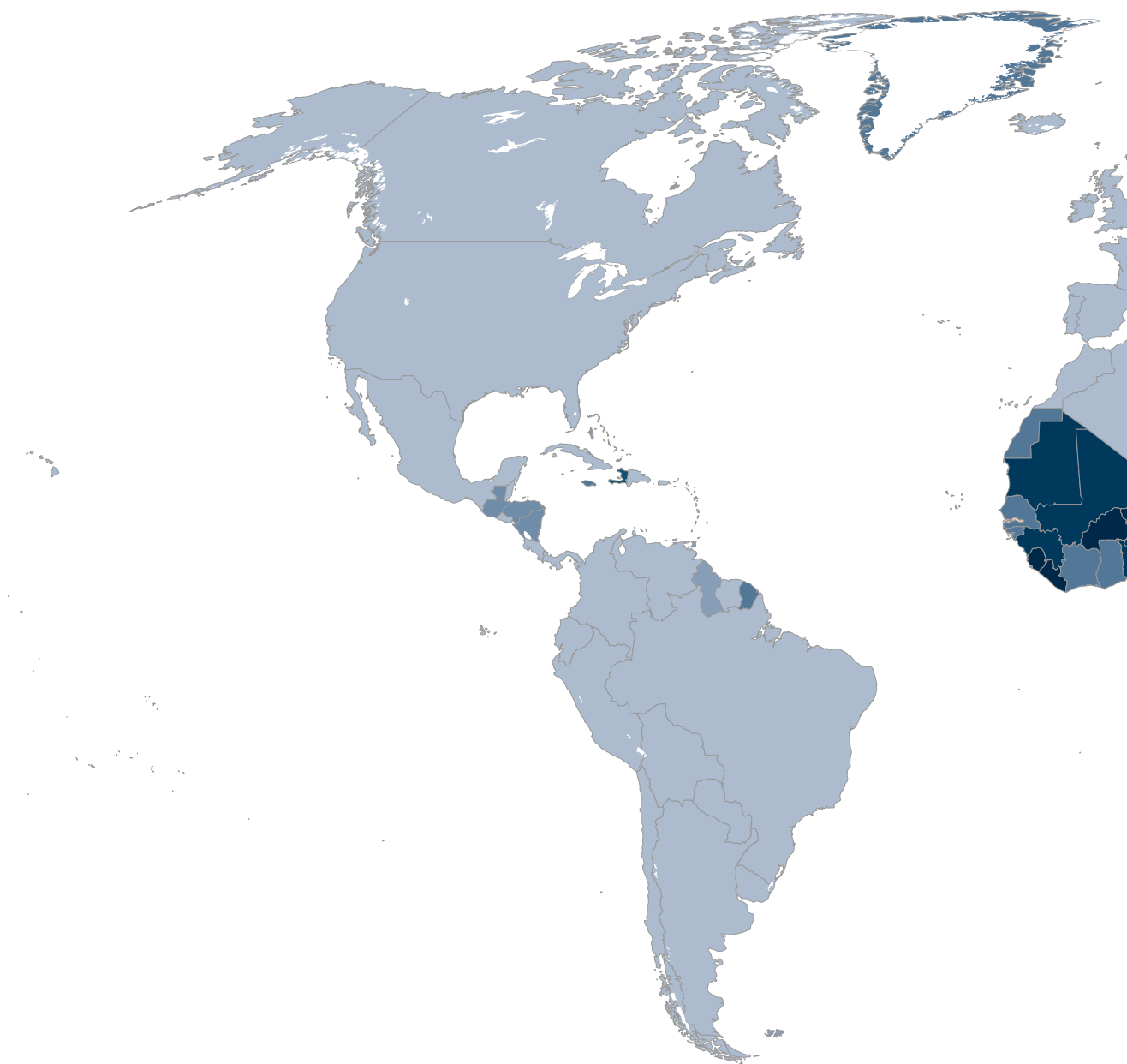
MANAGE THE HUNT, STORE THE CARBON

In 2016, in the *Proceedings of the National Academy of Sciences*, Taal Levi, Carlos Peres and colleagues reported that overhunting large fruit-eating mammals could result in losing an average of 2.5 to 5.8 percent of the forest biomass across the Amazon basin.

That may not sound like a lot, Levi says, "but in an area as vast as the Amazon, the impact could be huge – a projected 313 billion kilograms (345 million tons) of carbon not being absorbed."

Large fruit-eating mammals — especially tapirs and large primates — play a vital role in storing carbon in tropical forests. That's because they disperse the heavy seeds of dense, slow-growing fruit trees that store more carbon than do other types of trees.

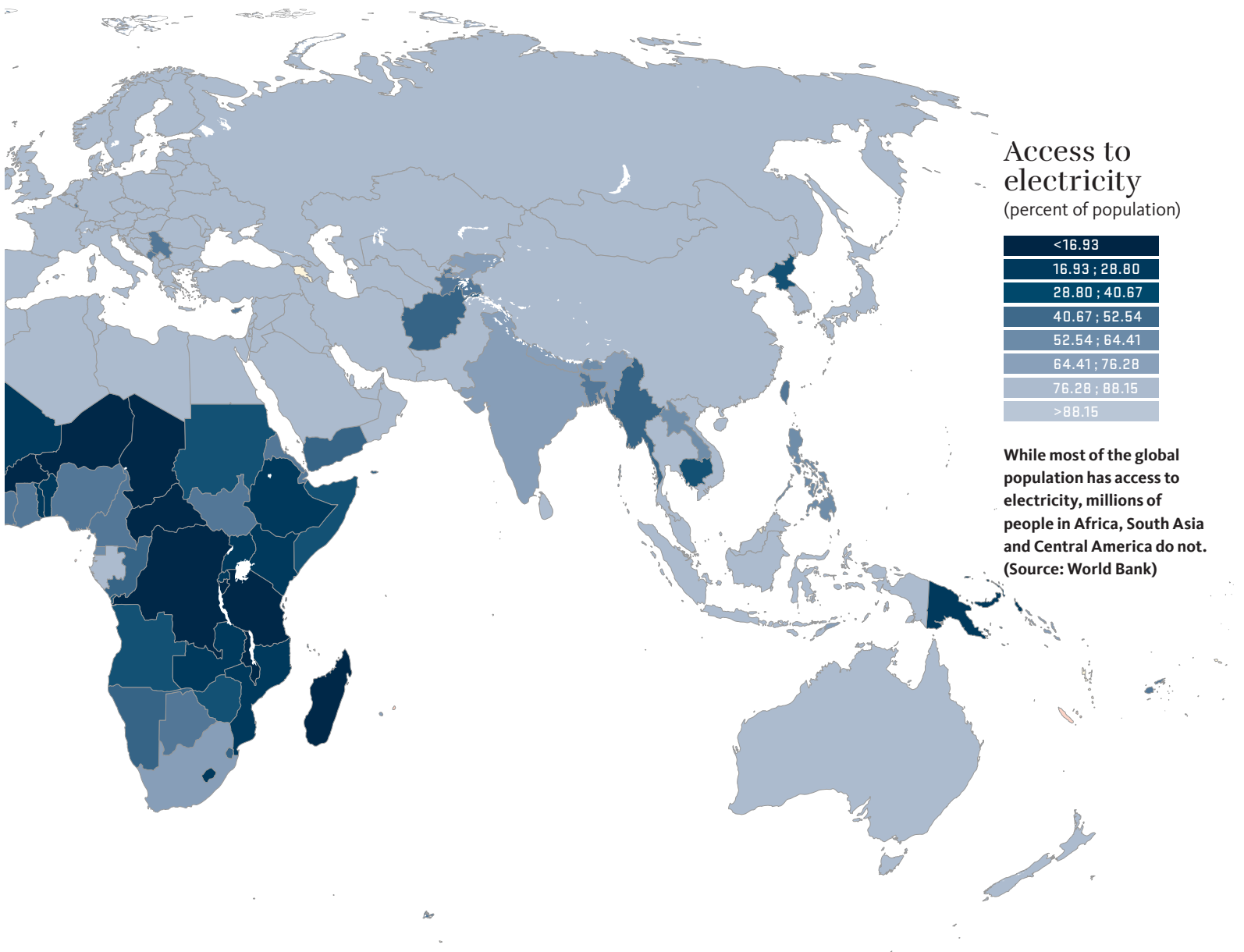
The researchers used a network of tree plots to simulate how forests might change if trees requiring seed dispersal by large primates were replaced with random trees from the same plot.



Solar Power to Rural People

It takes a different business model
to succeed in remote communities

BY MICHELLE KLAMPE



Flip a switch, and the lights come on. Insert a plug into an outlet, and the cell phone starts to charge. Turn a knob, and the stove burner begins to glow red. For many of us, access to safe, reliable electricity is an essential component of everyday life, at home, work or school. It's easy to forget how different life might be without it.

Yet electric power is still a luxury unavailable to more than 1.2 billion of the world's people. Most live in poverty in developing nations, in rural or isolated areas where steep costs, remote terrain and lack of technology make it impractical or even impossible to extend the electric grid. The barriers might seem insurmountable, says Inara Scott, an attorney and assistant professor in the College of Business at Oregon State University.

And yet, electricity can transform lives. Girls can study by electric lamp after the sun goes down. Women can run sewing machines or other small appliances to operate home-based businesses. Farmers can extend their harvest hours into the evening under

the glow of charged headlamps. Entrepreneurs can tap into financial systems using cell phones.

As the technology improves and costs come down, off-grid solar-energy systems present a potentially ideal path forward for communities in need of power. Solar could meet a basic need for millions of people without putting additional stress on our already taxed environment. But there are still many obstacles.

"The residents don't have money to invest in new technology," says Scott, whose research focuses on environmental law and sustainable business. "Charity doesn't seem to work. What people really want are jobs and the ability to define their own destiny."

Local Business

Undaunted, Scott is embracing the challenge through her work at Oregon State. She believes the solution may be found in effective social entrepreneurship, which marries strategies founded in market-driven enterprise with goals tied to social benefits.



In Ghana, solar panels provide power for aquaculture.
(Photo: John Selker)

“I’m extremely interested in the positive aspects of capitalism – how we can make enterprise and capitalism work in a positive way to solve challenges,” she says. “How can we use the system of entrepreneurship to make things better? Can you serve people’s needs while meeting societal goals and financial goals?”

In a recent study of organizations delivering off-grid power to this market, known as the “base of the pyramid,” Scott has found that success requires addressing the needs of each community. She has shown that effective enterprises combine business savvy with partnerships and knowledge of the social fabric.

Many commercial, nonprofit and government organizations, she says, are driven by the spirit of social entrepreneurship, a desire to do good for others while also doing well personally and professionally, but they aren’t always finding an easy path.

“Social entrepreneurs tend to be motivated by really powerful values, but they don’t always know how to handle the business side of things,” Scott says. “Meanwhile, the rules of traditional business don’t necessarily apply in base-of-the-pyramid markets. But I think the market is growing and will continue to grow. I see a lot of interest in working in these areas.”

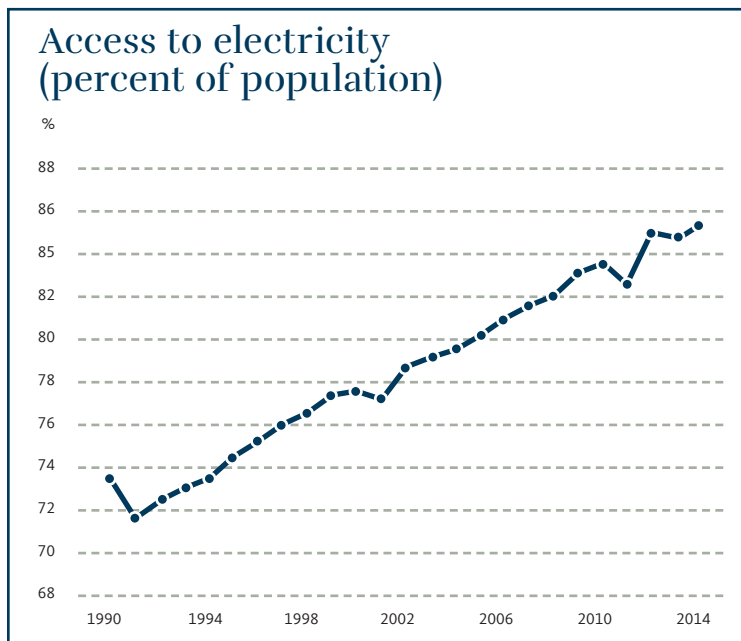
People in poor rural communities often lack access to financial resources, commercial institutions and markets that are needed to make a solar enterprise successful over the long haul. Even a small cost can be out of reach for people whose annual incomes are often less than \$3,000 per year, Scott says.

“You’re not going to be successful just trying to sell a product. This is really a social enterprise, with the goal of trying to bring people out of poverty while also emphasizing sustainable development. You want to create a positive cycle of development and growth, but surviving and growing in this market is very different than in a typical commercial enterprise.”

Building on Fundamentals

Nevertheless, the benefits aren’t just about the economy. “Energy access is enormously important for education and basic health and safety as well as for economic opportunities, and it’s critical for sustainable development,” Scott says. “Providing electricity starts an incredible cycle of improvement for communities without reliance on charities or government aid. There are also environmental benefits to encouraging sustainable development using renewable resources.”

The market for small solar lighting and charging units has grown dramatically in the last few years, and solar home systems offer cleaner, safer and cheaper lighting over time than kerosene, the



Access to electricity has been steadily improving over the past 28 years. (Source: World Bank)

primary alternative for lighting in developing nations. Health improves when light bulbs replace kerosene lamps and when indoor wood-fire cooking stoves give way to electric, reducing indoor air pollution dramatically.

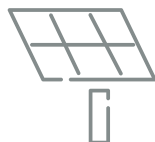
With her expertise in business and legal systems, Scott feels compelled to work on these issues. “I look at my own life and how lucky I am to live in the West, where resources are abundant. There’s a lot of suffering in the world. How do I, as a positive and moral person, help lift people out of that situation? That’s the end goal for me. I want to find ways to work with communities to solve problems. That’s something I feel like I can do to contribute.” **terra**

Comparing lowest price per kilowatt hour



5¢ / kWh

Fossil Fuels



2.9 ¢ / kWh

Solar Energy

Electricity costs vary with technology and location. In 2016, the low bid for solar electricity at the Mohammed bin Rashid Al Maktoum Solar Park in Dubai came in at 2.9 cents per kilowatt hour. The cost for fossil fuel steam generators averages 5.0 cents.
(Source: energysage.com)



Solar electricity could generate economic and educational benefits in remote rural communities, says Inara Scott. (Photo: Karl Maasdam)

PRINCIPLES FOR SUCCESS



In reviewing how organizations perform in some of the world’s most remote communities, Inara Scott found that success would likely include four primary components:

1. Community interaction, working to understand local norms, culture, social issues and economic systems
2. Partnerships with other companies, government organizations, nonprofit groups or nongovernmental organizations, to share ideas and resources and gain support

3. Development of local capacity by considering potential customers as both producers and consumers and by training local entrepreneurs to be distributors, marketers and equipment installation/repair technicians
4. Addressing barriers unique to the off-grid market, such as financing of upfront costs, educating people on the products and their benefits and building trust in quality and reliability

“You can’t do these things in a purely charitable way, but you also can’t have a pure capitalist approach,” she says. “The successful enterprises I’ve seen in these areas have all embraced a hybrid approach. The way to reach the market is by working with the market.”



GOING IN FOR THE KRILL

An abundant but imperiled species draws scientists to Antarctica

BY MARK FLOYD | PHOTOS BY CHRIS LINDER

“When all of a sudden the city air filled with snow,
the distinguishable flakes
blowing sideways,
looked like krill
fleeing the maw of an advancing whale.”

— Billy Collins, from *Neither Snow*



Krill (*Euphausia superba*) are a primary food for baleen whales, penguins and other marine animals. The crustaceans are also harvested commercially.



One of the most important animal species in the world lives in the frigid Southern Ocean, where individuals may reach a ripe old age of six or seven years, despite growing to a length of only 2 inches and not being able to swim against currents or tides to escape predators.

And the predators are many — from the largest animal to have ever lived on Earth, the blue whale, to Adélie penguins, seals and a host of seabirds. Of late, a new predator has emerged to this small, aquatic crustacean known as *Euphausia superba* — or Antarctic krill. It is humans, who are harvesting krill at an increasingly brisk rate as entrepreneurs have discovered lucrative markets for them as a nutritional supplement. Krill oil tablets, touted for their omega-3 oils and other health benefits, cost \$20 to \$30 for a small bottle.

Krill are so abundant, there historically have been few concerns about overharvesting them. In fact, if you put all of the Antarctic krill in the Southern Ocean on one side of a giant scale and the world's 7.5 billion humans on the other side, the scale would tip in favor of the krill.

On the other hand, it wasn't that long ago that people pointed to the iconic salmon in the Pacific Northwest and said it was a limitless resource.

Count Oregon State University marine ecologist Kim Bernard among those who are beginning to hear faint warning bells.

Krill abundance is a factor in Oregon State oceanographer Kim Bernard's studies of Adélie penguins in Antarctica.

It isn't just an increase in human harvesting of krill — which also are used for aquaculture feed and pet food — that concerns the native of South Africa. It is what humans are doing to the planet that may be the biggest threat to the Antarctic krill, she says.

"For being as important as they are, there is a lot that we don't know about Antarctic krill," Bernard says. "We know that there are certain regions or 'hot spots' of phenomenal numbers of krill in the Southern Ocean, and no one had really known why. We also know that there is a correlation between abundant sea ice and healthy krill populations. Again, we're not sure why.

"But we do know that warmer conditions along the West Antarctic Peninsula have resulted in reduced sea ice extent and duration and that is a major concern. It has had major ramifications across the entire pelagic (open ocean) food web in the region."

Krill is a Norwegian word for 'whale food', and it fits this tiny shrimp for a good reason. Most baleen whales eat little else — and they can really pork out on krill. One study found that the gargantuan blue whale, which can grow to the length of three school buses, eats as much as

4 tons of krill in a single day. In one mouthful, a blue whale can down half a million calories.

It's easy then to see how an abundant krill population is important for cetaceans. They are not alone. Bernard's own studies have found krill abundance, and convenience, is critical for Adélie penguins.

In a study funded by the National Science Foundation, the assistant professor in Oregon State's College of Earth, Ocean, and Atmospheric Sciences and her colleagues spent four consecutive summer seasons in the Antarctic mapping the patterns in distribution and biomass of Antarctic krill near Palmer Station, a known hot spot for the crustacean. They also sought to identify the environmental conditions responsible for the hot spot.

In their zodiac Ms Chippy (foreground), Kim Bernard (right) and Shenandoah Raycroft run acoustic surveys for krill. Bernard and her team are known at Antarctica's Palmer Station as "The Psycho Krillers."

What they discovered is a near-perfect system in which krill aggregations situated over the Palm Deep Canyon, a region of nutrient-rich waters that produce a lot of food for krill, are delivered close to shore by tidal currents and winds. When the winds are westerly and the tides are diurnal — one high tide and one low tide each day — the krill biomass close to shore is at its peak, and krill aggregations are huge.

"It's neat. We can predict exactly when humpback whales will be close to shore off Palmer Station just based on the tides," Bernard says. "When there are diurnal tides, you'll see krill from the surface to the ocean floor. They are everywhere. And when they are, the whales are there, too.

"This concentration and transport toward shore are particularly important for the penguins that breed there. The farther they have to go to forage, the less their chicks have to eat, and chick weight is a huge factor in their survival. A difference of a few hundred grams in chick weight is the difference between life and death."

Bernard became interested in krill while working as a post-doctoral scientist on the Palmer Antarctica Long-Term Ecological Research project. She began studying the variability of their distribution and aggregation structure and looking at the relationship between krill and Adélie penguins.

The research, and the region, gripped her.

"Working in Antarctica is incredible. It's hard to describe. I would spend all day out on a small, inflatable rubber boat with my field assistant, acoustically mapping krill. Some days would be bright and sunny, the ocean reflecting like a mirror. Penguins would 'porpoise' past us as we slowly motored along. Some days, we'd see humpback whales lunge-feeding on the krill. Other days were less calm and the wind can pick up very fast out there.

"I remember more than once when the winds picked up almost instantly, and waves of ice water were crashing over me as we raced back to Palmer Station, my hand gripping the tiller and staring



Baleen whales (including blue, humpback, gray and right whales) eat massive quantities of krill. Before commercial whaling, the Southern Ocean around Antarctica was home to as many as 300,000 blue whales. Today, scientists estimate that fewer than 2,000 survive.

straight ahead through snow- and ice-covered goggles as the frigid water stung my face. It was frightening, but honestly it was the most alive I've ever felt."

Now Bernard is hoping to return to Palmer Station, this time in the winter, to see how Antarctic krill survives the frigid months, how oceanic conditions may differ, and most importantly, what role sea ice plays.

"We see very strong correlations between krill biomass and sea ice," she noted.

"When the sea ice is low, the krill populations crash the next summer. It could be a change in algae or other food for them, or it could be that sea ice provides shelter from predators, or affects the currents in some way. We just don't yet know.

"But I'm hoping to find out." **terra**





HEAD GAMES



Research on brain injury
is changing athletics

BY THERESA HOGUE

ILLUSTRATION BY JAMES STEINBERG

A decade ago, a high school football player who had suffered a blow to the head during a game would likely be put on the sidelines, watched carefully and sent back out to play once he appeared to be acting ‘normally’ again. Walking it off was common practice, without much consideration of the long-term impacts of the blow or a thought to the cumulative effect of frequent head trauma, big and small.

Today, the evolving science of identifying, treating and preventing concussions is taken extremely seriously by sports professionals. High-profile cases of severe injury and death as a result of head trauma, as well as a growing body of research on concussions, has profoundly changed the way athletes, both professional and amateur, are treated when they receive a blow to the head. And those changes are saving lives.

Dr. Doug Aukerman is a sports medicine physician with Samaritan Health Systems in Corvallis and a senior associate athletic director for sports medicine at Oregon State University. He manages the sports medicine program for all of OSU’s intercollegiate athletic sports teams. He studies concussions and other sports-related trauma, and applies the latest research directly to the care being given to OSU athletes. For Aukerman, the beauty of working in the Samaritan Athletic Sports Medicine Center on campus is partnering with the OSU research community.

Watching for Signs

A concussion typically occurs when a blow to the head or to the body exerts enough force on the brain to produce immediate and transient symptoms of traumatic brain injury. Such symptoms can include a rapid onset of impairment and other neuropathic signs (changes in peripheral nerves) and symptoms that can’t be explained by drugs or other injuries. Symptoms of a concussion can include confusion, stumbling, balance problems, mood shifts and headaches.

“We’re looking for changes to an athlete’s behavior or actions that aren’t congruent with what we normally see,” Aukerman says. This can be the result of one large blow or a series of multiple small blows that accumulate.

The actual collision isn’t always immediately recognized, but in the case of college sports, a person who serves as a concussion monitor is typically present during games to pay attention to potentially harmful collisions or blows. Coaches and athletes are trained not only to look for such events but to also pay attention to physical or behavior changes in teammates that may indicate that a concussion has taken place. At that point, the concussion monitor can replay recent footage and determine if a collision occurred.



Swift diagnosis is vital, Aukerman adds. Studies show that delayed reporting and treatment lead to a longer recovery time. And if an athlete receives a second blow without the first impact being recognized, the results can be much more severe,

including massive brain swelling and the possibility of death.

“What happens during a concussion is a very complex process, and I don’t think that we have all the answers yet,” Aukerman says. “The things that are happening on a cellular and microscopic level are enormous. There are so many things happening at once.”

Ask the Athlete

While the science of concussions is still evolving, physicians have a fairly straightforward way of diagnosing them. A series of physical and mental tests can be applied quickly and easily on the sidelines of practice or a game to assess the athlete’s physical and mental state. The questions range from the time of day, to the last time the team scored, to the ability to remember and repeat a series of words.

If a physician determines that a concussion has occurred, the player is pulled from the field and further assessment is done. Then a plan of treatment is established. It includes cessation of any physical activity for a period of time and often academic activity and screen time as well. This can be difficult for students, especially when phones and computers become off limits. But screen time stimulates the brain areas that need to heal after a blow to the head.

It’s hard for athletes to stop playing, even briefly, but the break is crucial to healing.

“We’re very fortunate here to have a group of coaches who want what’s best for their student-athletes,” Aukerman says. “They



want to win but not at the risk of their players being injured or hurt. And we’re doing a good job with educating coaches and athletes. They know if they report concussions and we manage it quickly, there will be far less loss of time on the field. Not reporting it could lead to

weeks of recovery before they’re able to return to play.”

New Research Study

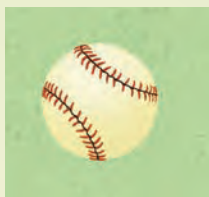
As part of the Pac-12 Conference, OSU will be taking part in the CARE Consortium as a CARE Autonomous Program (CARE stands for concussion assessment, research and education), an alliance between the NCAA and the Department of Defense. The large-scale, multisite study will focus on concussions in men and women in multiple sports in hopes of filling gaps in current knowledge and creating a large group of datasets for public use.

Doctors and researchers now recognize that there is not one type of concussion, Aukerman says. Subsets of the injury have different impacts to vision, emotion, balance and mental clarity. Some trigger headaches.

Each subset must be treated differently. Some may allow a faster return to physical activity, while others demand longer rest periods.

NCAA Division 1 athletic teams commonly use computerized and in-person tests to establish a baseline of “normal” functioning for every athlete. Having such a profile helps physicians determine when an injured athlete has returned to his or her pre-concussive state.

“It’s just one tool out of the box,” says Aukerman. “It guides us in terms of returning the athlete back to normal.”



Small Steps to Injury Reduction

While concussions aren't completely avoidable in high contact sports, both researchers and athletes are beginning to recognize that many small changes can add up to fewer harmful blows. Such changes

may include reducing the amount of full contact during practice and looking at how protective gear, especially helmets, can increase the severity of blows if not properly fitted. Athletes are being trained to be more conscious of how contact on the field can negatively impact themselves and their opponents. Coaches can experiment with alternating practice with rest and recovery times to limit the amount of contact episodes.

Dr. Nicholas Phillips runs the concussion clinic at Samaritan Athletic Medicine Center and is a certified impact practitioner. Current research and testing hasn't revealed anything that can effectively prevent concussions, he says, but focusing on best practices is a good start.

"Concussion prevention overall is a very difficult thing to study and to achieve," Phillips adds. "The best practices for prevention will likely be through appropriate equipment, appropriate rule adherence (with the possibility of evidence-based rule changes), proper technique on higher risk activities such as tackling, and potential activity restrictions to limit unnecessary exposures."

There are also still myths surrounding concussions that have to be dispelled, says Phillips.

"One myth that I still frequently run into is that regarding a pre-determined, finite recovery period for concussion. I commonly hear that a coach said that a player must sit out for one week after the injury, but every concussion timeline is variable and return to play must be tailored to each case.

"I'm also still concerned about the downplaying of potential concussions in which coaches and parents say the athlete just 'got their bell rung.' By definition, if a player exhibits any abnormal



neurologic signs or symptoms after a potential head injury, then that should be classified as a concussion."

Athletes suffering from a concussion may discover that their symptoms are worsened by certain activities, including screen time, dehydration, intense physical and cognitive activities. "That's why it's so

important to tailor treatment to each individual," Phillips adds.

"Our community clinic and student-athlete management focus on early identification of concussion to allow appropriate management of the injury. While there is no one particular intervention to 'cure' concussion, the right combination of recommendations can lead to the quickest and safest recovery."

Resources for Local Schools

In addition to work with OSU athletes, Aukerman, Phillips and others provide resources to local junior high and high schools regarding concussion prevention, identification and treatment.

And despite the risks of full-contact sports, Aukerman, who is a parent himself, says he hopes that families recognize that the benefits of taking part in team sports far outweigh the potential risks, especially when coaches and athletes are actively looking to minimize injury.

"There is so much that can be gained from sports participation," he says, "including working as a team, interacting with people who are different from you, learning how much can be accomplished together, so many positive things. I hope parents wouldn't say 'I won't let my child have that option.' Sports can be approached in a safer way. There is no way we as parents can mitigate every risk to our children, but there is a risk in being overprotective." **terra**

The Life of Beer

Plants and microbes inspire the brewer's art

BY NICK HOUTMAN

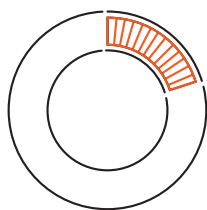
The next time you sip a beer with friends, consider the source: barley prompted to sprout, only to have its development arrested; yeast that turns barley sugars into alcohol and carbon dioxide; hops bred to produce fragrant oils for flavor and aroma. These are the tools of the brewer's art, which turns grain, microbes and flowers into a liquid feast.

Oregon State University assists the brewing industry by developing new varieties of barley and hops. And like chefs in a gourmet kitchen, students and faculty in OSU's fermentation science program — key to the new \$18 million Oregon Quality Food and Beverage Center being built on the Corvallis campus — collaborate with craft beer-makers on new recipes for this ancient drink.

Like all fermented foods, beer is the result of a finely tuned living process. It reflects the same biochemical principles that lead a seed to become a plant, make bread rise and enable us to savor and digest a meal.

While there are endless variations to the brewer's art, here are the simplified steps, courtesy of Tom Shellhammer, the Nor'Wester Professor of Fermentation Science in the College of Agricultural Sciences and an internationally recognized expert in hop chemistry.

Editor's note: For a thorough review of OSU's beer-making research from barley to hops, see the fall 2017 issue of Oregon's Agricultural Progress magazine.



Driven by health-conscious consumers, sales of low- or no-alcohol beers are growing and could account for as much as 20 percent of the market by 2025.

Origins: Making Malt



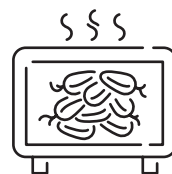
1. **Barley** soaked in water begins to germinate.



2. In the awakening seed, a hormone (**gibberellin**) triggers the development of enzymes within the barley that turn complex starches and proteins into nutrition — simple sugars and amino acids — for the growing embryo.



3. But before the new shoot can emerge, the maltster dries the wet **grain** to stop this enzymatic action and preserve it for the brewer.



4. For pale beers, the **malt** is lightly kilned. For darker brews, such as porters and stouts, the malt is kilned hotter and longer to develop more color and flavor.

“Variations in kilning can produce darker colors and stronger flavors, like an espresso or French roast coffee,” says Shellhammer.

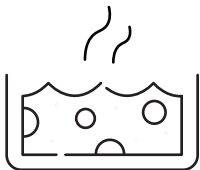
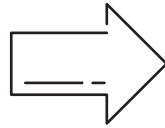


Tom Shellhammer, left, and Jeff Clawson, pilot brewery manager at OSU, review experimental brews for color, aroma and flavor. (Photo: Stephen Ward, Extension & Experiment Station Communications)

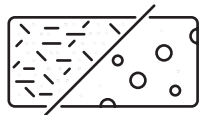
In the Brewery – Mashing and Boiling



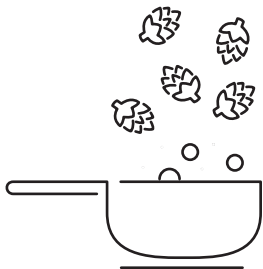
5. The brewer grinds the malt into a coarse **grist** and combines it with warm water to create a thin soup, aka **mash**.



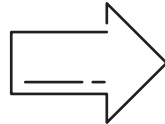
6. The enzymes created during malting begin breaking down the malted barley's starch to produce a rich broth containing sugars, amino acids and an array of compounds that provide flavor and aroma.



7. Separated from the spent grains, which are often sold off as animal feed, this liquid called **wort** is the foundation for the final product.



8. The brewer boils the **wort** to sterilize it and to extract essential oils and acids from hops, which are added as the liquid cooks.

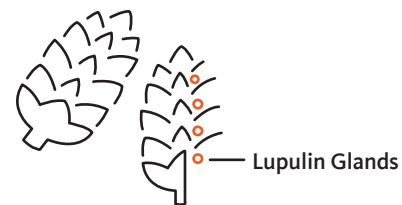


✓ SUGAR ✗ STARCH

Sugars produced during mashing can be fermented by yeast while the remaining starches cannot.

7-3

The average ratio of what's fermentable to what's non-fermentable in wort. Fermentable sugars will ultimately yield alcohol, while the non-fermentables will affect the beer's flavor, mouthfeel and satiating quality.



Lupulin Glands

Hops for Spice

The female flower of the hop plant, *Humulus lupulus*, includes **lupulin glands**. Found deep inside the hop cone, these glands contain the oils that deliver herbal, floral, citrus and tropical aromas and acids that can pack a bitter punch in the finished beer. Boiling hops in wort produces iso-alpha acids which contribute bitterness and antimicrobial properties to beer. Brewers sometimes add hops after boiling or during fermentation in an effort to turn up the hoppy aroma while minimizing their bitter contribution in the final product.

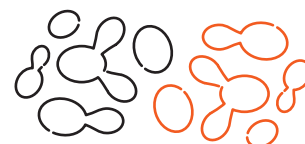
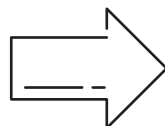
Yeast in Time



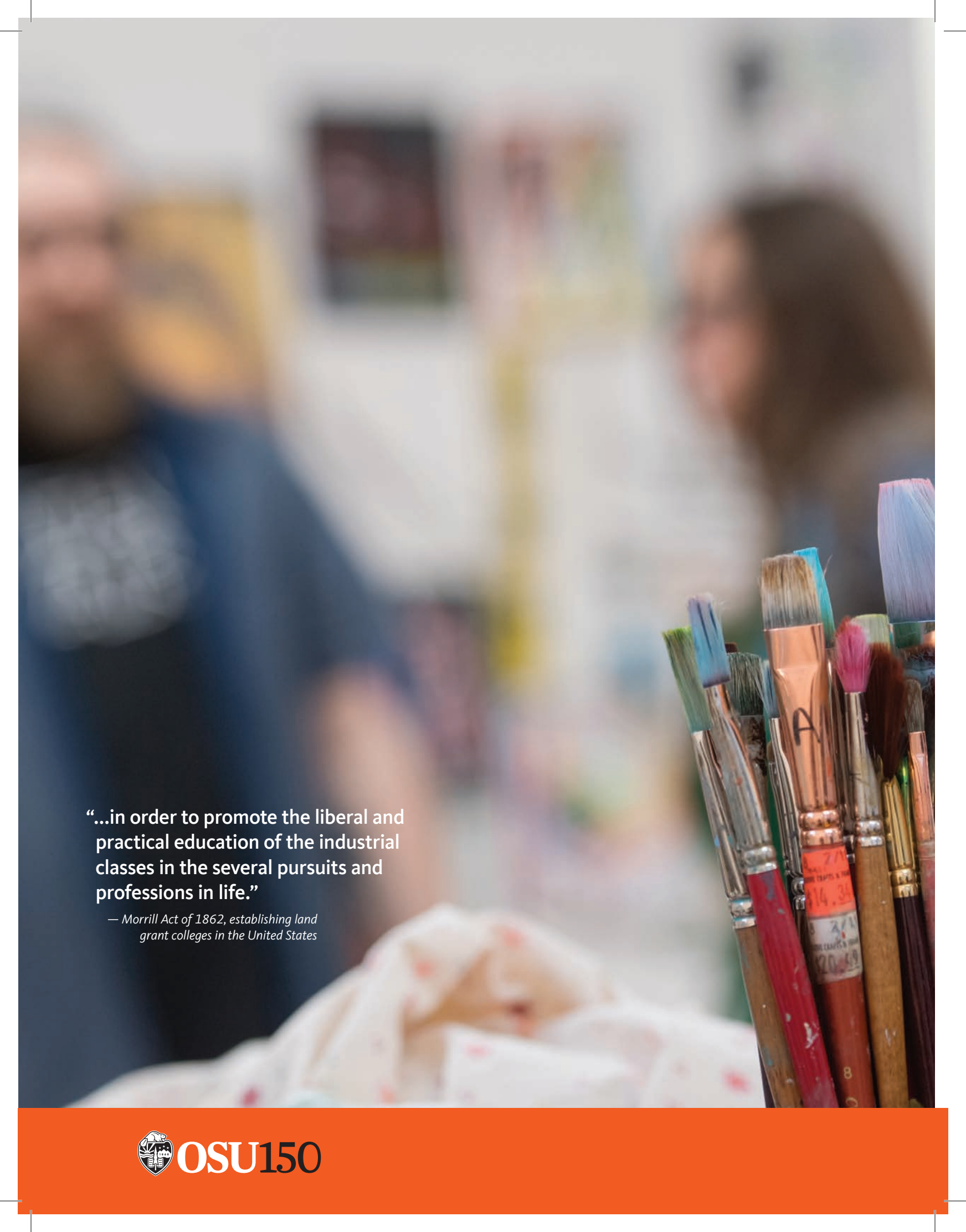
9. Enter a single-celled microbe, *Saccharomyces cerevisiae*, the workhorse of alcoholic fermentation. With the wort cleared of all microorganisms by sterilization, yeast provides the last critical transformation, turning simple starches and sugars into ethanol at a ratio of two units of sugar to one of ethanol.



10. Yeast also produces a host of other compounds (organic acids, esters and alcohols) that lend winy, fruity and other flavors to beer.



Brewers reuse their yeast from previous fermentations in a process that can take two to 10 days. Choosing one of the thousands of yeast strains is part of the art.



“...in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.”

— Morrill Act of 1862, establishing land grant colleges in the United States



OSU150

Oregon State University is celebrating 150 years of achievement as the state's land grant university. Enjoy the journey with *Terra* as we recognize examples of OSU's legacy and ongoing impact in Oregon and the world.



Gordon Gilkey, printmaker. (Photo: Robert Miller)

From the Margins to the Center

The liberal arts lie at the heart of the land grant mission

BY NICK HOUTMAN

At the beginning of World War II, as German tanks were rumbling into Czechoslovakia, an artist living in New York sent a letter to President Franklin Roosevelt. If the U.S. "got involved in the war in Europe," he wrote, "there should be knowledgeable people along with the troops to tell them what not to blow up." Roosevelt agreed, and the idea led eventually to creation of the Monuments Men, a corps dedicated to rescuing art stolen by the Nazis.

The artist was Gordon Gilkey. Born on a ranch near Scio, Gilkey was not part of the famous group but became the sole member of the Propaganda Confiscation Unit and recovered more than 8,000 pieces of art after the war.

In 1947, he headed back west to lead the art department at Oregon State College. At that time, liberal arts classes were limited, and no degrees were offered. The arts and humanities were seen as service units to science and engineering. But by the time Gilkey retired 30 years later, the College of Liberal Arts comprised 15 degree-granting departments, ranging from art and English to speech communication and psychology. Gilkey was its first dean.

In 2016, U.S. Senator Ron Wyden posthumously presented the Congressional Gold Medal to OSU President Ed Ray and Larry Rodgers, dean of the College of Liberal Arts, to honor Gilkey and Mark Sponenburgh, for their heroic actions during and after the

war. A member of the Monuments Men, Sponenburgh taught art history at OSU from 1961 to 1983.

Gilkey's story illustrates OSU's liberal arts legacy: its global connections, relevance, rapid growth and future promise. The arts and humanities focus on people, creativity and their relationship to technology and decision-making. Artists, scholars, philosophers and social scientists at Oregon State bring the human element into the Earth sciences, engineering and biomedical fields. As faculty members and students, they explore ideas, express the meaning and beauty of the human experience and make lasting contributions to communities. Here are a few of their milestones.



Elizabeth Barnes, theater program director, right, and others applying makeup to actors prior to a performance in 1925.

COMMUNICATION

THE HEART OF STORYTELLING

ELOCUTION AND RHETORIC

The liberal arts were key to an education in the early years at Corvallis College. In 1866, all first-year students took elocution (the art of speech), leading to what would become one of the first departments of speech communication on the West Coast. The debate team is OSU's oldest student club. In 1872, faculty members offered classes in moral philosophy and physics, languages and mathematics. Juniors were required to take rhetoric and logic.

ON STAGE

Theater at Oregon Agricultural College dates back to the 1870s. The student drama society (the university's second oldest club) and members of the senior class took their productions out to logging camps. In the 1920s and 1930s, Elizabeth Barnes, one of the first female directors in a field dominated by men, produced Shakespeare plays outdoors, foreshadowing today's Bard in the Quad productions. For nearly 40 years, the Mitchell Playhouse (now the Gladys Valley Gymnastics Center) was home to productions on campus before the theater moved to its current home in Withycombe Hall. All OSU students can participate in theater.

LITERARY ROOTS

A New Life (1961) tells the story of a young professor from the East who arrives at a rural western college to begin his teaching career. Bernard Malamud's third novel was written while the author was a faculty member in the English department at Oregon State College. Thought to be autobiographical, the book raised eyebrows with details about romantic affairs and academic tensions. Malamud also wrote *The Natural* at OSU and in 1967, after leaving Oregon for a position at Bennington College, received the Pulitzer Prize for Fiction for *The Fixer*.

NURTURING CREATIVE WRITERS

The Masters of Fine Arts degree program in creative writing has become one of the nation's most competitive. This year, 428 students applied for 14 available spots. In addition to full tuition support, the program links aspiring writers to exceptional faculty, such as Elena Passarello, essayist and winner of the Whiting Award for Nonfiction; Marjorie Sandor, winner of the Oregon Book Award and author of four books; and poet and essayist Karen Holmberg, whose work has been featured in magazines such as *The Paris Review*, *Slate* and *The Nation*. The Stone Award, given biannually to an acclaimed American writer, provides one of the most substantial awards for lifetime literary achievement of any university in the country. Recipients have included Joyce Carol Oates, Tobias Wolff and Rita Dove.

DIGITAL HUMANITIES

A 19th-century explorer's field notes emerge from decayed, nearly unreadable records. The Great Exhibition of 1851 at London's Crystal Palace opens to anyone with a cell phone or desktop computer. Data about the culture of laboring-class poets — their writings, occupations and locations — illuminate the lives of writers throughout the British Isles. An analysis of questions posted to the popular internet site Reddit reveals how people respond to social media. These are among the results of an ongoing collaboration between humanities and computer science researchers at Oregon State. Digital humanities provide a powerful window on art and literature.



Top: Bard in the Quad, *Two Gentleman of Verona*. August 2017. Bottom left: Bernard Malamud. Bottom Right: Rita Dove, recipient of The Stone Award in 2016.

IDEAS

CONCEPTS AND CHOICES

HABITS OF MIND

Oregon Agricultural College offered its first psychology course in 1872, taught in the School of Moral Science. The field was in its infancy in the latter 19th century, but psychology was required of seniors from 1889 to 1906. In recent years, undergraduates have been key to studies on topics such as how first impressions are formed when people meet, how people experience differences in ability and appearance and how adolescents face risks associated with depression, sex and other stresses. A new Ph.D. program offers students opportunities to pursue projects in human-machine systems (such as multitasking on mobile devices and driving), applied cognition (human-robot interactions, the effects of trauma on attention) and health (disability, substance abuse and gender).



Christopher McKnight Nichols, (right) associate professor, director of the Oregon State University Center for the Humanities with Andrew Su, undergraduate in the School of History, Philosophy and Religion.

IDEAS OF GOD

"How people think about God matters," Marcus Borg told a reporter in 1998. "Some concepts of God make God incredible and result in atheism. Other concepts make God seem remote and irrelevant. And still other concepts of God, grounded in experience, make God the central reality in human life." As a professor in the Department of Philosophy, Borg became one of the nation's foremost Biblical and historical Jesus scholars. He published 21 books and organized conferences — Jesus at 2000 and God at 2000 — that captured international attention. Borg, who died in 2015 was named the first Hundere Chair of Religion and Culture at OSU and was the first College of Liberal Arts faculty member to be designated an OSU Distinguished Professor.

DECISIONS FOR THE COMMON GOOD

Collaboration over natural resources has come to be known as The Oregon Way. In every corner of the state, people from different walks of life meet to hash out issues over water, wolves, rangeland, forests and fish. With the only master's in rural policy program in the nation, OSU attracts students from around the United States and the world to learn how to replicate the state's signature approach to environmental management. Alumni of the School of Public Policy work in Washington D.C. and in governments and communities around the world. A partnership between the school and nuclear engineering brings disarmament negotiator and U.S. Ambassador Thomas Graham to OSU to teach a class from his frontline perspective on nuclear weapons. Through the Marine Studies Initiative, researchers will expand their collaboration with coastal communities.

THINK TANK FOR THE HUMANITIES

For more than 30 years, brisk conversations on art, history, poetry, philosophy and other human-centered disciplines have flowed through a Tudor-style house just east of the Corvallis campus. Established in 1984, the OSU Center for the Humanities has been a gathering place and supportive community for scholars to explore the meaning and expression of the human experience. "We need the humanities to understand how we arrived at this moment, to sort fact from fiction, to find shared values, and to ask and address profound questions about society, nature, justice, religion, art, community and so much more," says Andrew Carnegie Fellow Christopher McKnight Nichols, center director, historian, member of the Council on Foreign Relations.

MEDICAL DILEMMAS

When should doctors intervene? And when should they let nature take its course? Who gets access to expensive medical treatments? Who decides? These are some of the issues confronted by biomedical ethicist Courtney Campbell, who has worked with Good Samaritan Hospital, Benton Hospice and other organizations. The Hundere Professor in Religion and Culture has addressed Oregon's Death with Dignity law, the Oregon Health Plan and other policies that have life-and-death implications for all.



OSU150



The OSU Marching Band in action on football gameday, November 1972, Parker Stadium.

BEAUTY FOR THE EAR AND THE EYE

MUSICAL BEGINNINGS

The OSU Marching Band and the Corvallis-OSU Orchestra were among the first such musical groups in the West. Founded in 1891, the marching band is the oldest in the Pac-12. Oregon's longest continually operating orchestra started as a collegiate group in 1906 with nine male members. Today, under the direction of Marlan Carlson, its 110 musicians perform five concerts each season.

THE RIGHT NOTE

In 1890, every student at Oregon Agricultural College was required to participate in choral singing. Daily practice was obligatory, and choir classes met three times a week in the chapel. As OAC grew, student choral groups — the Men's Glee Club and Women's Madrigal Group — gave concerts and combined to perform operas on campus and throughout the state. Robert Walls transformed the music program into an academic department.

Student choirs first traveled abroad during his tenure. Under Ron Jeffers, Walls' successor, the OSU Chamber Singers participated in the prestigious St. Moritz International Choir Festival in Switzerland. Music director Kathryn Olson arranged for the choir to travel to China where it performed in Shanghai, Beijing and other cities. The music education program has a nearly 100 percent placement rate for graduates who teach music and choral singing at high schools throughout the country.

ART FOR THE WORLD

The visual arts grew slowly in the early years. Not until 1889 was drawing (freehand, mechanical and perspective) offered to students. But through the art department (created in 1901), OSU faculty provided students with a transformative look into a worldwide art culture. Educated in Paris, John Leo Fairbanks became chair in 1923. The namesake of OSU's Fairbanks Hall grew up in Utah and had already established a reputation as a landscape painter and a sculptor. In addition to teaching, he continued a productive artistic career. In his footsteps, OSU faculty members continued to inspire students. They included photographer Harrison Branch, whose iconic large-format images have been exhibited in North America and Europe, and art historian Henry Sayre, author of *A World of Art* and a PBS television series of the same name. Today, the Fairbanks Art Gallery hosts shows by national artists as well as OSU faculty and students.

ENVELOPE PLEASE

In 1988, animator and production designer Harley Jessup, a 1976 OSU art graduate, won an Oscar for Best Visual Effects honoring his work as art director of *Innerspace*. Jessup also won an Emmy and an Ani (for animation). His credits include *Monsters, Inc.*; *Ratatouille*; *Cars 2*; *Up*; *Toy Story 2*; and *The Hunt for Red October*.

PERFORMING ARTS CENTER

Spurred by a \$25 million gift from an anonymous donor, Oregon State will expand the LaSells Stewart Center on campus to create a state-of-the-art space for education, performance and technology in the performing arts. With additional private and public support, the \$60 million project fulfills a vision expressed by Gordon Gilkey, first dean of the College of Liberal Arts, to establish a "great hall" on the OSU campus. The new center will serve all OSU students, regardless of their field of study, who participate in band, symphony and choral groups and other endeavors.

CULTURE

SHAPING THE HUMAN EXPERIENCE

SUSTAINABILITY STUDIES

It takes the insights of the sciences and the creative wisdom of the arts to address thorny environmental issues. Two initiatives — The Spring Creek Project for Ideas, Nature and the Written Word; and the Environmental Arts and Humanities graduate program — gather writers, poets, artists, scientists and citizens to grapple with the human footprint in a changing world. In places across the Northwest — the slopes of Mount St. Helens, a cabin in the Oregon Coast Range, the H.J. Andrews Experimental Forest in the Cascades, the Oregon State campus — Spring Creek fosters conversation and reflection, sometimes deep into the night. Students in the new master's program in Environmental Arts and Humanities combine the rigors of science with the creative insight of the humanities. In a time of extinction and global change, they ask, how shall we live?

HISTORY OF FILM

"There's something communal about going to the movies," says Jon Lewis, distinguished professor of film studies. "It's like church." Lewis is one of America's foremost authorities on censorship, film history and Hollywood institutions. His work (more than a dozen books on the film industry, including a best-selling film anthology) has formed the basis for OSU's growing film program. Assistant professor Mila Zuo addresses gender, culture and sexuality stereotypes in her work. This year, film studies provide a platform to explore the decade of the 1960s through a course taught by Lewis and Robert Santelli, director of popular music and performing arts.

HUMAN ORIGINS IN NORTH AMERICA

The first peoples of North America may have traveled from Asia overland or along an icy ocean shore. Evidence of their presence

has been found by OSU anthropologists and colleagues at places like Fort Rock and Paisley Caves south of Bend and at Cooper's Ferry along the lower Salmon River in Idaho. The search continues offshore where people could have settled at a time when the oceans were 300 to 400 feet lower than they are today. As noted by the discovery of mammoth bones at OSU in 2016, humans shared the land with ice-age animals. Over thousands of years, their descendants developed diverse cultures and languages. Encounters with Europeans brought disease and conflict and led to the modern system of Indian reservations. Researchers, including OSU students, have documented Civil War-era artifacts at the sites of Fort Hoskins and Fort Yamhill in the Oregon Coast Range.

THE LAST SUPPER

The plates are simple, white porcelain painted with deep blue images of food. Oregon State artist Julie Green has made more than 500, each honoring the memory of a prisoner executed on death row in the United States. Featured in national media and displayed at galleries around the country, Green's work recognizes the humanity of people often portrayed as monstrous and unworthy.

CULTURAL COMPETENCY

Traders and migrants have crossed cultural boundaries for centuries, but world events are bringing people closer together than ever before. In the 1990s, Oregon State took steps to foster understanding and collaboration through creation of an Ethnic Studies department. In the face of institutional budget cuts, the university expanded its commitment to exploring the dynamics of race, gender, sexuality and social justice. In addition to preparing students to participate in an ethnically diverse society, Ethnic Studies connects minority communities to OSU for academic and other programs often affiliated with OSU's seven cultural resource centers.



EXPERIENCE THE SIGHTS AND SOUNDS OF OSU

Oregon Historical Society exhibit takes visitors on a trip through time

Listen to the music and voices from the past. Spin the wheel to explore historical events such as the Walk Out by the Black Student Union in 1968. Measure yourself against the high-jump bar crossed against all expectations by Olympic gold medalist Dick Fosbury. The OSU150 exhibit runs from February 9 to September 9 at the Oregon Historical Society, 1200 SW Park Avenue in Portland.



OSU150

AT THE INTERSECTIONS

In 1972, a sex discrimination lawsuit over a hiring decision at OSU led to the creation of a Women Studies program and the Women's Center. One of the first academic programs of its type in the country and staffed by a single tenure-track position through the 1990s, the program has expanded. Women, Gender and Sexuality Studies is one of 19 programs in the nation that grants a Ph.D. in this field. Its 14 core faculty take an inclusive approach to studies of race, class and sexual identity as well as gender. The program has editorial responsibility for *Feminist Formations*, a leading national journal, and helps to facilitate the OSU ADVANCE project, funded by the National Science Foundation to expand female participation in STEM fields (science, technology, engineering and mathematics).

SERIOUS ABOUT DISCRIMINATION

In 1990, a series of racially motivated incidents led Oregon State to create what has become a national model for education about social systems of discrimination. Known as Difference, Power and Discrimination, or DPD, the program offers courses required of all OSU students. It certifies additional courses across the curriculum to guide faculty and students in a deep dive into the inherent biases and beliefs that affect relationships among people of dominant and marginalized cultures. DPD leaders are regularly asked to advise colleges and universities in developing their own approaches to this topic.

PRACTICING MINDFULNESS

In fields from biology and geoscience to psychology and philosophy, students and faculty are using meditation and other "contemplative practices" to inspire their thinking and creativity. Researchers are investigating the effectiveness of meditation techniques and the relationship between Buddhism and science, among other topics. The Contemplative Studies Initiative is supported by a fund established to honor James Blumenthal, a Buddhist scholar and professor in the School of History, Philosophy and Religion, who died in 2014. [terra](#)

Editor's note: Joseph Donovan and Rebecca Olson contributed to the story about Gordon Gilkey. Thanks to Celene Carillo, communications director in the College of Liberal Arts, for her guidance.



Top: Jesseanne Pope, Social Justice and Diversity Educator, outside the Women's Center. **Bottom:** The OAC Cosmopolitan Club, the first campus organization for international students and among the first to promote diversity. Image originally appeared in the 1919 Beaver yearbook.

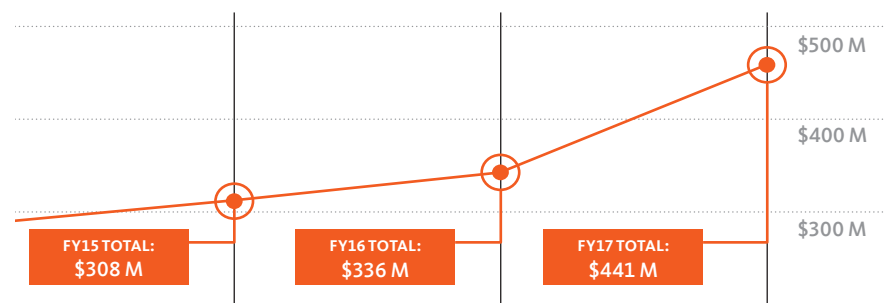


Oregon State University Earns Record \$441 Million in Research Revenues

RESEARCH VESSEL GRANT WAS OSU'S LARGEST EVER

In the wake of a federal grant to design and build a new regional research vessel, Oregon State University crossed the \$400 million threshold in grants and contracts for the first time in the fiscal year that ended June 30.

Oregon State received \$441 million from state and federal governments, businesses and foundations for research on a wide range of projects in natural resources, health, engineering and science across the state and around the world. That represents a 31 percent increase over last year's record-breaking total of \$336 million. Over the past 10 years, Oregon State's research revenues have more than doubled.



OSU research totals took a dramatic leap in June with a \$122 million grant from the National Science Foundation for a new regional research vessel, which will be stationed at the university's Hatfield Marine Science Center in Newport. It was the largest single grant ever received by the university.

Revenues from business and industry — including technology testing, sponsored contracts and licensing of innovations developed at the university — grew to \$34 million last year, up 10 percent from the previous year.

"Investment in research pays back dividends in economic growth for Oregonians. Researchers are starting new businesses and assisting established companies. Our latest success is the result of hard work and strategic decisions by our

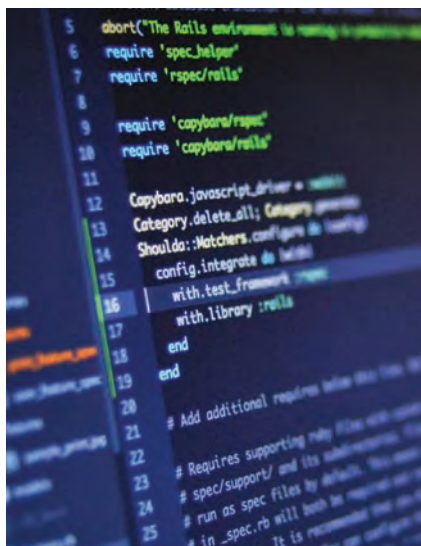
faculty and partners in business, local and state government and the federal delegation," said Cynthia Sagers, vice president for research.

Based on past OSU research, startup companies such as Agility Robotics (animal-like robot motion), Outset Medical (at-home kidney dialysis) and Inpria (photolithography for high-performance computer chips) are attracting private investment and creating jobs. Advances in agricultural crops (winter wheat, hazelnuts, small fruits and vegetables) and forest products (cross-laminated timber panels for high-rise construction) are bolstering rural economies as well.

Since it began in 2013, the Oregon State University Advantage program has provided market analysis and support services to more than 70 local technology businesses and startup companies.

Opening the AI Black Box

AUTONOMOUS SYSTEMS WILL EXPLAIN THEIR REASONING



Eight computer science professors in Oregon State University's College of Engineering have received a \$6.5 million grant from the Defense Advanced Research Projects Agency to make artificial-intelligence-based systems like autonomous vehicles and robots more trustworthy.

The success of the deep neural networks branch of artificial intelligence has enabled significant advances in autonomous systems that can perceive, learn, decide and act on their own.

The problem is that the neural networks function as a black box. Instead of humans explicitly coding system behavior using traditional programming, in deep learning the computer program learns on its own

from many examples. Potential dangers arise from depending on a system that not even the system developers fully understand.

The four-year grant from DARPA will support the development of a paradigm to look inside that black box, by getting the program to explain to humans how decisions were reached.

"Ultimately, we want these explanations to be very natural — translating these deep network decisions into sentences and visualizations," said Alan Fern, principal investigator for the grant and associate director of the College of Engineering's recently established Collaborative Robotics and Intelligent Systems Institute.



BOOK NOTES

RECENT PUBLICATIONS BY OSU FACULTY



SPALTED WOOD

THE HISTORY, SCIENCE, AND ART OF A UNIQUE MATERIAL

Sara C. Robinson, Department of Wood Science and Engineering

Published by Schiffer Publishing

For the first time, the history of spalted wood — wood coloration caused by fungi — is detailed in a comprehensive resource covering the science, history and applications of spaling. Featuring 870 photos and photomicrographs, this resource goes back 700 years to the beginning of written records of spaling and follows its evolution from closely guarded guild secret to scientific curiosity and mainstream art form.



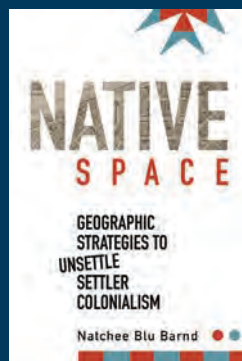
THE PEOPLE'S SCHOOL

A HISTORY OF OREGON STATE UNIVERSITY

By William Robbins, Emeritus Professor of History

Published by Oregon State University Press

The People's School is a comprehensive history of Oregon State University, placing the institution's story in the context of state, regional, national and international history. Rather than organizing the narrative around presidencies, Robbins examines the broader context of events, such as wars and economic depressions, that affected life on the Corvallis campus.



NATIVE SPACE

GEOGRAPHIC STRATEGIES TO UNSETTLE SETTLER COLONIALISM

By Natchee Blu Barnd, School of Language, Culture and Society

Published by Oregon State University Press

Native Space explores how Indigenous communities and individuals sustain and create geographies through place-naming, everyday cultural practices and artistic activism, within the boundaries of the settler colonial nation of the United States. Diverging from scholarship that tends to treat indigenous geography as an analytical concept, Barnd instead draws attention to the subtle manifestations of everyday cultural practices — the concrete and often mundane activities involved in the creation of indigenous space.



NEW STRATEGIES FOR WICKED PROBLEMS

SCIENCE AND SOLUTIONS IN THE 21ST CENTURY

Edited by Ed Weber, Denise Lach and Brent Steele, School of Public Policy

Published by Oregon State University Press

A “wicked problem” isn’t one with an evil nature but a problem that is impossible or difficult to solve. Classic examples of wicked problems include economic, environmental and political issues. The editors have assembled contributions from a wide variety of accomplished scholars in science, politics and policy to address this challenge.



THE GREAT ESCAPE

Migration spurred by rising seas could reshape the country

This is what mass migration looks like on a map of the United States.

On a screen the size of a small theater, Oregon State University student researchers display the country's coastline. Along every sea-washed state from New England to the Gulf of Mexico and up the West Coast, they run a chain of boxes like a pearl necklace around the perimeter of the continent. Each box represents a region such as Downeast Maine, southern Florida, Louisiana, the San Francisco Bay Area and Puget Sound.

With a single click of a mouse on a box, Hoda Tahami sends a web of lines to other parts of the country. By clicking on Miami, for example, she launches threads running up the East Coast, into the Midwest and inland to the cities of the West and South. Each line represents a human outflow, a pathway of people based on records of actual migration between counties across the country.

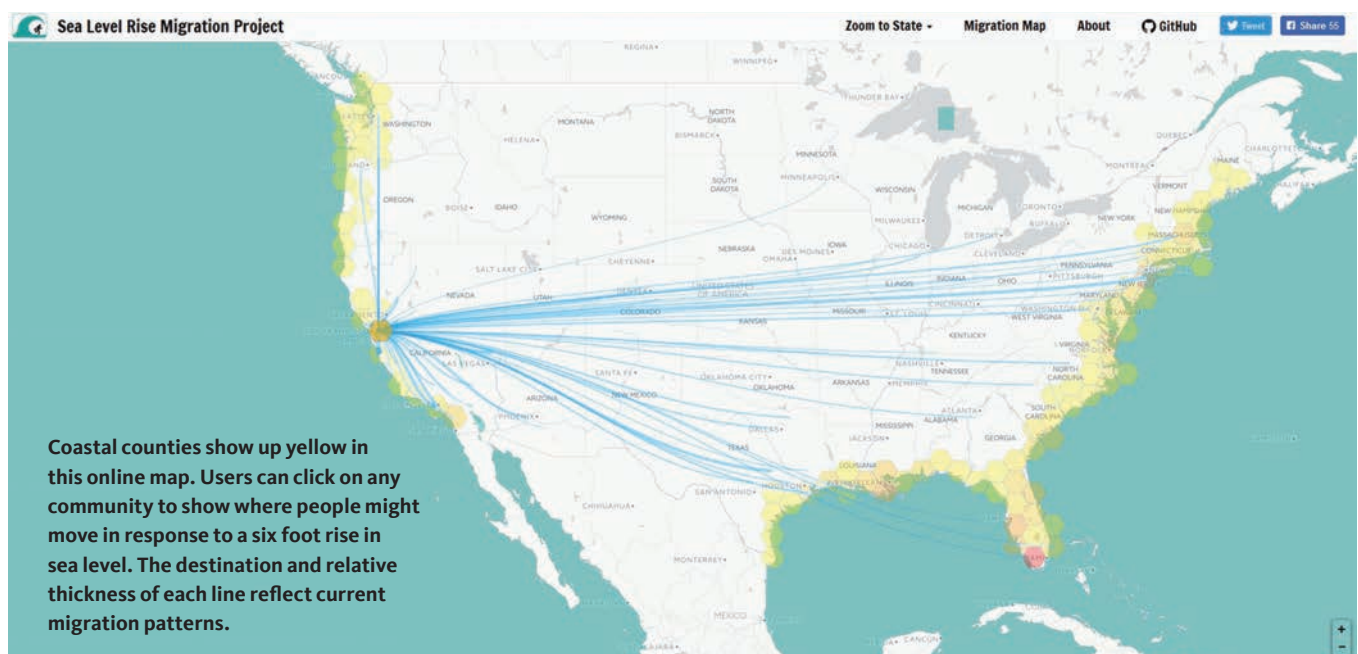
In the future, the inexorable rise of average sea levels could trigger migrants to travel along these paths. Scientists such as OSU Distinguished Professor Peter Clark estimate that sea levels will continue to rise through this century well into the future, although just how much depends on how effectively emissions of greenhouse gases can be reined in. University of Georgia demographer Mathew Hauer has calculated that if seas rise 1.8 meters, just under 6 feet, more than 13 million people could be displaced in the United States. (Cornell researchers have estimated that globally, 2 billion people could be forced to move by the end of this century.)

Projecting that possibility for the United States, students in Oregon State's geovisual analytics course ("geoviz" for short), created the migration map to show how the country's population might shift. "I wanted to understand how sea level rise will affect people in their lives," says Tahami, a Ph.D. student in geomatics, the practice of surveying and measuring the Earth's surface.

"Sea level rise is not just a problem for coastal communities," adds Nick Mathews, a graduate student in geotechnical engineering who participated in the project. "These people will have to move inland after they're displaced. This will really reshape the population landscape. It was shocking to see it."

Tahami and Mathews were joined by Efrain Noa-Yarasca, a Ph.D. student in water resources, and by Riley Johnson, an undergraduate in geography. Using data shared by Hauer, they worked with Bo Zhao and David Wrathall, assistant professors in the College of Earth, Ocean, and Atmospheric Sciences, to produce the map.

For their efforts, the students earned a first-place award in the 2017 Ecological Visualization contest funded by a National Science Foundation grant to the VISTAS project at Evergreen State College and OSU. The map is online at johnsorib.github.io/slr/index.html.





THE OREGON STATE UNIVERSITY ADVANTAGE

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

COLLISIONS ARE NORMALLY TO BE AVOIDED

But not at ATAMI

At the Advanced Technology and Manufacturing Institute, they happen naturally, they're going to happen more often, and their impacts are positive — for faculty and students, industry and Oregon's economy.

Located on the HP campus in Corvallis, ATAMI provides an ideal meeting ground for makers of all types, where they can produce and test their inventions. Oregon State University has occupied the building for over a decade, when it was the Microproducts Breakthrough Institute. This year, it is remodeling and equipping the facility to accommodate the growing needs of innovators, researchers and industry partners, effectively doubling the usable square footage. Simultaneously, the Advantage Accelerator program, which is currently based in downtown Corvallis, will take over the second floor.

Karl Mundorff, co-director of OSU Advantage Accelerator, says the space will facilitate “natural collisions” between young startups and more established companies. For example, Inpria is developing advanced semiconductor patterning materials, called photoresists, for high-performance electronics.

Inpria received an infusion of \$23.5 million in venture capital funding last summer. COO Ann Carney Nelson remembers the challenges of being a new startup and of people telling them they were “crazy for starting a photoresist company.” It was a tall order in an industry dominated by large public corporations. She credits much of their success to an early and strong relationship with Oregon State faculty and students and access to campus facilities.

As the company continues to grow, Carney Nelson hopes to give a leg up to the next generation. She sees Inpria acting as a “big sibling company” for the Advantage Accelerator and other ATAMI residents.

Several professors from the School of Mechanical, Industrial and Manufacturing Engineering will also move into the building. They will join faculty researchers like Brian Paul, a leader in the national



ATAMI is located at the HP campus in Corvallis and will house the Advantage Accelerator next year.

effort to reinvigorate the U.S. economy through advanced manufacturing. Paul is developing modular chemical plants that can be assembled from Lego-like pieces and shipped just about anywhere. Thanks to a multimillion-dollar, multiyear Department of Energy grant, Paul's work will continue to expand at ATAMI.

Cindy Sagers, vice president for research, expects ATAMI to stimulate faculty and student innovation. “It's not simply commercialization. It's not simply creating new businesses and new jobs. It's really about expanding the role of the university in training our students and grad students,” she says. “It's creating opportunities for them to work more closely with industry, to get exposure to entrepreneurial startups and that mindset.”

The Advantage Accelerator plans to be completely moved in by the end of 2018, but Mundorff estimates that it may be done in phases, starting as soon as next spring. He's excited to watch the collisions happen.

To discover what the **Oregon State University Advantage** and the **Advantage Accelerator program** can do for your business, contact Brian Wall, assistant vice president for research, commercialization and industry partnering, 541-737-9058, brian.wall@oregonstate.edu, oregonstate.edu/advantage



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A pet night monkey, aka an owl monkey, rests on the head of a Matsigenka woman in the Peruvian Amazon. These nocturnal monkeys eat fruit, leaves and insects. Other species of night monkeys live throughout the neotropical forests of southern Central America and tropical South America. Matsigenka people survive by hunting a variety of animals, including spider monkeys. See "Hunters and Their Prey," Page 6. (Photo: Taal Levi)

