terra

DISCOVERY | CREATIVITY | INNOVATION • Spring 2018

ETHICAL FOOD

How animals, environment and religion shape the answer to a simple question: What's for dinner?

ALSO IN THIS ISSUE:

The Road to Plenty | Puppy Love
The Biochemistry of Cannabis

Oregon State University

terra

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Oregon's leading public research university

FEATURES

The behavior of dogs and other pets is under scrutiny in OSU's Human-Animal Interaction Lab. Lead scientist Monique Udell and her students use theories of human development to understand how animals respond to people. See "Puppy Love," Page 22. (Photo: Oliver Day)

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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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Illustration by Nicole Xu

THE STORIES WE CARRY

Notes on our legacy and the future

Stamped into the sidewalk by my house in Corvallis are this name and date: W. L. Read 1928. At that time, the city had been incorporated for only 70 years. The sidewalk crosses streets named for past U.S. presidents: Harrison, Tyler, Polk and Taylor.

On my way to work, I pass the building named for Benton County citizens who, 50 years before this sidewalk was poured, dug into their pockets to buy land and erect a home on the hill for the young land grant college. I ride past the Kerr Administration Building. Jasper Kerr came to Oregon from Utah in 1907, and during his 25-year tenure as president of Oregon Agricultural College, most of OSU's major schools were established, including the School of Mines, which became part of the College of Engineering in 1932.

Despite our focus on the successes and problems of today, we're never far from the people who shaped the community under circumstances that are very different from our own. And as the recent conversations about OSU building names have shown, we struggle to reconcile our values with the attitudes and actions of our predecessors. We judge them in a modern context, fairly or not. While we may not all agree on how to interpret their legacies, we all stand on their shoulders. Understanding their stories — and those of people whose names are not on the sidewalks or buildings or in the history books — helps us shape our own for the generations that will come after us.

In celebrating the accomplishments of Oregon's land grant university, OSU150 highlights the people who have come together in this place. In this issue of *Terra*, we focus on a story that will unfold over the next century: How the state and OSU are positioned to feed a growing global population in a time of environmental and social upheaval. The problem is technical (how to produce more food sustainably), social (how to share what we have) and economic (how to maximize value).

Where better to look for answers than in the creativity and partnerships that drive the Agricultural Experiment Station and College of Agricultural Sciences? Solutions will take every bit of expertise in what Dan Arp, the soon-to-retire dean of the college, calls this "cauldron of experimentation."

And by way of milestones, this editor is adding one more. At the end of June, I will retire. Thank you co-workers, faculty, students and readers for the amazing privilege of telling the stories of this place for the past 13 years. There are many that remain to be told, and I look forward to continuing to learn about them in the pages of *Terra*.

Editor

NEW VIEWS

Science advances through emerging technologies

BY CYNTHIA SAGERS, VICE PRESIDENT FOR RESEARCH

As a young scientist, I was trained in hypothesis-driven research. I was taught that advances in knowledge come from a testable idea and a clever experiment. From one experiment to the next, evidence accumulates, and we become increasingly confident in our understanding of how the world works.

That process still stands at the heart of the scientific enterprise, but technology adds an important twist: As our machines become more powerful, we open new windows on the world and ask questions that we could have barely imagined in the past. For example, rapid genome sequencing and analytical methods offer tools for understanding and manipulating life. Geographic information systems help us grapple with trends in climate, vegetation and human health. Miniature sensors track wildlife, from whales to birds, and fuel the application of robotics and artificial intelligence to transportation and other aspects of daily life.

We make discoveries, gather data at a rapid rate and find creative ways to tease meaning out of mountains of details. And it couldn't come at a more important time.

Through a renewal of the Scientists' Warning to Humanity, first published in 1992, Oregon State researcher Bill Ripple and his colleagues have shown that we face daunting challenges and an uncertain future. We need to sustain ocean fisheries and coral reefs, to feed a growing global population and to help people displaced by war and climate change. Energy is critical for raising living standards, but we must simultaneously reduce our carbon emissions. And if we are to pass on a wild and beautiful world to the next generation, we must find ways to maintain habitats and still meet human needs for food and fiber.

The study of the marbled murrelet, featured in this issue of *Terra*, illustrates this point. The species is sensitive to conditions at sea and in our forests and is declining in the Northwest. With the support of the forest products industry and the state Legislature, Jim Rivers in the College of Forestry leads a team learning how the murrelet responds to changing conditions. The goal is to maintain an ecosystem and a forest products industry that directly and indirectly employs more than 60,000 Oregonians. Their project is a great example of OSU's signature Marine Studies Initiative, which connects the health of our coastal ocean with communities and the economy.

Researchers at Oregon State University and their partners in business and government have been pioneers in new ways of observing the world:

- Remote sensing by satellites, airplanes and unmanned vehicles (underwater and in the air)
- Rapid detection and analysis of the consequences of chemical exposure to life
- Genome research tools to treat infectious diseases, develop new agricultural crops and understand microbiomes and their relationship to environmental and human health
- Geographic information systems that enable us to map the locations and to meet the needs of people displaced by war and natural disaster

Advances in these fields are more likely when disciplinary and cultural boundaries fall, when engineers and scientists work with people in the arts and humanities. The research enterprise at Oregon State University is committed to fostering interdisciplinary networks and applying emerging technologies to the most pressing problems out there.

Marbled murrelet illustration by John Megahan, Oregon State University

A SPACE FOR PUBLIC DREAMING

Film can help us confront conflict and truth

BY MILA ZUO, ASSISTANT PROFESSOR IN THE SCHOOL OF WRITING, LITERATURE AND FILM; AND THE OSU ASIAN STUDIES PROGRAM

I study cinema because there is something about the film experience that cannot be reproduced in any other medium. It's a form of shared storytelling that engages every part of your body. It generates physiological and emotional reactions and a cognitive response. It connects with all of our senses. Film represents a synthesis of the arts. I call it a space for public dreaming.

But film also reflects our values, priorities, ethics and politics — the way we regard other people. It has the power to shift perspective. We saw its negative power in D.W. Griffiths' racist 1915 epic *Birth of a Nation*. The Ku Klux Klan, which had been almost nonexistent, became a huge social force as a result of the film.

Fast forward to *Black Panther*, the latest superhero blockbuster and the first centered around a black leader in a world that hasn't been tarnished by Western colonial rule. We're seeing how people are responding and how it empowers certain communities. It says to me that film has the power to change perspective.

At any given moment, film can tell you where we stand in relation to our values. I also think it can change our minds.

In my own research, I have focused on the depiction of Asian women in Hollywood films, particularly as objects of sexual desire, but also as foreigners to be feared. In the early to mid-20th century, the United States was grappling with issues of immigration and ideas of foreignness. The first ethno-racial law passed in the U.S. was directed at the Chinese and then at other Asian cultures. The language used then in the media described Asians as vermin, rats, subhuman.

Hollywood played its part. We see Charlie Chan and Fu Manchu, the *Daughter of the Dragon* with Anna May Wong. We see these noir-like and fraught stories that deal with the mysterious other, that show either a benevolent racism — they're smart, sneaky, clever and sly — or monstrous depictions. These Asian characters are often played by white actors.

In 1960, we get the *World of Suzi Wong*, which stars Nancy Kwan, a Eurasian. There's this tension being played out between fear and desire. She needs a white paternalistic partner to save her from herself, to civilize the savage. You can see that story, even though it's coursing through sexual narrative and interracial possibilities. It encodes the Asian woman as an infantilized colonial subject who needs to be saved from herself and her backward Asian culture. Desire and fear often work in tandem. You see that ambivalence around Asian women in general.

American film history has been built upon fantasizing the other — stereotyping, fearing and desiring the other. The first sound film, *The Jazz Singer*, has a man in blackface. I can't teach these canonical texts without addressing race, gender and nationality. Some of our students would rather not deal with these uncomfortable topics, but I think there's something generative about being uncomfortable. It's about taking us out of our comfort zones, out of our shells. As an educator, I'm about gently pushing boundaries.

Note: This essay stems from a conversation between Mila Zuo and Terra *editor Nick Houtman.*

FILLED WITH CURIOSITY

Nicole Hams likes to ask "what if?"

If a cat can have nine lives, why not a scientist? Nicole Hams has already had several. She has dived into nitrogen fixation, coral reef biology, fuel cells, fish health and protein chemistry. And she's just getting started.

"My mind doesn't necessarily sit still. I'm not afraid to be working on a lot of different things," says Hams. As a recently graduated doctoral student in the Department of Biochemistry and Biophysics, she published a paper in 2017 on otoferlin, a protein critical for human hearing, in the *Proceedings of the National Academy of Sciences*.

Currently, Hams is a post-doc in the Department of Microbiology with professor and department head Jerri Bartholomew. Her project focuses on a parasitic disease in Klamath River salmon, specifically identifying extracellular proteins involved in the ability of the parasite, *Ceratomyxa shasta*, to sense salmonids.

It's a journey a less resilient person might not have taken. When she was 14, Hams approached a high school guidance counselor about graduating early. The counselor laughed. "That interaction was the first time I realized sometimes what you don't get can motivate you," says Hams. "I got mad. I took college classes at night and went to summer school. With moral and financial help from my mom and zero help from that counselor, I graduated from high school at 15."

A determined personality and a tendency to follow light-bulb ideas comes with risks, she says, especially if the academic clock is ticking away, but the benefits are worth it. "I'm a wannabe engineer. I like to tinker. In my graduate project, I applied techniques that I had learned at an undergraduate summer engineering research experience. It reinforced that it's OK to be curious."

Homeschooled as a child in the rural Washington community of Summit south of Seattle, Hams loved to roam the woods. On family camping trips, she recalls setting out on her own with a compass and a dose of wanderlust. She hunts and finds time to spend in the woods with her two dogs, activities that round out her life in science and connect her with other people.

Despite her accomplishments, Hams finds her greatest satisfaction in networking, learning about people and helping other students. For example, she is developing a two-part STEM literacy program for high school students in Linn and Benton counties. Students will have the opportunity to explore research at OSU for a day while they learn about the scientific process. Afterward, they will have the option of putting together a research proposal to compete for a scholarship.

"When you are a research scientist, you spend a lot of time amassing knowledge and sharing that info with others in your field," she says. "But, it's important to remember to take time to interact and share your expertise with people outside of your field. It's hard to communicate — your science or otherwise — with others when you only interact with people from your scientific field. At the end of the day, if you diversify your circle, you will diversify your thought process."

Hiking and archery are two of Nicole Hams' passions. "Science is great, but you can't do it 24/7. You need ways to clear your mind." (Photo: Chris Becerra)

THE BIOCHEMISTRY OF CANNABIS:

OREGON LOOKS TO SCIENCE TO UNDERSTAND HOW MARIJUANA AFFECTS HUMAN HEALTH

BY LILLIAN PADGITT-COBB

At the High-Throughput Screening Facility in the College of Pharmacy, researchers screen thousands of drug-like molecules to assess their bioactivity. Marijuana is not under scrutiny at Oregon State. (Photos: Matthew Brodeur, left; Jan Sonnenmair)

In 2015, the Oregon SB844 Task Force comprised of scientists, marijuana growers, politicians and drug abuse professionals convened to assess the direction of marijuana research in Oregon. Members faced a daunting task. Since the research typically required to produce and approve a therapeutic agent simply does not exist for marijuana, ensuring safety for users represents a race against time.

One of the scientists appointed to the task force is Jane Ishmael, associate professor in the College of Pharmacy at Oregon State University. Her perspective on marijuana research stems from her expertise with the pharmacology and biochemistry of what scientists call natural products, compounds produced by microbes, plants and animals. Ishmael focuses on how such compounds affect processes occurring in cells. In particular, she studies cell receptors and how natural product compounds impact the central nervous system.

Such knowledge is critical for Oregon's marijuana task force. The group was charged with, among other things, reporting on the development of the medical cannabis industry that provides patients with the medical products they use to treat the symptoms of a variety of diseases. The initial task-force conclusions appeared in a 2016 report published by the Oregon Health Authority. Significantly, the report found that research on the health effects of marijuana is lagging and that legal and regulatory hurdles impede its progress.

Ishmael's research is unrelated to marijuana. She investigates the anticancer activity of naturally occurring, novel compounds discovered in marine environments around the world by Oregon State researchers. She wants to know how these natural products might impact cell growth and death in glioblastoma, a particularly aggressive form of cancer of the central nervous system, and triple-negative breast cancer cells.

Jane Ishmael, left, and graduate student Xuemei Wan review test results in Ishmael's lab in the College of Pharmacy. (Photo: Chris Becerra)

> "We're studying things we may never have the full answer to, and we might never see the impact on human health."
>
> **- JANE ISHMAEL**

In her lab, Ishmael studies compounds that have been isolated from a complex mixture of chemicals and analyzes them for their therapeutic potential. In particular, she studies the mechanism of action (the process by which a compound impacts its biological surroundings) of a chemical known as coibamide A. Oregon State professor Kerry McPhail isolated this compound from a marine cyanobacterium that she first reported in 2008 off the coast of Panama. McPhail and Ishmael have been investigating the capacity of coibamide A to kill cancer cells.

"We know so much less about the chemicals made by marine microorganisms," says Ishmael. "It's an area that holds great potential. We get to ask biological questions to determine the usefulness of novel structures, including their impact on cell signaling in human disease." Their methods are similar to those used for studying the therapeutic potential of marijuana.

Natural Product Medicine

The process of determining which compounds in a mixture have therapeutic potential is complex and can take many years. Natural products have inspired some of our most valued medicines. Notable examples include aspirin, penicillin and morphine. Considering the enormous diversity of novel compounds made by plants and marine organisms, our grasp of the potential of natural product-derived therapies is superficial. Few have been studied thoroughly or even identified.

As an extension of her teaching in the college, Ishmael conducts continuing education programs to inform health care providers about what scientists know and don't know about marijuana biochemistry. In addition to the science, she incorporates guidelines about marijuana use among patients. Medical practitioners are not alone in seeking to learn how to navigate safe marijuana use. There are plenty of people, she says, who simply want to know more about the effects of its myriad cannabinoids, any of the hundreds of compounds produced by marijuana plants that act on human cells.

As the stigma associated with marijuana use slowly dissipates, it's becoming possible to have open conversations about the plant's unique properties, safe use and colorful history.

In March 2018, Ishmael participated in an interdisciplinary continuing education

WHAT ARE RECEPTORS?

A biochemistry lesson for human health

The cells of the central nervous system possess the ability to react to changes in their environment by sending and receiving signals in the form of neurotransmitter chemicals. Embedded in the surface of cells are protein molecules called receptors that bind chemicals such as THC (tetrahydrocannabinol, a psychoactive compound), like a lock to a key. The unique shapes of these molecular combinations ensure that each key will conform only to the binding site of its corresponding lock.

Investigation of the affinity of THC for specific receptors on the cell membrane has helped to demystify the function of the endocannabinoid system. As a result of endocannabinoid-related research, deeper clarity into the biology has revealed how it might be possible to design a drug to target these receptors. Scientists have explored the possibility of using endocannabinoid receptors as therapeutic targets in the treatment of disorders such as nerve pain, neurodegenerative diseases, seizures, nausea and glaucoma.

Research into the safety and efficacy of marijuana remains critical as the abundance of active compounds in the plant has changed with long-term breeding strategies over the last several decades. Moreover, marijuana strains

event held at the Oregon Health & Science University in Portland. Health care providers — physicians, dentists, pharmacists and physician assistants — shared their experiences and insights regarding patient marijuana use. Doctors and pharmacists can't prescribe marijuana because of the requirement that they hold a U.S. Drug Enforcement Administration license. Marijuana remains illegal at the federal level, with a Schedule I classification under the Controlled Substances Act of 1970.

Nevertheless, health care providers are caring for more patients who use marijuana recreationally, in addition to patients who hold a card from the Oregon Medical Marijuana Program. Conversely, some people who might be eligible to hold a medical marijuana card are opting to obtain marijuana recreationally. The fallout from state legalization in October 2015 is still unfolding.

Involvement in the state task force has inspired Ishmael to stay positive about the future of research in natural product drug development. "We're studying things we may never have the full answer to, and we might never see the impact on human health," she says. "But understanding how cell signaling occurs, by using new chemical structures to probe the disease state, might eventually reveal new pathways and connections. We're really investing in research for the future." terra

Note: The author is a Ph.D. student in the Department of Biochemistry and Biophysics. She is also a host of Inspiration Dissemination, *a weekly radio show about graduate student research on KBVR.*

are highly varied and contain unpredictable amounts of active compounds, which confounds the comparison of therapeutic effects among users.

Although we have no record of human death resulting from a marijuana overdose, cannabis use disorder can occur. This disorder is characterized by the interference of marijuana in the tasks of daily life, and is accompanied by adverse symptoms.

THE MARIJUANA PHARMACOPOEIA

Cannabis contains more than 480 distinct chemicals

Deconstructing a network of compounds in order to parse the contribution of one of them is not a problem unique to marijuana. Plants have evolved tightly woven biochemical networks comprised of compounds and the enzymes that produce them. To study one compound is not necessarily enough to understand what is happening and how or why.

Marijuana contains more than 480 distinct chemical compounds, including both primary and secondary metabolites, which are the intermediate products of chemical reactions. While primary metabolites are required for basic cell functioning and found in all plants, secondary metabolites vary in structure and function across the plant kingdom. They are produced in variable quantities for optimal growth and survival in distinct environments.

Plants experience oxidative stress, exposure to pathogens, UV damage and cell death. All invoke a response through chemical defense. By gathering evidence and modifying hypotheses as new information becomes available, scientists try to make sense of how individual compounds in plants behave in a cooperative constellation.

Since it was first cultivated in Central Asia thousands of years ago, *Cannabis sativa* has been utilized across the world in agriculture as a source of medicine and fiber for textiles. The species includes marijuana and hemp, which differ only in terms of their tetrahydrocannabinol (THC) content. In order to be classified as hemp, the plant must contain less than 0.3 percent THC by dry weight. Cannabinoids present in the marijuana plant, including THC and cannabidiol (CBD), are among its most studied secondary metabolites, due to their well-documented psychotropic effects, which include the feeling of being high.

Once in the body, foreign cannabinoids compete with cannabinoids that occur naturally in the human body. When they bind to what scientists call endocannabinoid receptors on human cells, these foreign compounds contribute to their well-known effects.

Interest in studying terpenes, another family of marijuana compounds, is gathering momentum. Evidence shows that these chemicals can modulate the effects of cannabinoids. Among the 120 different terpenes that have been identified in marijuana are those that produce its characteristic aroma. Terpenes are also involved in essential plant cell processes, such as photosynthesis and chemical defense against pathogens.

The polypharmacology (the study of how multiple compounds interact to give rise to a unique or enhanced effect) of marijuana remains elusive. Only a few of its most well-known compounds have been investigated rigorously.

(Photo: Ryan Lange)

Food of the Faithful

Tibetan studies scholar Geoffrey Barstow explores the limits of Buddhism

BY NICK HOUTMAN | ILLUSTRATION BY NICOLE XU

"Available sources almost universally agree that meat is delicious. Perhaps more importantly, meat is often considered necessary for human health."

"Compassion, placing the needs of others before one's own, lies at the very center of Tibetan religious rhetoric and self-conception."

– *Food of Sinful Demons*, Geoffrey Barstow

What's for dinner? The question is repeated daily in households and languages across the world, and the answers come back in endless variety. Whether we grab a burger on our way to a meeting, enjoy a steak or a stir fry with family or gather in a circle around a shared meal eaten with our hands, what and how we choose to eat reflects our traditions and religious beliefs.

In Islam, the holy month of Ramadan calls for believers to fast during daylight hours to honor the revelation of the Quran to the Prophet Mohammad. In Judaism, keeping a kosher diet means following the rules of food preparation as revealed in the books of Leviticus and Deuteronomy in the Torah. For many Buddhists, Hindus and Christians, the practice of vegetarianism stems from principles laid down in sacred texts.

In a new book, *Food of Sinful Demons* (Columbia University Press, 2018), Geoffrey Barstow has opened a window on how culture and Buddhism in Tibet have interacted for more than a thousand years to influence food choices — specifically the decision about whether or not to eat meat. Through documents and interviews, he explores the tensions that have shaped the historical and the contemporary debate in that country. The first of its kind in Tibetan studies, Barstow's analysis offers a model for considering the values that underlie such choices elsewhere.

"I'm not the first to think about all this," he says. "People have made careers connecting food, ethics, religion and culture. But Buddhism has been largely outside of that conversation, and so I hope this work will contribute to remedying that."

The Tibetan studies scholar and assistant professor in the School of History, Philosophy, and Religion at Oregon State University grew up in a Christian household. He became fascinated with other religious traditions as a teenager, and during his undergraduate studies at Hampshire College in Massachusetts, he spent a year abroad studying Buddhism in India, China and Nepal.

A chance to travel to Tibet that year gave him a new perspective on a culture that has been romantically perceived in the West since at least 1933, when British writer James Hilton depicted an idyllic, secluded valley he called Shangri-la in *Lost Horizon*. "I had naïve first impressions about this exotic culture," Barstow says, "without any of the intellectual tools at that point to analyze or reflect. It seemed like a wild world of the mind that I was fascinated by philosophically and practically. Since my junior year in college, I never really thought about doing anything else."

After receiving a bachelor's degree, Barstow returned to Asia to study Buddhism. For four years, at the Rangjung Yeshe Institute in Kathmandu, Nepal, he delved into Buddhist history and principles. He learned to speak Tibetan and became familiar with the many faces of a faith tradition followed by about 10 percent of the world's people.

The knowledge and skills he gained would become invaluable in his investigation of vegetarianism, which he undertook for his Ph.D. at the University of Virginia.

Barstow began his research by visiting monasteries in eastern Tibet, a region known as Kham where Westerners rarely traveled. "I would go to a monastery and

Horse races are popular among Tibetans. Here, a competitor reaches to snatch a white scarf from the ground. The racer with the most scarves wins! (Photo: Geoffrey Barstow)

just sit and wait for someone to approach me," he says. "Often the fact that I could talk to them in Tibetan would get them interested. Pretty soon they would be asking me what I was doing there, and I would tell them and ask if they ate meat at this monastery. They would say 'no' or 'yes we do' and that would prompt a whole other set of questions."

By asking monks about their knowledge of written commentaries on eating meat, Barstow found perspectives that allowed him to trace religious leaders' positions on the topic back nearly to the introduction of Buddhism to the Tibetan plateau.

An Ongoing Debate

In 2011 and 2012, as Barstow was interviewing monks and scholars, the issue of vegetarianism had re-emerged as a hot topic in Tibet. Major lamas were advocating abstinence from meat and linking it to the core Buddhist principle of compassion for all sentient beings.

However, the push to avoid meat was meeting resistance from people who regarded vegetarianism as a foreign import at odds with the country's traditionally nomadic culture. In Tibet's grasslands, herds of goats, sheep and yaks are an important source of wealth and food.

Historically, in pre-Communist Tibet, most vegetarians were also monks and nuns, Barstow writes. Not eating meat — showing compassion for animals — aligned with other practices, such as celibacy, avoiding alcohol and not touching money. For the religious community, these and other commitments were seen as a path of awakening to the enduring truths of the world.

However, Buddhist scriptures do not uniformly agree, and in his book, Barstow separates three distinct perspectives on meat eating, each of which is derived from a particular set of religious vows. In the first of these, the Monastic Code, meat is seen as acceptable as long as the animal was not killed specifically for the monk in question. The second, known as the Boddhisattva Vow, emphasizes compassion and sees meat in a largely negative light. The third set of vows, the tantric commitments, actually mandates eating a small amount of meat, but only within a particular ritual context.

While monasteries adopted practices that aligned with their tradition, most Tibetan people ate meat as a matter of course. "For most Tibetans, meat was simply a necessary part of a normal diet," writes Barstow. "They may not have eaten it on a daily basis, but it remained an important part of the ideal diet, understood to be necessary for optimal health. Without it, an individual would weaken physically and become susceptible to illness."

Meat was also seen as a symbol of wealth and masculinity. Tibetan medicine recommended meat consumption to treat specific illnesses.

"The question of meat was never a settled or simple issue in Tibet," writes Barstow, "a fact that spurred a variety of attempts to promote vegetarianism while also acknowledging the difficulty of adopting such a diet."

Impact Beyond Tibet

In a review of *Food of Sinful Demons*, Holly Gayley, a writer for the Buddhist magazine *Tricycle*, says the book is "essential reading … for those following the vegetarian debate as it unfolds on the Tibetan plateau and as Buddhism spreads to new contexts…."

But Barstow hopes that his work has an impact beyond the Tibetan sphere as well. "This is a Tibetan story," he says. "But I would hope that people who read it would self-reflect about their food choices and consider what narrative they're buying into. When I refuse to pay more for the 'ethical' meat, what choice is that reflecting? What is that saying about my values? I'd be happy if people read the book and think about where their food comes from."

Barstow maintains connections with many of those he interviewed and with others who debate the role of vegetarianism in Tibet. He is translating a volume of Tibetan texts on the subject under contract with a publisher that serves Buddhist communities.

Meanwhile, he is starting a new project to explore the interactions between students and teachers in monasteries and schools. "The tradition suggests that students should have complete devotion to their teachers and do everything they say," he says, "but what happens when the teachers say something the student might not agree with?"

With support from the OSU Research Office, three Oregon State undergraduates are working with Barstow on the project. Barstow is also arranging for OSU students to study abroad at the Rangjung Yeshe Institute in Nepal, where he first gained his foothold in Tibetan Studies. terra

Nuns turn prayer wheels at Yachen Gar in the Kham region of Eastern Tibet. (Photo: Geoffrey Barstow)

OSU ASIAN STUDIES PROGRAM

Oregon State connects students with vibrant cultures, growing economies

For decades, Oregon State University has collaborated with scientists and scholars in China, Japan and other Asian countries. Researchers have studied contemplative traditions in India, tsunamis in Indonesia, consumer preferences in Taiwan and South Korea and political history, air quality and turf grass in China.

OSU musicians and artists have participated in exchange programs that bring performers and scholars face-to-face with colleagues and the public on both sides of the Pacific.

OSU's Asian Studies Program in the College of Liberal Arts fosters these relationships and offers students the chance to

delve into ancient cultural traditions and to learn how their peers are addressing contemporary issues. Faculty affiliated with the program work in art, anthropology, philosophy, languages, film, history and political science.

"Asian Studies offers our faculty and students the chance to get to know and study with researchers in Asia," says Hua-yu Li, director of the Asian Studies Program. "These opportunities open us to new insights and enable us to communicate more effectively. They are part of what makes Oregon State a great place to study and learn."

See more online at liberalarts.oregonstate.edu/asian-studies-program

OSU150

The Road to Plenty

New ways to feed the world are emerging through technology and environmental stewardship

BY NICK HOUTMAN

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.

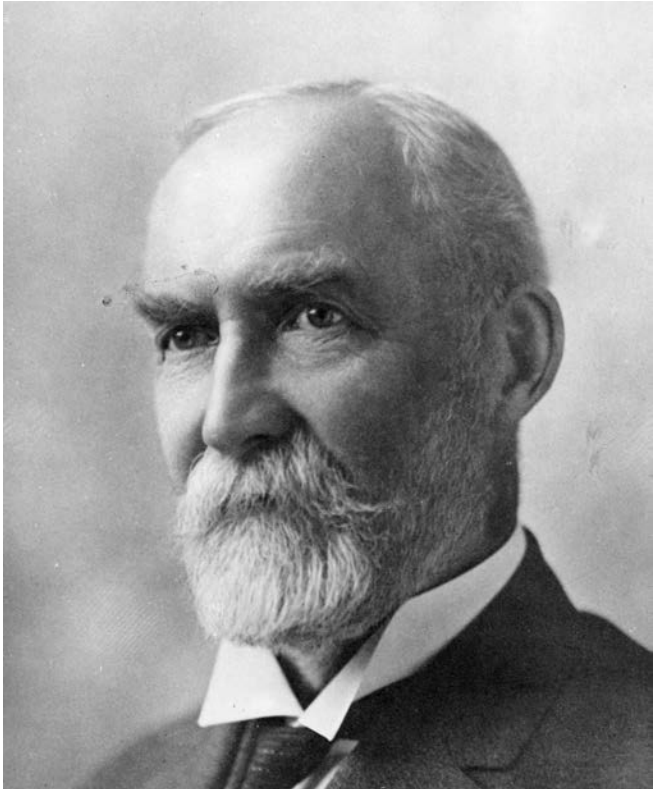
Left: Pendleton-area wheat producer Chris Williams takes a break from planting wheat to talk with OSU cereal pathologist Christina Hagerty. (Photo: Lynn Ketchum)
Below: In 1915, an agriculture class studied in a field with a horse-drawn harrow. (Photo courtesy OSU Libraries Special Collections & Archives Research Center)

In 1937, Oregon Agricultural College was reeling from five years of Depression-era budget cuts and staff reductions. The School of Agriculture had lost a quarter of its faculty positions. The survival of the Agricultural Experiment Station — OAC's statewide research network — was at stake.

However, with record-breaking success in fields from poultry to plant breeding and dairy science, OAC was delivering on its land grant mission. It was building the state's economy. For station director William A. Schoenfeld and his team, it was time to celebrate.

Created by the federal Hatch Act in 1887, the station had 50 years of achievements under its belt. Development of a way to remove arsenic-based pesticide residues from fruit topped the station's own list of its 15 most important accomplishments. The innovative process had been adopted around the country and saved the state's apple and pear industries from threatened market sanctions abroad.

It was the kind of success that led to broad public support. During the 1930s, even as resources were shrinking on the Corvallis campus, new branch stations were opening in Medford, Burns and Klamath County. The Experiment Station was evolving into the broad-based, locally connected enterprise it is today.



James Withycombe was the Experiment Station director from 1908–1914 and the governor of Oregon from 1915–1919. (Photo courtesy OSU Libraries Special Collections & Archives Research Center)

Other milestones included a solution for Bang's Disease (aka brucellosis), a destructive dairy cattle problem; development of the Oregon seed industry through the leadership of OAC scientist George Hyslop; a system for breeding champion egg-laying chickens; and a method for making maraschino cherries.

Three-legged Stool

"When the land grant started (1862), President Lincoln was in the middle of the Civil War," says Dan Arp, dean of the College of Agricultural Sciences and director of the Experiment Station. "But he had the good sense to do the land grant, homestead and the railroad. That's so amazingly forward thinking."

Nevertheless, universities struggled to do the research that was necessary to fulfill their mission, and it took another 25 years for the nation's agricultural practices to be given systematic scientific support through the Hatch Act.

Sharing hard-won knowledge was another matter. Those scientists — including James Withycombe, the respected Hillsboro farmer who became Experiment Station director and then governor — boarded trains and conducted farmers' institutes in southern and western Oregon. They gave lectures and showed photos with a steriopticon, a predecessor of slide and film. These events were so popular that the state Legislature allocated funds to conduct more, and 25 years after the Hatch Act, the federal government created the Extension Service.

"Now we've got this system in place that eventually grows to become the envy of the world," says Arp. "We have the Cooperative Extension Service coupled with research coupled with the land grant university.

"Remember, that about 70 percent of the people were farmers. It was a very different world in terms of the technology they were using. Knowledge was passed down from father to son and not so much daughters at that time. It was very much an art and not so much science, and people learned by watching their neighbors."

Today, advances in plant and animal breeding, diseases, soil management, irrigation and ecology have transformed agriculture, but art is an underappreciated part of the story. While science provides the best evidence-based approach to managing the land, applying that knowledge is ultimately an act of creativity. "Each piece of land is unique," says Arp, "and your responsibility as a farmer is to understand your property and how you use science for that piece of land."

Cauldron of Experimentation

Solving local problems has been the bread and butter of agricultural science: how to raise wheat where rainfall is abundant or barely fills a coffee cup; how to produce grass seed without burning the harvested stubble; how to foster native bunch grasses and sage brush on weed-infested rangelands. But increasingly, says Arp, it's the global challenges that keep researchers awake at night.

Models of population growth point to 9 to 10 billion people on the planet by 2050. "That's only 32 years away. That's not very long to figure out how to feed another 2 billion people or more," he says. "There isn't getting to be a lot more arable land. So how do we get to that?"

Technology is likely to be part of the answer. Genomics, robotics, sensors, geoengineering, artificial intelligence and other tools are already reshaping food production. They are contributing, says Arp, to what Paul Jepsen, director of OSU's Integrated Plant Protection Center, calls "sustainable intensification." In short, we'll need to produce more food per acre in a way that can be sustained for the long haul.

Oregon will play a pivotal role because of its diversity and entrepreneurial spirit. "We are this remarkable cauldron of experimentation, given all the different growing regions we have. All of the major soil groups in the world are here in Oregon. We will be more recognized as this place to come to learn about production practices."

The Future of Agriculture

For a perspective on that future, it helps to start with old photos. Chad Higgins, associate professor in the Department of Biological and Ecological Engineering, wonders if his predecessors — who are pictured with horse-drawn carriages, dressed in coats and ties

for the lab — would have had a clue about how agriculture would change over the following century. Likewise, researchers and food producers 150 years from now might look back and wonder if we really had any idea where things were headed.

"But the trend has always been to increase the efficiency, increase the productivity, increase the automation, increase the control," says Higgins, "and I wonder if the end state is complete automation.

"Farmers are decision engines, but as with all of our jobs, automation is going to continue. First the physical aspects are going to be automated, planting and harvesting. The management decisions, data collection and optimization of farm operation and irrigation scheduling could get automated. Same with fertilizer and pesticide applications."

Higgins explores the intersection of farming and technology. For example, he and his students are testing the idea that RFID (radio-frequency identification) devices, which are commonly used to track inventory in retail stores, can generate a round-the-clock, area-wide picture of soil moisture. Such information could help fine tune planting and irrigation schedules. The researchers are using unmanned aerial systems (drones) to record light reflected from plant leaves and to translate data into indications of stress.

Competition over land, he adds, will drive further innovations. The push for renewable energy is a case in point. In Eastern Oregon, Higgins and his colleagues have already shown that planting some crops under solar collectors can reduce water stress while simultaneously increasing plant productivity and the operating efficiency of the solar array. It would not work with all crops, such as those that require combines or other large machinery.

Nevertheless, farmers in Central and Eastern Oregon could manage sunlight in the same way they now manage other inputs such as water and fertilizer.

"I think there will be a whole advancement in systems thinking as it relates to agriculture in a more inclusive sense," says Higgins. "There will be competing demands for water, for land and for agricultural products. And I think we're going to think more broadly about those demands and how the farm is being managed and squeezed on every side."

Soils as Living Systems

While tomatoes and other vegetables can be produced in hydroponic systems — networks of pipes that carry water-based nutrients to plant roots — most crops will continue to be planted in the soil. And despite the inherent properties of earth from place to place, says Jay Noller, professor and head in the Department of Crop and Soil Science, agriculture is increasingly being done in soils that are the result of geoengineering.

By that, he means that farm fields will be constructed on site or wrapped in bioplastic sheets to meet the needs of a particular crop under a particular set of climate conditions. "We come in with solar-powered land levelers, and it's all terraced," he says.

Top: Modern tractors can be equipped with a GPS that can drive itself by following a recorded track under the driver's supervision. (Photo: Jennifer Hamilton)
Bottom: Researcher Qingyue Ling demonstrates RFID (radio-frequency identification) to visitors during an Oregon State University Roads Scholar Tour stop. (Photo: Lynn Ketchum)

Soil scientists probe the soil to understand its chemical, physical and biological characteristics. (Photo courtesy of Extension and Experiment Station Communications)

"So this idea of the soil having an innate inherited paradigm will be shed. The plat (land ownership map) says you have this part of the world, but you bring in all these materials at great cost and say here's the starting condition for the next few centuries. That's the big change. The markets are taking us there, or authoritarian governments are taking us there."

As examples, Noller points to terraces near Boise, Idaho, where "they brought in a Southern California housing development approach," bulldozed hills into level terraces and constructed a mixture of soils on site. In the Yangtzee River delta in China, bioplastic-wrapped rice fields can be measured by the square mile.

That approach contrasts with the ongoing shift toward no-till practices in much of the United States. By not plowing their fields and drilling seeds into undisturbed ground instead, farmers reduce the likelihood of soil erosion, cut carbon emissions to the atmosphere (and possibly store more carbon in the soil) and allow underground ecosystems to develop. Weeds are generally managed with herbicides in conventional practice today, whereas in the future, they'll be outcompeted by new crop varieties or obliterated by automated field machinery. Plant pathogens will be moderated by a grower focus on healthy soil.

Soils evolve over centuries, says Noller, and it will probably take at least 150 years to determine what soil properties — biological, chemical and physical — result from current no-till practices. To understand such changes, researchers are already developing the ability to scan all the genomes present in a soil sample. As farmers test their soils for growing specific crops or to determine the results of geoengineering, "that genetic fingerprint will let us know if we're successful, if we have what we need to grow food," says Noller.

Fish for the Future

Although Oregon policymakers have set the state on a clear path toward wild instead of farm-raised fish, Oregon State University has been a leader in international freshwater aquaculture. Growth of this industry, what economic development experts call the "blue revolution," means that it is likely to become a bigger part of global food production in the future.

Through the efforts of Hillary Egna, lead scientist and director of OSU's Aquafish Innovation Lab, fish farming has become an increasingly important source of nutrition and economic development in places like Southeast Asia, sub-Saharan Africa and Central America. Over the last decade, largely with funding from the U.S. Agency for International Development, Egna and her colleagues in the United States and abroad have trained more than 10,000 people in aquaculture methods and marketing. Production has increased to the point that in some countries, farm-raised fish are being sold to meet local needs and to provide badly needed export income.

"Let's face it," says Egna, "aquaculture is harder than other cropping systems. First, you can't see what you're growing. That's probably the most important. But also, the supply chain can get

quite expensive, and it isn't well-established. It involves more risk than something like sorghum or even horticulture."

Egna's interest stemmed from her conviction that fish farming could provide a source of vital protein and micronutrients for children as well as a sustainable business in much of the world. "People sometimes question why we would help everyone else and not do this for ourselves," she says. "We do have return benefits. Many of these overseas companies buy U.S. products. They might buy our satellite time so they can look at what's happening with their offshore production to manage their auto-feeders, or they might buy our auto-feeders. They buy the feed that they use or buy our soy that goes into their feed."

In Oregon, aquaculture is likely to serve high-value, niche markets. The state has a long history with oysters, and another opportunity lies with dulse (seaweed), especially the variety that tastes like bacon when properly cooked. Although Oregon's natural resources could support well-regulated, freshwater fish farms, environmental laws and concerns over wild fisheries, says Egna, are likely to constrain future development.

Location Matters

When it comes to breeding new plant varieties, Pat Hayes takes the long view. The professor in the Department of Crop and Soil Science and director of Barley World at OSU notes that two years before Oregon State was designated a land grant college, an Austrian monk published groundbreaking work on the nature of trait inheritance in peas. However, Gregor Mendel's paper was largely forgotten until 1900. Before that, there was little to no plant breeding for scientific purposes at Oregon Agricultural College or anywhere else. Its rediscovery launched a frenzy of research to identify Mendel's "elements" that are responsible for variations in plants.

"One hundred and fifty years ago," says Hayes, "Mendel figured out what variants were and how they're inherited, and now we can create new variants, new genes." Geneticists can explore and manipulate the genome with precision, although, says Hayes, developing varieties with desirable traits can usually be done by traditional breeding techniques.

Hayes and his colleagues specialize in barley, one of the first domesticated crops. With a genome that is smaller than that of wheat, barley offers plant breeders the advantage of relative simplicity. Hayes' lab has focused, for example, on the genes responsible for cold tolerance and light sensitivity, traits that could be important for helping varieties adapt to climate change.

Scientific curiosity and the ability to breed plants adapted to specific places, says Hayes, will drive plant breeding innovation in the future. And when he asks his students what breeders should try to achieve through research, he hears this: "You want crop varieties to give something back and get away from mining the environment," says Hayes. "They might give back in terms of carbon sequestration, in terms of nitrogen fixation, in terms of ecosystem services. We need to get away from crops that create dead zones in the ocean or contaminate aquifers."

Top: 1960s. William Foote, OSU agronomist, removes anthers from inbred barleys in preparation for crossing with other lines. (Photo courtesy OSU Libraries Special Collections & Archives Research Center)
Bottom: Pat Hayes examines a barley stalk, which has a smaller genome than that of wheat, and offers plant breeders the advantage of relative simplicity. (Photo: Lynn Ketchum)

Top: OSU Harvey Ranch manager, Jared Kerr, moves cattle into the high country outside Paisley, Oregon. (Photo courtesy of Extension and Experiment Station Communications)

Shared Rangelands

In the late 1800s and early 1900s, ranching in Eastern Oregon nearly became a "tragedy of the commons." With no regulation, cattle were allowed to overgraze on native bunchgrasses and other high-quality forage. "We're still dealing with the consequences of that," says David Bohnert, director of the Eastern Oregon Agricultural Research Center in Burns.

Today, to be a cattle rancher takes more than knowledge of livestock and business. Increasingly, ranchers share the range with endangered and invasive species and become embroiled in debates about wildfire, water rights and the management of public lands. "You almost have to be a lawyer with what's going on with public lands policy," says Bohnert. "You have to be a natural resource manager and understand the Endangered Species Act and wildlife issues and be a tech guy."

Both Oregon State University and the USDA Agricultural Research Service employ researchers at the EOARC. Bohnert and his colleagues tap expertise across the West to answer common problems, from cattle genetics to sage-grouse restoration and the consequences of grazing by wild horses and burros.

When breeding new livestock, for example, ranchers tended to stick with favorites such as Angus or Hereford. That may change as a result of ongoing studies of how cattle genetics affect an animal's fitness for a specific environment, says Bohnert.

In the future, ranchers will take advantage of knowledge from rangeland studies of grazing impacts on invasive plants and the effects of horses on sage-grouse nesting behavior. They are also likely to be using GPS to track their herds.

It costs about $200 to put a GPS unit on a cow. "You don't need to put them on every animal," says Bohnert, "but what if you could put them on a few animals that are representative of your herd and see where your cattle graze?"

Although Bohnert sees a continuing demand for mass-market beef, ranchers will pay more attention to managing cattle for specific consumer preferences. "Organic," "grass-fed" and animals raised without the use of antibiotics will likely continue to command a higher price in the marketplace, he says.

Community Resilience

Even as agriculture continues to change through technology and other innovations, rural economies will reflect the stunning variety of Oregon's landscape: rivers, mountains, forests, grasslands, bays and harbors.

"Something that we often miss is that there is a tremendous amount of diversity in rural America," says Mallory Rahe, an Extension community economist and instructor in the Department of Applied Economics. "People might have personal experience with areas that are losing population. That's a very specific trajectory caused by different things in these communities. It's hard to reverse. But there are a lot of communities that are growing and changing, and here in the West, some of them are growing against their will."

Future development depends on local leadership and community willingness to experiment, to take advantage of niches in the marketplace and to find connections with urban centers. For communities with a strong agricultural focus, technology is likely to be an opportunity for future growth. "The real need to balance economic and environmental issues on the farm is creating a lot of areas for opportunity, for innovation and for jobs," Rahe says. "Students who are aware of those trends and can help shift production in that direction will find jobs in agriculture."

Nevertheless, for the community as a whole, technology can also raise the threat of external competition. Success increasingly demands that local businesses keep track of trends outside the community in order to respond to economic changes.

"Communities that don't look at how things are changing are more likely to be passed by or have change affect them," adds Rahe. "By the time they recognize that things are changing, it's too late to mitigate all the negative impacts."

Efficient Food Processing

The astounding variety of modern foods becomes apparent just by walking down the aisles of a grocery store. While the produce, meat and seafood sections offer fresh, minimally processed products, everything else has been dried, canned, fermented, baked or frozen. All of it has been packaged at a cost in materials and energy.

The future of this industry will be driven by the need to become more efficient, says Yanyun Zhao, professor in the Department of Food Science and Technology and an Extension specialist in value-added food processing. "Increased population and reduced resources are driving innovation in food processing," she says. "From the consumer's standpoint, we are looking for new ways to reduce food waste and energy demand."

Zhao's lab focuses on such natural, biodegradable packaging materials as chitosan, which stems from crab and shrimp shells and offers antimicrobial and antioxidant benefits. By combining chitosan with other natural substances, Zhao and her team have created edible coatings and films that can help extend the shelf life of fruits, fish, meats and other products.

Zhao is also exploring the uses of a fruit processing and winemaking byproduct known as pomace, which consists of stems, skins and seeds. While fruit juice and wine makers must find ways to have pomace removed from their facilities, Zhao has shown that the material can be turned into a nutritionally beneficial food ingredient or converted into biodegradable packaging materials.

OSU food science researcher Yanyun Zhao holds a muffin made with grape pomace — the skins, stems and seeds leftover from winemaking. (Photo: Lynn Ketchum)

"Ideally we could eat everything fresh, but it's not possible," says Zhao. "When we process food, we need to be aware of qualities like taste, smell and flavor, but the big priority is food safety." terra

150 SPECIES SUSTAINED

See an online display of conservation driven by OSU research

Research in the Department of Fisheries and Wildlife reaches back to 1935 when Oregon State College established the Department of Fish, Game and Fur Animal Management. The name changed to its current form in 1964 as the mission broadened from management of a few species to the conservation of many.

Faculty and students study and share what they learn from cell to ecosystem with a focus on how natural systems are influenced by human activities. The goal is to provide people with knowledge for making informed decisions on issues of conservation, sustainable use and ecosystem restoration.

In honor of OSU150, the department created the 150 Species Sustained project. This online catalog includes more than 150 creatures from aardvarks to zebrafish. In each case, OSU researchers have made a major contribution to a policy, management decision or conservation plan to advance the species' sustainability.

To view it go to fw.oregonstate.edu/150species.

Research as Diverse as Oregon

OSU's land grant heritage arises naturally from the state's diversity. The College of Agricultural Sciences, Agricultural Experiment Station and Extension Service serve people and communities from the coast to the mountains and rangelands of Eastern Oregon. They work from the valleys of southern Oregon to the Portland metro region and the Columbia River. The perspectives reflected in this story offer a diverse but small slice of the community of experts who serve Oregonians and collaborate with people throughout the world.

PUPPY LOVE

Why understanding the human-animal bond is essential to their happiness — and ours

BY THERESA HOGUE

When Monique Udell looks into the eyes of a puppy or kitten, she sees more than just a cute face. She sees an animal whose fate, happiness and success are intimately intertwined with that of humankind. Pets, especially dogs and cats, hold a unique place in the homes of many humans around the world, but exactly how they form attachments to us, and how our own attachments benefit them, has only recently been explored.

Udell is an assistant professor in the Department of Animal and Rangeland Sciences at Oregon State University. She is also director of the OSU Human-Animal Interaction Lab, where she and her team study dog and cat cognition as well as how dogs and cats relate to humans. Her work is funded by the National Institutes of Health and Maddie's Fund, a nonprofit organization that supports companion animals.

Growing up, Udell dreamed about becoming a veterinarian. But while taking pre-vet courses in college, she discovered another compelling field: animal behavior. She was immediately smitten.

"Initially I was very interested in social behavior," she says. "I did work with birds and rodents because they're social animals. I was interested in aspects of imitation and communication."

When she exhausted the options in biology, she started taking psychology classes and became struck with how the process of attachment — how we form social bonds — affects both people and animals. This dual interest led her to do graduate work in psychology with a focus on animal behavior.

Animals and Us

In the past, Udell says, studies on animal behavior, including attachment and cognition, were often done so that scientists could apply that research to humans, using animals as a substitute for human subjects. But in the last 20 years, the field of animal behavior has greatly expanded. Researchers focus more on how their work can benefit pets and their owners.

"It's fascinating that we're just answering some of these questions now because we have this really long history with companion animals," Udell adds. "We've taken another species into our home and raised them with that level of attention and affection and in many cases make such substantial sacrifices to keep these animals in our lives, and yet our understanding of why we do that and how we can develop these bonds is limited. We have a long way to go."

After years of looking at how animals can inform our understanding of human behavior, the tables are now turned as research on human parent-child attachment is being applied to dog and cat subjects. The similarities are remarkable. Because it appears that human and dog attachment is not that different, Udell hopes to use decades of human-child research to improve human-animal connections.

"What have human psychologists learned about the way these attachment styles impact children? And can we find similar relationships in dogs? Can we say these things might be true in dogs?" Udell asks. "If so, there's a lot of great literature that tells us what we can do about that and how we can make animals' lives better."

Documenting similarities in human and animal attachments, says Udell, could lead to improvements in understanding animals. Such knowledge could help predict the development of problem behaviors or what it takes for an animal to successfully bond to a person.

"We know that dogs and cats can form attachments to owners much in the same way that children form attachments to their parents. We're trying to understand how these relationships work," she says.

Secure, Ambivalent or Insecure

Udell's research has shown that, like humans, dogs typically fall into three different categories of attachment. Securely attached dogs usually greet their owners happily and then, after a short time, go back to their usual behavior. Other dogs fall into a category known as "insecure ambivalent." They are excited about their owners but are desperate for attention and don't calm down easily.

A third category is called "insecure avoidant." These animals don't greet or acknowledge their owners or seek their attention.

"These are all patterns that were identified in the 1960s in children and their parents," Udell explains. "It maps on incredibly well. The dog videos look so much like the child videos. You can spot these categories very quickly." Cats fall into the same categories as well.

When conducting research on dog behavior and attachment, Udell says the first step is to identify the ideal human-dog relationship.

(Photo: David Baker)

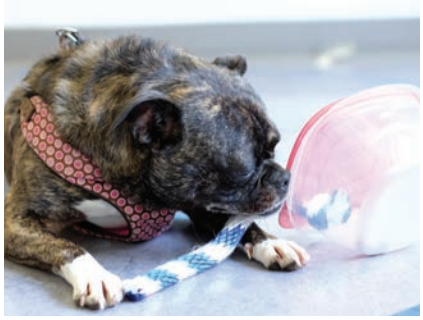
"A lot of what we do is trying to figure out what the goals are, what type of relationships lead to the best outcomes and mutual well-being in home or work settings, so we can then provide advice about how you go about reaching those targets," Udell says. "But a lot of that information just doesn't exist yet."

Science has yet to describe the ideal profile for behavior that leads to a successful, well-adjusted dog, she emphasizes.

A key to that knowledge may come from working with dogs in shelters and comparing behavior and attachment to that of dogs living in homes. These tests could eventually be predictors for a dog's likelihood of being adopted or help change the way shelters work with dogs and cats. Research may help shelter workers assess an animal's ability to bond with future owners and even potentially help operators better match animal personalities with owner profiles to ensure better adoption success rates.

"With cats, that includes looking at things like training classes and trying to understand if formal socialization has added benefit in terms of increasing the human-cat bond," she says. "If we

Top: Monique Udell reviews the steps in her research on dog-human attachment with writer Theresa Hogue and Hogue's dog Simone. Bottom: Udell observes Simone's interactions with her owner as well as her focus on a variety of tempting toys. Below: Simone's ability to focus on a food puzzle is part of Udell's animal attachment research. (Photos: Jen Pywell)



understand that a certain type of relationship profile more or less predicts how those relationships will develop in the adoptive home, we could potentially provide tips on fitting that interaction profile."

Animals for Human Development

Another area of research Udell and her team are exploring, in collaboration with Megan MacDonald of Oregon State's College of Public Health and Human Sciences, is dog-assisted therapy. They're currently examining the relationships between children with developmental disabilities (both motor and social) and their family dogs, not necessarily a pet that has been specifically assigned as a therapy dog.

Adolescents in these studies are assigned to one of two programs. The first is a dog-walking program where children learn the rules of safe dog-walking and are assigned to walk their dog for 30 minutes a day. The second group also engages in "Do-As-I-Do Dog Training," which is an imitation-based, positive reinforcement dog training exercise. The end goal is to strengthen the bond between child and dog, so they're trying to achieve a goal together.

"It's an active goal," Udell explains. "Ultimately we are trying to increase physical activity levels to improve the health of the child and dog. And because it's imitation-based learning, we're hoping that will translate into improved social well-being and social skills."

Imitation-based interventions are commonly used in children with developmental disabilities, but typically it's human to human, Udell says. "We're essentially doing this with their dogs so they can have a sustainable relationship and skill development that they can continue at home after the intervention."

There are many facets to the human-animal interaction that can be explored through the program, and the benefits to adolescents with developmental disabilities can be broad.

For example, she says, if children are having difficulty controlling their emotions and this behavior is impacting their interactions with their dog, the researchers work on building those skills on both sides of the relationship. "So the goal is to try to help the child figure out ways of interacting with the dog and help the dog figure out ways to interact with the child. That enhances that bond and leads to this joint mutual success."

While research will likely lead to predictive factors that may improve how we relate to our closest animal companions, it's also important to remember that each dog and cat in our life may relate to us a little differently.

"Animals are individuals. They have their own predispositions, and people in the household are individuals and have their own relationships," Udell says. "This is something else we're looking at, that it's totally possible for a cat or a dog to have different attachment styles to different people. Often when we look at the literature on humans, we find evidence of having at least one secure attachment that's important. Not every relationship has to be a secure attachment."

As researchers continue to search for the keys that make our centuries-old relationship with companion animals even stronger, it is comforting to know that at this point, we've been together so long, we can't do without each other.

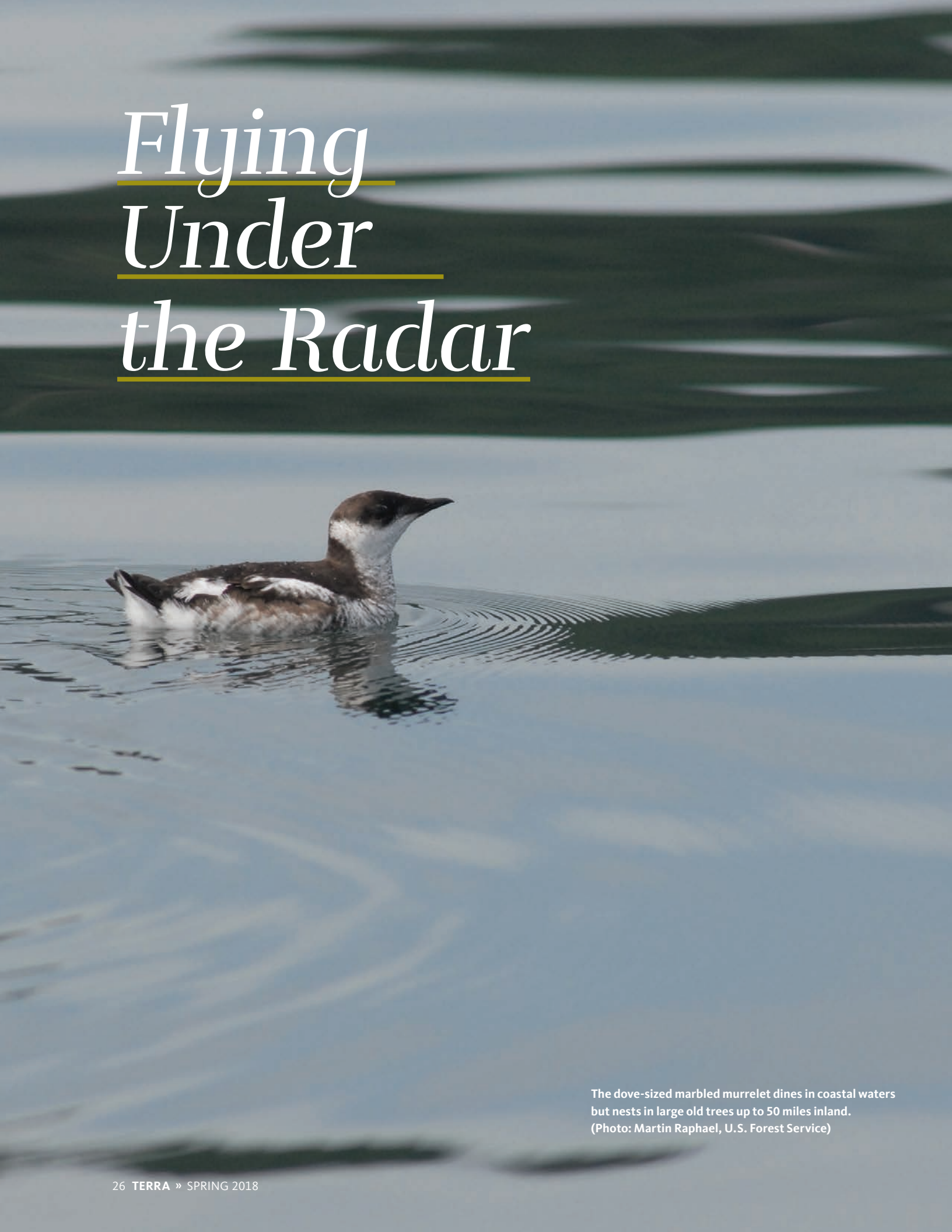
"If people all completely disappeared," Udell says, "dogs would be in rough shape. Many of us might feel the same way about a world without dogs." terra

"If people all completely disappeared, dogs would be in rough shape. Many of us might feel the same way about a world without dogs."

— Monique Udell

(Photos: University Marketing)

Flying Under the Radar



The dove-sized marbled murrelet dines in coastal waters but nests in large old trees up to 50 miles inland. (Photo: Martin Raphael, U.S. Forest Service)

(Photo: Peter Halasz)

"Close up, though, brown becomes sooty brown, brownish black, chocolate, rufous, rusty-buff, light tan, and cinnamon on the bird's back, head and wings. Brown becomes light brown marbled with soft whites on its throat, flanks and breast."

— Rare Bird: Pursuing the Mystery of the Marbled Murrelet, by Maria Mudd Ruth

BY NICK HOUTMAN

In a small plane high above the Oregon coast last spring, researchers heard the signal they were looking for. The soft ping in their earphones told them that a bird with a tiny transmitter glued to its back was bobbing on the ocean swells below. One of the crew radioed the news to Oregon State University in Corvallis.

It was the first of many signals received from some of the more than 60 birds that had been tagged in hopes of following their movements. Over the following days and weeks, however, things turned quiet. The pings gradually disappeared and with them, at least temporarily, so did the plans to learn more about threats to a creature that has eluded scientists for decades. A few weeks later, the researchers were in for a surprise.

Called "The Enigma of the Pacific" by Canadian naturalist Charles Guiget, the marbled murrelet dines on krill, capelin, anchovies and other small prey at sea. Once she has mated and built up her own reserves, it's time to nest. She darts inland. And that's where the fortunes of this dove-sized bird intersect with West Coast forests. Large old trees are thought to be essential for murrelets to nest and raise their young, but murrelet populations are declining, and scientists don't know if the reduction in older coastal forests is the only bottleneck or if other factors, such as predation or conditions at sea, might be making it harder for the birds to reproduce.

"Murrelets are a species of two worlds," says Jim Rivers, assistant professor in the College of Forestry and leader of the Oregon Marbled Murrelet Project. "They're a marine bird. They get all their food from the ocean, but they have this curious behavior of moving inland to nest." For reasons not fully understood, murrelet populations have declined as much as 90 percent in California, Oregon and Washington. The bird is listed as threatened under the federal Endangered Species Act in all three states.

Along the West Coast, marbled murrelets range as far south as Santa Cruz, California, where they winter, and as far north as the Aleutian Islands. Their populations have been declining by about 4 percent a year.

With funding from the state Legislature, forest ecologists and ornithologists at Oregon State are conducting a long-term, large-scale study to determine what the marbled murrelet needs to survive. In addition, the scientists aim to provide forest managers on public and private lands with information that can be used to balance habitat conservation with timberland management. Leading the project are Rivers and Matthew Betts in the College of Forestry and Kim Nelson and Dan Roby in the Oregon State Department of Fisheries and Wildlife.

Management of Oregon's productive coastal forests requires a balance between timber production and habitat protection for species such as the marbled murrelet, say leaders in the College of Forestry. The college's investment in this project spans a range of interests from timber companies to environmental organizations. Decisions benefit from the best data and science available.

Gone to Find Food

Last spring, when the first transmitter signals faded and others failed to show up, the scientists decided to expand their search. They sent planes as far north as the Olympic Peninsula (they were unable to access Canadian air space) and as far south as the San Francisco Bay Area. And that's when they found signals from the birds they had tagged along the central Oregon coast.

In short, the murrelets had simply picked up and left. Ocean conditions were known

Marbled Murrelet Facts

Fast, solitary and secretive, marbled murrelets have escaped detailed scientific scrutiny. Here are a few things we know about these elusive seabirds.

High-Speed Flyers
Marbled murrelets are known to cruise about 60 miles per hour between their nests and ocean feeding grounds. One bird was clocked by radar at 98 miles per hour.

Home on the Branch
In Oregon, murrelets typically find a large branch, at least 4 inches in diameter, with moss or other substrate to lay their eggs. They do not build a nest.

Relatively Speaking
Marbled murrelets are members of the Auk family, which include puffins, murres and guillemots. All except three species of murrelets nest in colonies along the coast.

What's in a Name?
Loggers had a different name for the marbled murrelet. They called it a "fog lark," because of its secretive nature and ventriloquistic dawn calls.

to be poor; the cupboard was bare. So the murrelets had gone to find food elsewhere, and the nests that the researchers had hoped to observe never materialized. When the birds are stressed by a lack of food, they have been known to forgo reproduction and not lay any eggs, says Nelson, an ornithologist and wildlife ecologist.

Despite these unexpected findings, the project continues to receive broad support from the timber industry and conservation groups. "The goal of our project is to determine more about the murrelets' requirements for nesting," says Rivers, "to learn more about where the birds are located on the landscape and to understand more about the factors that influence nest success and their relationship to active forest management."

Many seabird species, such as common murres, terns and gulls, tend to nest in colonies, but murrelets are comparatively solitary, nesting in the forest and sometimes within small groups. They typically lay a single egg high in a tree in a depression on a horizontal limb that is at least 4 inches in diameter.

"The end goal for these birds is to be very secretive and quiet so predators don't find their nests and they can produce young," Rivers says. Globally, marbled murrelets are one of the few seabirds that nest in this fashion. Scientists don't know why the birds have evolved this particular habit.

Searching for Murrelets

The first known murrelet nest was found near Santa Cruz in the California redwoods in 1974. In Oregon, only 75 nests have been documented since Nelson identified the first one in 1990. "I was on Marys Peak in 1985 when I heard a seabird and wondered what this bird is doing so far from the ocean," she says. She saw murrelets that year at some of her study sites in the Coast Range.

Three years later, she began a series of systematic murrelet surveys funded by the Oregon Department of Fish and Wildlife and the U.S. Forest Service. Progress was slow, since identifying the birds required people to be physically present at specific locations by dawn for extended periods of time and to listen for the birds' smooth, high-pitched call. Nonetheless, throughout the Oregon Coast Range, they found more than 20 active nests and hundreds of occupied sites.

In a project funded in the 1990s by the Oregon Department of Forestry and the National Council for the Advancement of Air and Stream Improvement, a forest-products industry research organization, Nelson and other scientists climbed about 5,000 trees in a search for murrelet nests. That study identified an additional 45 nests in Oregon and more in Washington, although most of those nests were not active.

The researchers aim to learn more about how human activities in the forest affect

the risk that predators pose to murrelets. Little is known regarding the effects of logging, camping and the presence of garbage dumps on predator numbers and the chances that predators will find and depredate murrelet nests. Based on studies of known nests in the listed range, scientists have found that Steller's jays and other corvids, such as crows and ravens, are the main predators of murrelet nests.

Drones and Cameras

This past spring, the OSU research team again captured and tagged murrelets with miniature VHF radio transmitters. Only adult birds with a "brood patch," a spot with little or no feathers on the breast, are tagged. Such patches indicate that the bird is preparing to breed and incubate an egg.

Other research methods include the use of cameras to watch nests 24/7, drone-mounted infrared cameras to search for nests in the forest canopy and a customized audio recorder that can pinpoint murrelet calls and help researchers document inland movements.

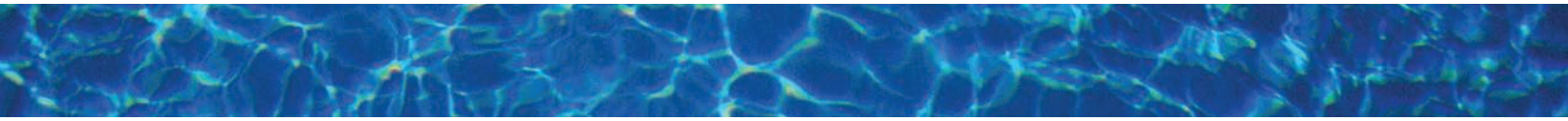
Long-term studies such as this enable scientists to understand how birds adjust to unpredictable ocean conditions, which can influence murrelet behavior from year to year. "We will be able to document rare conditions that might not be detected by a typical two- to three-year study," says Rivers. "Those conditions might have important consequences for the population." terra

Listening for signals from tagged murrelets are field technicians Brendan Popp (top) in a plane high above the Oregon coast and Ethan Woodis (bottom) on a coastal headland.
(Photos: Chelsea Hutton, top; Stuart Fety, bottom)

CLEAN WATER for a Thirsty Region

Researchers use microorganisms to consume groundwater contaminants

BY JOHANNA CARSON



In a semi-arid climate where water is scarce, groundwater contamination is a critical problem. To address the issue, researchers are cleaning polluted water with the help of some talented microorganisms and a little bit of sugar.

Starting in the early 1960s, the Umatilla Chemical Depot in Eastern Oregon housed a large supply of ammunition and explosives. As part of operations — and before the risks of dumping wastewater into the ground were fully understood — munitions were washed out into a lagoon, inadvertently creating a plume of contaminated groundwater.

Groundwater is an important resource in the Umatilla region. It is used for drinking, crop irrigation and commercial needs. In the hydrologic cycle, rainfall can run off into rivers, lakes and eventually the ocean, or it can permeate the soil where it becomes part of a groundwater aquifer. In arid regions like Umatilla, much of the groundwater accumulated in the distant past, when conditions were wetter than they are today.

The contamination at the Umatilla site is in a shallow aquifer that could be used in the future for irrigation. However, the objective of U.S. Army Corps of Engineers (USACE) is to clean the contaminated water to a level suitable for drinking water.

OSU alumna Mandy Michalsen, left, and Jack Istok, professor in the College of Engineering, are collaborating on a groundwater restoration project in Umatilla County. (Photo courtesy of the College of Engineering)

After identifying the contamination, the USACE initially implemented what clean-up experts call a pump-and-treat approach. In that process, contaminated groundwater is extracted and filtered above ground using activated carbon. The clean water is then reinjected through a series of large, horizontal pipes below the ground, known as an infiltration gallery. The process is slow and expensive, so after a few years of pumping and treating, researchers sought a more efficient approach.

Feeding the Microbes

To tackle the challenge, Mandy Michalsen, an Oregon State University alumna ('07) and research engineer at the U.S. Army Engineer Research Development Center Environmental Lab, partnered with her former doctoral adviser, Jack Istok, professor of water resources engineering at OSU. They tested an alternative clean-up technology that uses bioremediation — a process employing microorganisms — to break down contaminants.

To begin, Istok and Michalsen implemented a process called "the single-well push-pull method," a technique developed by Istok at Oregon State. It consists of injecting a prepared test solution into a well and then extracting a combined sample of the test solution and groundwater.

"Hundreds of industrial sites and national labs — including the Hanford Site in south-central Washington and several military bases in the western U.S. — have now applied the push-pull method," says Istok, the recognized expert in its application. Istok has performed thousands of push-pull tests to detect and quantify a wide variety of biogeochemical reactions occurring in the subsurface and to pilot test larger-scale remedial processes.

Within the aquifer, contaminants in the test solution are broken down by a combination of physical, chemical and microbiological reactions. By measuring the concentrations of the dissolved compounds during the extraction phase, the mass of reactant consumed and the product produced, researchers are able to calculate the reaction rates.

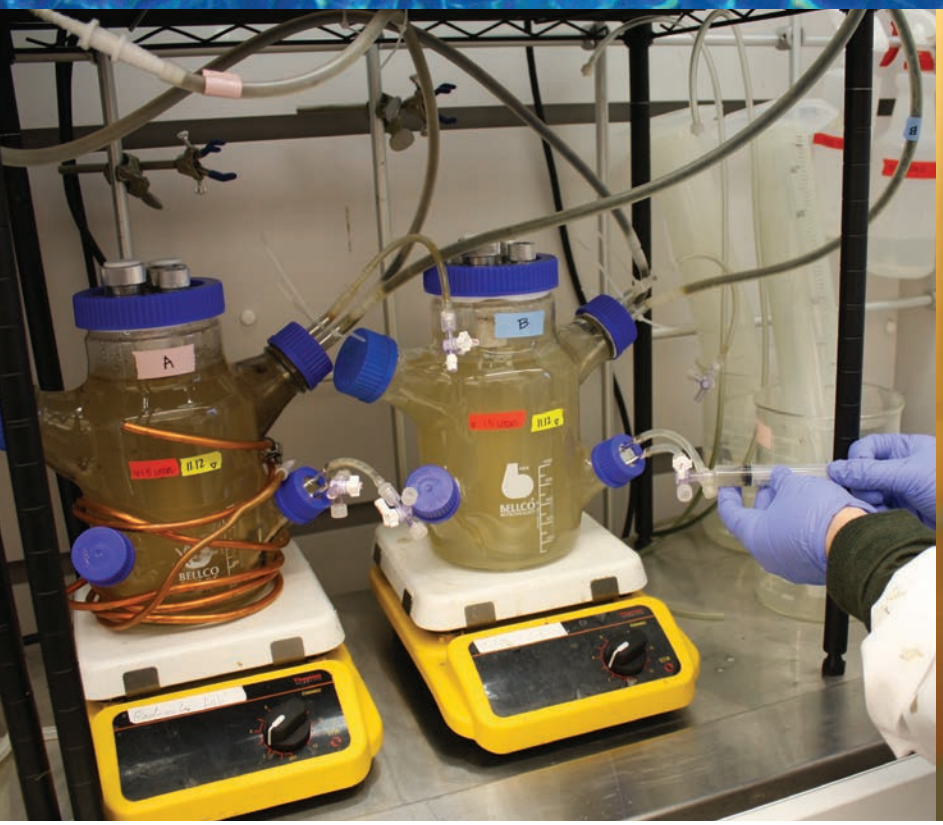
During their push-pull tests, Istok and Michalsen amended the solution with fructose in a technique known as biostimulation. In short, by feeding microbes, they promoted the development of an anaerobic, or oxygen-free, environment in the aquifer. The addition of a carbon source to the groundwater, where many different types of bacteria are present, led to conditions that are favorable for the growth of other organisms and the rapid degradation of the contaminants.

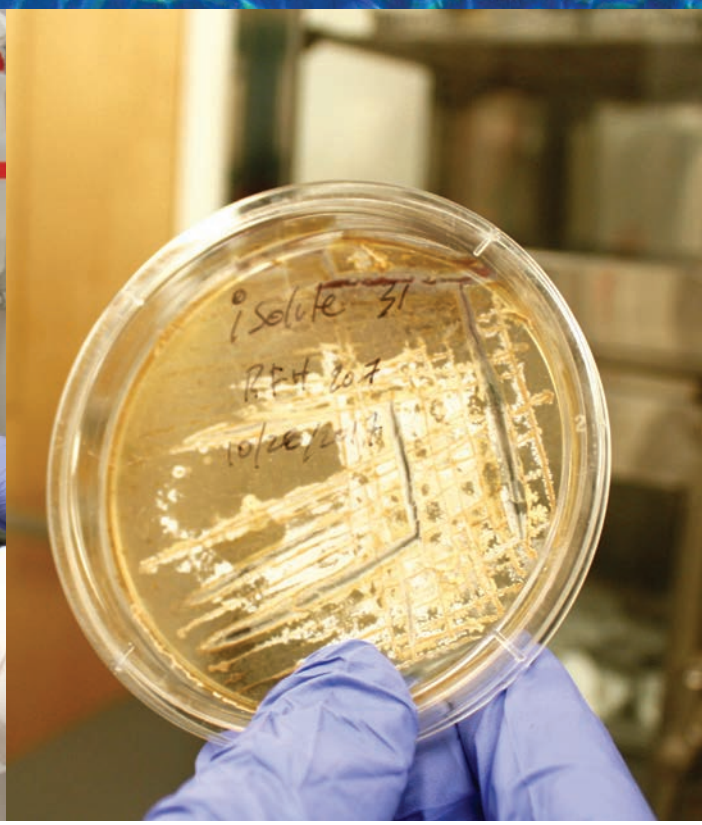
"Results of the small-scale, single-well push-pull tests showed that fructose addition worked and allowed us to predict how fast it would happen," Istok explains. "That gave everyone confidence that we could go to a larger scale."

To treat more of the contaminated area, Michalsen and a team from the U.S. Army Corps of Engineers, Seattle District, and the U.S. Army Engineer Research Development Center introduced large quantities of fructose-amended groundwater throughout the aquifer by using an existing infiltration gallery, which covered the original lagoon.

"It's been remarkably successful, and the RDX (an explosive) concentrations are now much lower," says Michalsen. "The extent of the groundwater above the clean-up level is much smaller too. The plume map has changed significantly — and for the better."

But, Michalsen adds, "that's not where the story ends."





In Tyler Radniecki's lab in the College of Engineering, titanium oxide nanoparticles interact with sunlight and generate a reactive form of oxygen, creating molecular cannonballs that destroy waterborne toxins. Radniecki's research is supported by the Clean and Sustainable Water Technology Initiative. (Photo courtesy of the College of Engineering)

The Right Stuff

Although it removes contaminants, anaerobic bioremediation has drawbacks, including an unpleasant odor in treated groundwater. To improve their process, Istok and Michalsen teamed with a group of researchers to show how adding a different type of bacteria to the groundwater, a method known as bioaugmenation, could avoid some of the water-quality impacts associated with anaerobic treatment.

"After using biostimulation, where we add fructose to stimulate the growth of bacteria already present, we moved on to bioaugmentation, where we add specific organisms grown in the lab," says Istok. "While many have studied both approaches, our innovation is introducing microorganisms that can degrade contaminants under aerobic conditions (where oxygen is present), which requires the addition of much less fructose — therefore less unpleasant odor and other side effects."

"The special bacteria added can use the contaminants as a nitrogen source for growth under aerobic conditions — using 95 percent less fructose," adds Michalsen.

"Our project is the first one to try this approach on degrading explosives such as TNT and RDX," says Istok.

Now that Michalsen and her team have produced positive lab and field results using the bioaugmentation process and published their results, they are working on additional publications to share their lessons and to support implementation at other sites.

"Top scientists and engineers worked with stakeholders — including state and federal regulators who offered valuable technical input — to solve problems and clean up a significant portion of the aquifer," says Michalsen.

Together, Istok, Michalsen and U.S. Army collaborators are producing groundbreaking applied research that will produce clean water for a region that needs it — and ultimately contribute to cleaner water throughout the nation and the world.

"I feel really good about the work we did," Michalsen says. "It was carefully executed, well-documented and wildly productive." terra

Note: Johanna Carson is a public information representative in the College of Engineering.
Keith Hautala, public information representative in the College of Engineering, contributed to this story.

TO YOUR HEALTH!

OSU initiative targets a global water problem

The world's precious supply of clean water faces numerous and growing threats: industrial and agricultural pollution, groundwater contamination, population growth and displacement, climate change, wastefulness and other pressures. Without proper treatment, water can carry pathogens that cause cholera, typhus and dysentery. The World Health Organization estimates that one in 10 people lack access to clean drinking water, and about 1.5 million children die every year from drinking tainted water.

Now, supported by a $3.28 million gift from Jon and Stephanie DeVaan, Oregon State has launched the Clean and Sustainable Water Technology Initiative to address this urgent and widespread public health emergency. Led by Lewis Semprini, distinguished professor of environmental engineering, the initiative will concentrate the talents of faculty researchers, graduate students and undergraduates who are investigating novel technologies to create sustainable sources of clean water for generations to come.

Jon DeVaan graduated from OSU in 1985 with degrees in mathematics and computer science. He received an Honorary Doctorate in Computer Science from OSU in 2011. He and Stephanie DeVaan, a print artist, retired from Microsoft and are active community volunteers.

In addition to Jack Istok's work on the use of microorganisms to treat contaminated groundwater, here are four other projects supported by the initiative.

Microbial Detox

Semprini is developing bioremediation strategies to detoxify groundwater contaminated by chlorinated organic solvents. Over the years, these dangerous industrial chemicals have migrated through the soil into groundwater supplies where they persist indefinitely. Semprini's approach relies on anaerobic bacteria and other microorganisms to transform the solvents into benign molecules.

Water Purifier

In partnership with InStove, a nonprofit organization in Cottage Grove, a team of researchers led by Nordica MacCarty, an assistant professor of mechanical engineering, has developed a novel water purification system. Her design produces enough safe drinking water for 1,000 people every day and significantly reduces the amount of wood fuel needed to heat the water.

Wetland Digestion

Tyler Radniecki, an assistant professor in environmental engineering, is studying cost-effective ways to clean up wastewater treatment systems by integrating complex microbial processes with constructed wetlands.

Living Downstream

Meghna Babbar-Sebens, an associate professor of civil and construction engineering, is formulating new applications for green infrastructure – like wetlands, filter strips, grassed waterways and even new agricultural management tools – to reduce upstream contamination and clean up fragile watersheds.

Clean water flows from a novel purification system developed in Nordica MacCarty's lab. (Photo courtesy of the College of Engineering)

Pharmacy professor Fred Stevens, right, and graduate student Ines Paraiso examine a ball-and-stick model of the hop-derived compound xanthohumol.

Hops for Health

NOT JUST FOR MAKING BEER

A group of compounds derived from hops can likely improve cognitive and other functions in people with metabolic syndrome, new research at Oregon State University and Oregon Health & Science University suggests.

A patient is considered to have metabolic syndrome if he or she has at least two of the following conditions: abdominal obesity, high blood pressure, high blood sugar, low levels of "good" cholesterol and high levels of triglycerides.

A diet high in saturated fat leads to the development of metabolic syndrome, which is associated with cognitive dysfunction and dementia as well as being a major risk factor for cardiovascular disease and Type 2 diabetes.

Led by Fred Stevens of Oregon State's Linus Pauling Institute and Jacob Raber, professor at OHSU, the research focused on xanthohumol, a compound contained in hops, and two of its derivatives. Earlier research had suggested xanthohumol could be an effective treatment for metabolic syndrome, but this benefit also carries a risk: the compound can transform into a form of estrogen and cause side effects including endometriosis and breast cancer.

Stevens thought that chemically modifying xanthohumol might be the solution to the estrogen problem, and he was right.

Researchers tested the idea in mice and showed that xanthohumol and its derivatives improve glucose intolerance and insulin resistance, as well as sensitivity to leptin – a hormone that tells you to feel full when you've eaten enough and also helps regulate energy expenditure.

The modified compounds also ameliorated impairments in spatial learning and memory induced by the high-fat diet the mice had been fed.

Finding the Lost, From Space

HELP SOUGHT FROM CITIZEN SCIENTISTS

Oregon State University geographer Jamon Van Den Hoek is using technology and something akin to citizen science to identify people around the world living in settlement camps or villages in their own countries.

His targets are "internally displaced people" who have been forced to leave their homes because of violent conflict, natural disasters or some other major event. Unlike refugees, IDPs have chosen not to leave the borders of their country or seek asylum.

With support from NASA, Van Den Hoek hopes to use satellite imagery to locate IDP settlements that are not in national or global maps and then assess their status as it relates to United Nations sustainable development goals.

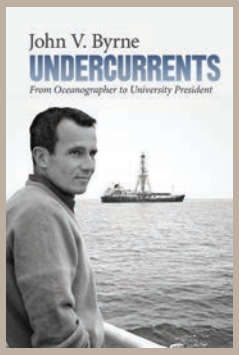
To get started, he and colleague David Wrathall hope to tap into a network of thousands of volunteers to scan satellite imagery using a smart phone application called MapSwipe, through which users can scan for features like roads and buildings. This form of crowdsourcing already has turned up some IDP settlements; now he will ask his MapSwipe volunteer network to focus on unexplored priority areas of the globe.

"No one's ever done this," he says. "Settlement appearance will vary from site to site, and there will be differences between those with formal versus informal planning, and differences among countries, conditions and building materials.

"IDPs are a unique group," Van Den Hoek adds. "They are like floating populations. Their settlements could be temporary; some could be seasonal. They can be planned or unplanned. They are often unaccounted for in census data, so we sometimes refer to them as 'the missing millions.'"

BOOK NOTES

RECENT PUBLICATIONS BY OSU FACULTY



UNDERCURRENTS: FROM OCEANOGRAPHER TO UNIVERSITY PRESIDENT
By John V. Byrne

Published by OSU Press, 2018

From his early days on Long Island during the Great Depression to his work in Washington, D.C., former Oregon State University President John Byrne's career stretches across the nation and to the upper echelons of science administration.

A somewhat indifferent student as a young man, Byrne thought that he'd have a career as a math teacher. Then he became enamored with his first college geology course. Spurred to do research, he also developed an interest in university administration.

Byrne worked as an oil company geologist before coming to Oregon State in 1960 during the early days of OSU's oceanography program. He focused on the geology of coastal Oregon and was a key player in the development of the Hatfield Marine Science Center. Byrne served as chair of the Department of Oceanography before becoming the center's director. During one sabbatical, he also worked for the National Science Foundation.

In 1981, an opportunity to work as administrator for the National Oceanic and Atmospheric Administration arose, and Byrne left the university to pursue it. The only thing that lured him back to Corvallis was the opportunity to serve as the university's 12th president, a term he began in 1984.

As president, Byrne guided the university through severe state budget restrictions. Despite the economic hard times, he was able to grow programs, facilities and external funding. He was one of the first to introduce total quality management techniques to higher education and created the university's first long-range plan. During his tenure, the Honors College was created, and a push toward a more international emphasis also expanded OSU's reach.

Byrne retired as president in 1995 and lives in Corvallis.

For more information, go to **osupress.oregonstate.edu**

FACULTY HONORS

RECIPIENTS IN ENGINEERING, GEOSCIENCE, FUNGAL GENETICS AND PHYSICS

Jose Reyes, professor emeritus of nuclear engineering at Oregon State University and founder of NuScale Power, has been elected to the National Academy of Engineering. On the faculty of OSU's College of Engineering for 30 years, Reyes was one of 99 new members elected this year, each one of the world's most accomplished engineers.

OSU Distinguished Professors

Edward Brook, Joey Spatafora and Janet Tate have been named the 2018 Distinguished Professor recipients, the highest academic honor Oregon State University can bestow on a faculty member.

Brook, a professor in the College of Earth, Ocean, and Atmospheric Sciences, is one of the most recognized and highly regarded ancient climate scientists in the world. He created the Oregon State ice core laboratory and has received more than $15 million in grant funding, primarily from the National Science Foundation.

Spatafora, a professor in the Department of Botany and Plant Pathology, has developed a world-class research program in molecular systematics and population genetics of fungi. He has curated OSU's mycological collection in the botany herbarium with nearly 100,000 specimens, dramatically increasing the opportunity for undergraduate and graduate student participation in curation.

Tate is a professor of physics and the Dr. Russ and Dolores Gorman Faculty Scholar. Her research, in collaboration with materials scientists at Oregon State, is focused on creating new semiconductors with transparent circuits that help to solve problems such as efficient light emission and conversion of solar energy. Among her contributions is the transparent oxide transistor, which enabled technology for the Retina 5K display now found in many Apple products. Her work has been supported in part by more than $7 million in research grants.

MOUNTAIN WATER

Meadow restoration unlikely to benefit river flows

Storing more water in mountain meadows may benefit grazing and crop production, but such strategies are unlikely to increase downstream water flows.

A recently published study by Oregon State University concludes that storing more water in meadows may promote the growth of water-dependent plants such as grasses. But as plants tap moisture reserves in the soil, water is pumped back into the atmosphere through a process known as evapotranspiration. As a result, flows downstream are likely to be unaffected and may even be diminished.

The research was conducted by Caroline Nash, a Ph.D. student in the Oregon State Water Resources Engineering program, and Gordon Grant, adjunct professor in the OSU College of Earth, Ocean, and Atmospheric Sciences and a hydrologist with the U.S. Forest Service. They installed weirs to back up and monitor water flow in Cottonwood Creek north of Burns in the John Day watershed and developed computer models to test the impacts of water storage scenarios on flows.

The results were published in the journal *Ecohydrology*.

"By ponding more water in meadows on higher terrain, people have suggested that extra water would become available to increase flows downstream, especially in the late summer. No one had tested that rigorously until now," says Grant.

Water managers will need to find other ways to increase flows in late summer, adds Nash, when streams typically run low.

See "Meadowlands," *Terra*, winter 2017.

LOGGING AND WATER QUALITY

Long-term studies of sediment, temperature, fish

Results from three decade-long watershed studies in the Oregon Coast Range and the western Cascades have shown no adverse water-quality impacts from logging operations carried out under the Oregon Forest Practices Act.

Passed by the Oregon state Legislature in 1971 and amended frequently since then, the act requires unharvested buffer strips along fish-bearing streams, among other things. Controlled studies of logging in the Alsea River, Trask River and Hinkle Creek watersheds have shown that sediment concentrations below harvested areas do not increase when trees are left along the stream. Stream temperatures, other researchers found, tend to be strongly controlled by local geology.

In another Alsea study on fish populations, cutthroat trout actually increased in stream reaches where trees had been cut, although the study did not pinpoint the causes.

The studies "provide some very nice evidence that current best management practices are proving to be much more effective than historical practices," said Jeff Hatten, lead author of the report on sedimentation and associate professor in the OSU College of Forestry. Nevertheless, Hatten and other researchers advise caution in extending these results to actual harvesting activities elsewhere. Much depends, they say, on the specific circumstances — soil, geology, topography and climate — that affect the interaction of water flows and forested landscapes.

See "Windows on Watersheds", *Terra*, spring 2008.

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.

FLIGHT TIME

OSU-Cascades team aims to extend drone operations

Beating the air like a swarm of bees, drones at Oregon State University lift off on research missions: farm field surveillance, power line inspections, whale monitoring and mock search and rescue operations. These remotely piloted flying machines are saving lives, boosting food production and showing us unprecedented views of the natural world. However, the technology faces a major limitation: Battery-powered motors usually run out of juice in about 20 minutes.

Now a team led by Chris Hagen, professor of energy systems engineering at OSU-Cascades, is developing a hybrid powertrain (gas engine and electric motor) that has already tripled the time that unmanned aerial vehicles (UAVs) can spend in the air. Through the Oregon State University Advantage Accelerator, Hagen and his collaborators — students, alumni and business partners — are evaluating the market and developing an entrepreneurial approach to one of the fastest growing industries in the United States.

"The UAV industry is growing by leaps and bounds," Hagen told *Forefront*, the newsletter of the School of Mechanical, Industrial and Manufacturing Engineering. "Having a powertrain that extends the range of these vehicles is a great enabler for adoption."

The team's hybrid motor uses the gasoline engine to charge the batteries. While that might sound simple, researchers have to balance every ounce of additional payload with the demanding performance of lightweight aircraft.

Hagen's lab includes a device known as a Small Engine Dynamometer, a powertrain testbed for gathering data on engine performance, fuel use and other factors.

Oregon State researchers conducted more than 300 drone operations in 2017. OSU participates in a UAV collaboration known as ASSURE, the Alliance for System Safety of UAS through Research Excellence. Among the participants in ASSURE are 23 of the world's leading UAV research institutions and 100 industry and government partners.

Former graduate researcher Sean Brown, now at SpaceX, conducted drone test flights near OSU-Cascades in Bend.

With support from the MJ Murdock Charitable Trust and OSU's University Venture Development Fund, Hagen and his students – Sean Brown (now with SpaceX) and James Benbrook — are partnering with KDE Direct as well as with consulting engineers Tom Herron and Matt Smith, both OSU alumni. Working through the Oregon State University Advantage Accelerator, the team is applying for a slot in a national technology commercialization program known as iCorps, funded by the National Science Foundation.

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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AGRICULTURAL ARTS

Agriculture combines art and science, says Dan Arp, dean of OSU's College of Agricultural Sciences and director of the Oregon Agricultural Experiment Station. For 150 years, OSU researchers have worked with farmers, ranchers and other producers to manage natural resources and grow food for the world. See "The Road to Plenty," Page 14.

Since 1983, OSU's Art About Agriculture program has supported artists who explore the visual qualities of farming and rural landscapes. Traveling exhibits in Oregon and the Northwest bring the collection to urban and rural audiences. The permanent collection is online at **agsci.oregonstate.edu/art-about-agriculture**.

A recent acquisition, *Farm off Helmick Rd., OR* (2018) by Eugene artist Connie Mueller, captures the interplay of color and light on a field. Mueller is a printmaker known for her rich reduction linocut relief prints, a process that builds up many layers of vibrantly colored inks onto the surface of the paper.

Mueller was granted the 2018 Dean and Director, College of Agricultural Sciences and Oregon Agricultural Experiment Station; and the Paul Lamb and Reese Lamb Memorial Art About Agriculture purchase awards, sponsored by Dan and Wanda Arp, the Lamb Foundation, and the College of Agricultural Sciences, Oregon State University.

Connie Mueller, *Farm off Helmick Rd., OR*