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DISCOVERY | CREATIVITY | INNOVATION • Fall 2018

MIND AND MATTER

Living with artificial intelligence and robotics

Oregon State University

terra

Volume 13 Number 1 // oregonstate.edu/terra // Fall 2018
Oregon's leading public research university

FEATURES

DEPARTMENTS

The Spicer family farm pictured on a sunny day in 1971 — two years after Christopher Spicer watched waters from the newly built Hugh Keenleyside Dam inundate his fields. He and his family were allowed to stay in their home, but BC Hydro had ordered the structure to be burned after his death. The home was later saved by a reprieve from the company president. See "River Renewal" on Page 26. (Photo courtesy of John Osborn.)

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Oregon State is Oregon's leading public research university with more than $382 million in research funding in FY2018. Classified by the Carnegie Foundation for the Advancement of Teaching in its top category (very high research activity), OSU is one of only two American universities to hold the Land-, Sea-, Sun- and Space-Grant designations. OSU comprises 11 academic colleges with strengths in Earth systems, health, entrepreneurship and the arts and sciences.

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Oregon State University

NEW BEGINNINGS

> *"Broad, wholesome, charitable views of men and things cannot be acquired by vegetating in one little corner of the earth all one's lifetime."*
> *– Mark Twain*

As I gunned the motor to pull out of our steep driveway in Williamsburg, Virginia, I was reminded of Twain's quote. My car was jam-packed with a wooden sea kayak, two bicycles and an assortment of personal belongings.

After immigrating from South Africa twice, followed by four cross-country relocations, I am quite in the mood to vegetate "in one little corner of the earth"— Oregon, for the next 20 years. It's the only place I have felt at home since leaving my native South Africa. I consider myself extremely fortunate to have landed this leadership role at *Terra*.

The drive took me through the remnants of the great deciduous forests of the East Coast, the prairies of the Midwest and the sagebrush, deserts and mountains of the West. And, if you should call the cornfields an ecosystem, add that in as well. With "The Oregon Trail" playing on Audible, my thoughts constantly wandered to the benefits of science over the years since the mid-1800s. All the while I am reminded by local news that humankind kick-started climate change shortly after the pioneers packed their earthly belongings into Conestoga wagons for that arduous journey west.

Arriving in the midst of the OSU150 celebration, the 15-month commemoration of Oregon State University's 150th anniversary, I understand that it is *Terra's* responsibility to tell the story of OSU's research accurately. In truth, world-leading research that supports a healthier, prosperous and more sustainable future for all generations.

In this issue, we explore the promise and potential perils of artificial intelligence with a Q&A, and we revisit the Columbia River Treaty from the perspective of how it can improve. We also learn about methane bubbling out of our ocean floor, the cutting edge — so to speak — of elastic robots and the surprising findings of OSU-Cascades FORCE lab regarding super-cushioned running shoes.

As I take over the helm from former *Terra* editor Nick Houtman, I recognize that I am filling a size-large pair of shoes. I hope to emulate his grace and wisdom, if not his eloquence. When I asked Nick if he will miss Terra, he said to me, "There are things I want to do now." As he pursues them, we tip *Terra's* cap to both its past and its future.

Ian Vorster
Editor

BENEFITING EVERY CORNER OF THE STATE

Oregon State University recorded its second-best year ever in competitive grants and contracts for research that benefits every corner of the state and provides students with opportunities for hands-on experience.

As Oregon's largest comprehensive public research university, OSU earned a total of $382 million in the fiscal year ending June 30. A National Science Foundation grant of $88 million for the construction of a second coastal research vessel buoyed the university's total, which dropped from 2017's record of $441 million – a year that the university received a $121.9 million NSF grant to build the first of the latest generation of ocean-going research vessels.

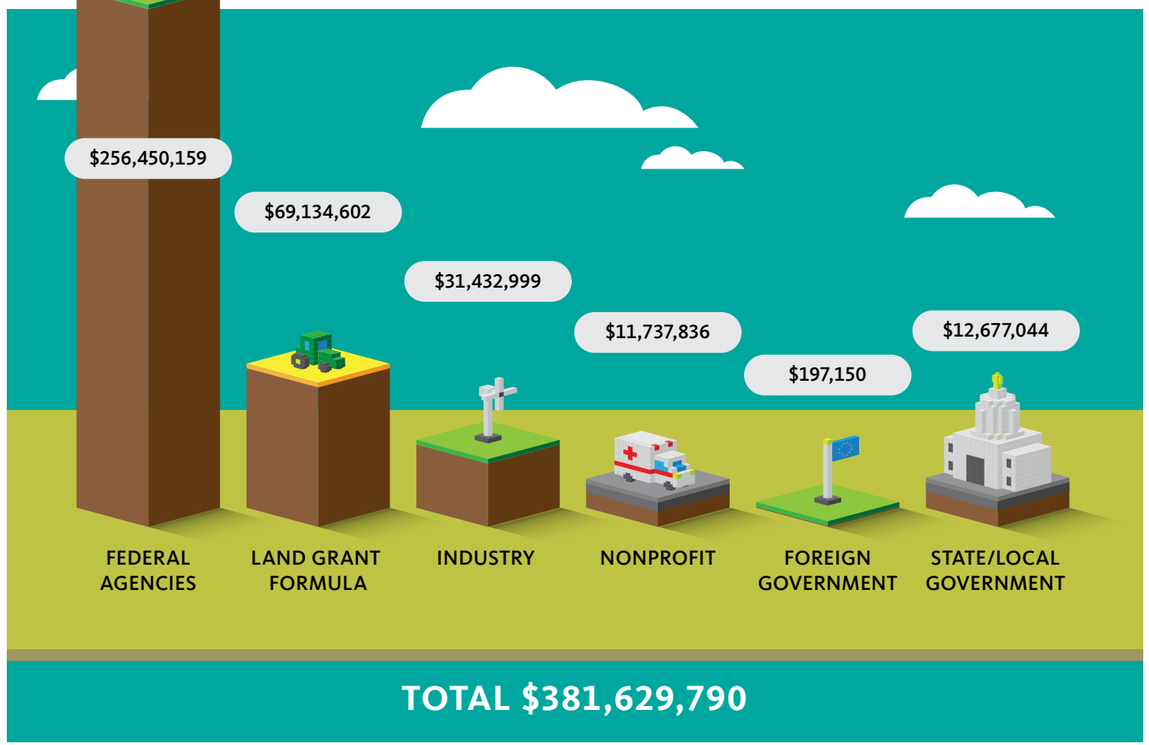
Oregon State Provost and Executive Vice President Ed Feser said OSU researchers focus on major challenges facing the state, the nation and the world.

"Over the years, OSU scientists have produced disease-resistant crops such as varieties of soft white wheat and hazelnuts, found new ways to fight infectious diseases, and treat cancer and contributed to improving livelihoods in sustainable ways," he said. "Research conducted at Oregon State creates jobs, solves problems and trains our future workforce."

As Oregon's land grant university, OSU conducts research from basic science to projects inspired by the needs of businesses and the public. For example, in the health sciences, researchers have documented the benefits of midwifery for better birth outcomes. Other scientists have identified potential compounds produced by dirt-dwelling microbes that could be effective in treating melanoma, a deadly form of skin cancer.

"Oregon State's success in earning federal, state and private-sector support for research is due to the amazing efforts of our faculty and their desire to achieve and engage in excellence," added Feser. "Writing successful research proposals takes teamwork and commitment over and above the day-to-day responsibilities of teaching, running a lab and mentoring student researchers."

RESEARCH BY THE NUMBERS



PROMISE & POTENTIAL PERIL

Artificial intelligence — the next big challenge

BY ANNIE ATHON HECK | ILLUSTRATIONS BY CHRISTIANE BEAUREGARD

The term “artificial intelligence” is everywhere today. It is written about in news stories and social media, and discussed on TV talk shows and morning radio. And it is becoming more and more prevalent in the daily lives of people around the world. From cell phones and personal assistants to internet searches and photo sharing, artificial intelligence — or “AI,” as it is commonly known — helps power the systems at the foundation of these and many other tools.

Although it is now becoming ubiquitous and well-known, the field of artificial intelligence can be traced to World War II and the code-breaking work of English computer scientist Alan Turing, best known for cracking intercepted messages that helped the Allies defeat Germany. The field of AI research was founded years later at a workshop at Dartmouth College in the summer of 1956.

Artificial intelligence is closely related to the growing realm of robotics as well. The notion of autonomous robots emerged as far back as 1818 with the publication of Mary Shelley's *Frankenstein*. Today, artificial intelligence lies at the heart of robotic systems that already help scientists gather and analyze data with implications for agriculture and food supplies, human health, national security and a host of other applications.

Tom Dietterich, professor emeritus in computer science at Oregon State University, is a leading expert on the topic of artificial intelligence. He is a co-founder of the field of machine learning and has published more than 200 scientific papers. Dietterich served as president of the International Machine Learning Society from 2001–2008; president of the Association for the Advancement of Artificial Intelligence from 2014–2016; and executive editor of the journal *Machine Learning* from 1992–1998. *Terra* writer Annie Athon Heck recently interviewed Dietterich about artificial intelligence, its relationship to robotics and its future.

Terra: What exactly is artificial intelligence or "AI" as it is commonly known?

TD: Artificial intelligence is a collection of techniques in computer science for programming computers to do things that only people can currently do. Often, these are things we associate with human intelligence, such as planning an international trip or writing a complex news story or controlling a robot. Now only people are able to do these things. The field of artificial intelligence tries to come up with ways to program computers to do them instead.

The use of machine learning is the most common way we do this — by gathering data from humans about the things that people do. For example, if we are trying to understand human speech, we collect speech with a tape recorder. We next ask a person to tell us the words that were spoken. Then we try to figure out how to get the computer to take that speech from the input — someone speaking — and produce the words with the output — text of the spoken words, such as dictating a text message into your phone.

Terra: You raised another question in your response. What is machine learning?

TD: Machine learning is a technique for programming computers using data. In machine learning, the computers learn from studying data rather than programming things through step-by-step instructions, which is the way computers are usually programmed. Early in my career, I wrote a program to do some accounting tasks. I interviewed an accountant and asked what steps he goes through for certain tasks. Then I wrote down those steps and programmed them into the computer. Computers are great at following steps.

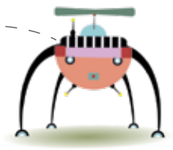
But if you ask a person to tell you the steps you go through to understand the words that I'm speaking to you right now, you wouldn't know what they are. It's subconscious. You can't tell me the steps you go through. And that's why we need to use something that's more like machine learning where we collect "input/output pairs," as we call them, and then try to develop some sort of a computational program that can produce the correct outputs when given the inputs.

Terra: There are many disciplines that study human thought and reasoning, such as psychology, philosophy, engineering and artificial intelligence. What do these disciplines have in common, and how do they differ?

TD: I think all of these disciplines are interested in understanding how people learn from their experience in the world. I got my start in computer science, coming from the philosophy of science. The philosophers' methodology is primarily to think clearly and carefully about the questions themselves: How can scientists learn about the world? Is science self-correcting? And so on. Psychology directly studies humans and tries to measure and assess how humans think, and where and how our thinking fails in some way: for example, when we draw incorrect conclusions.

Artificial intelligence differs because we approach these problems purely as engineering problems. So, we don't study people directly. We collect data from them but we don't study them. For example, we might have people look at images and tell us what objects they see and to draw a box around each one. But we don't look at their brains to try to understand how they're working.

Tom Dietterich, professor emeritus in computer science believes that the most accurate view of the future is from *2001: A Space Odyssey*. There, the HAL 9000 computer doesn't "go rogue." HAL was just incorrectly programmed. (Photo: Ian Vorster)



Terra: Looking into the future what is realistically possible when it comes to AI?

TD: I don't know what's possible in the long run, but in the short run there's certainly a lot of discussion about self-driving cars, robotic surgery and more intelligence in military systems. Let's look at the self-driving car case. It's quite controversial, even among AI people, how far we can go with complete autonomy in self-driving cars.

Most AI systems work best when they're working as an assistant to a human, such as a navigation system. We are in the driver's seat, literally. Similarly, we ask Google questions. When we get back answers, we decide whether to believe them or not. And we can tell if Google completely misinterpreted our question, or if we need to rephrase it until we figure out the right way to ask it.

Back to autonomous cars, we now have some automatic braking and lane-keeping assistance. But it's clear that if we automate too much, then drivers stop paying attention, and we have these fatal crashes, like that of the Tesla and of the pedestrian that was killed by a self-driving Uber vehicle.

The question facing us is: Can we really achieve 100 percent automation so that it is safe for the driver to not pay attention? The jury is still out on that. I don't know. The car is driving in a very complex and open world. It's not a fixed problem like playing chess. These errors are life and death errors, not just getting the answer wrong on your query to Google. So I think it is important to proceed very cautiously.

Terra: Is this where "robust" artificial intelligence, a term that we are beginning to hear and read about more, comes into play?

TD: Yes. To apply AI safely in these kinds of high-risk applications, we need the technology to be much more robust. This means that the system will have the desired behavior even when assumptions underlying the system are violated. For example, training data are noisy or a human operator makes mistakes. A culture of safety in the creation and testing of software must be adopted. That's much more difficult for software that's created with machine learning because with machine learning we train the software on a collection of training examples, but we ask the machine-learning algorithm to interpolate or generalize from those training data to decide how to act in all situations — even though we haven't shown the computer all possible scenarios.

When you program a computer by hand, you think through all possible situations, and you write logic that's supposed to cover all of them. Of course, programmers fail at this. That's why app software crashes on our phones.

That's a big challenge. Another challenge is that our AI systems have their own model of the world. For instance, a self-driving car keeps track of where it thinks the road is just like the blue dot on Google Maps does now.

TOP FIVE SUCCESSES ... SO FAR

ARTIFICIAL INTELLIGENCE

From global businesses to driving directions, artificial intelligence is making a significant impact in our daily lives. These are some of the top AI successes so far, according to Tom Dietterich, OSU professor emeritus of computer science:

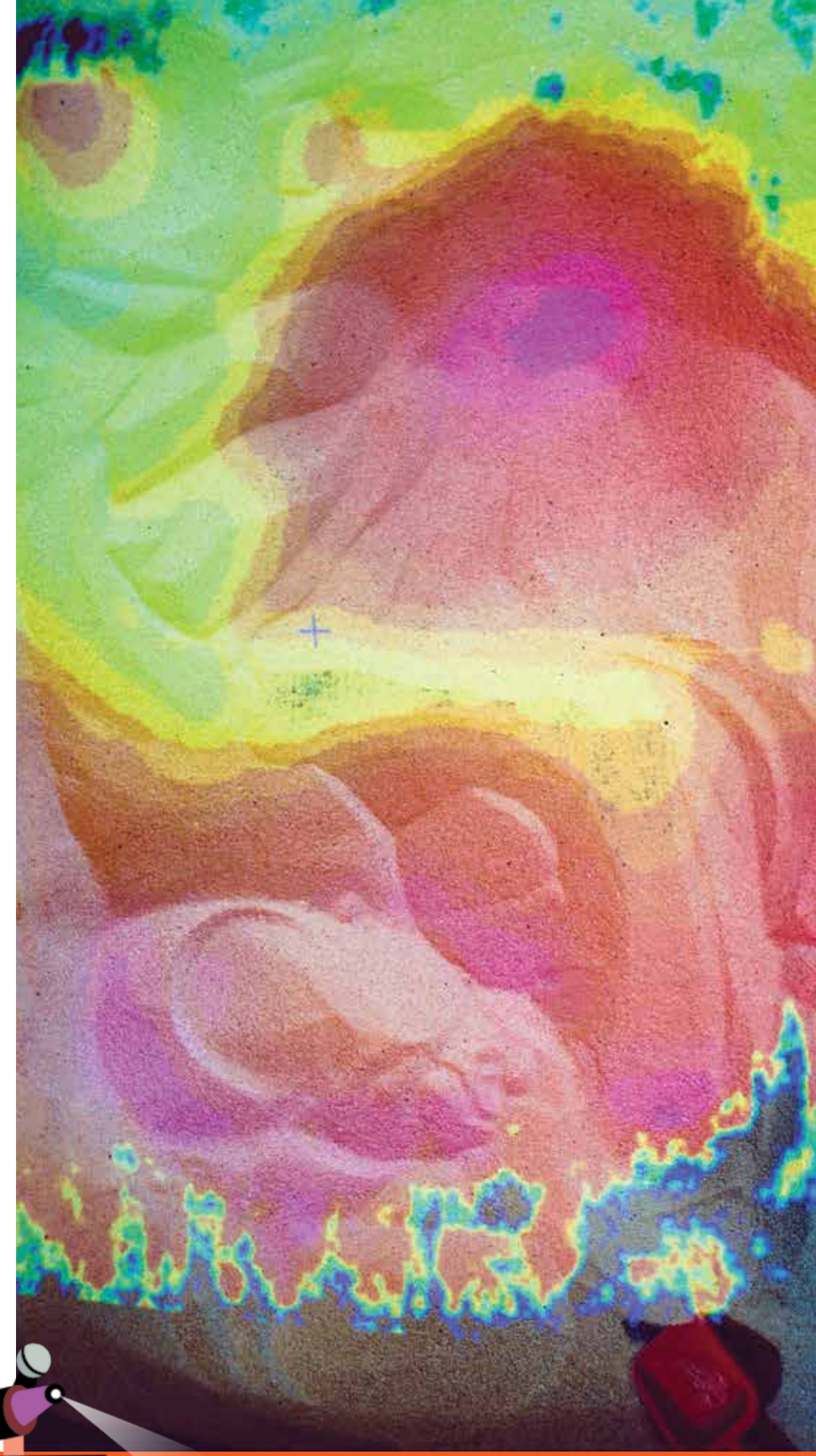
PLANNING AND LOGISTICS: Package routing that is now common with companies like Amazon, FedEx and others.

COMPUTER VISION: Face detection and face recognition. This is being used now by Apple to unlock phones, by Facebook to tag friends in photos and by several photo sorting applications. Security and law enforcement use it as well.

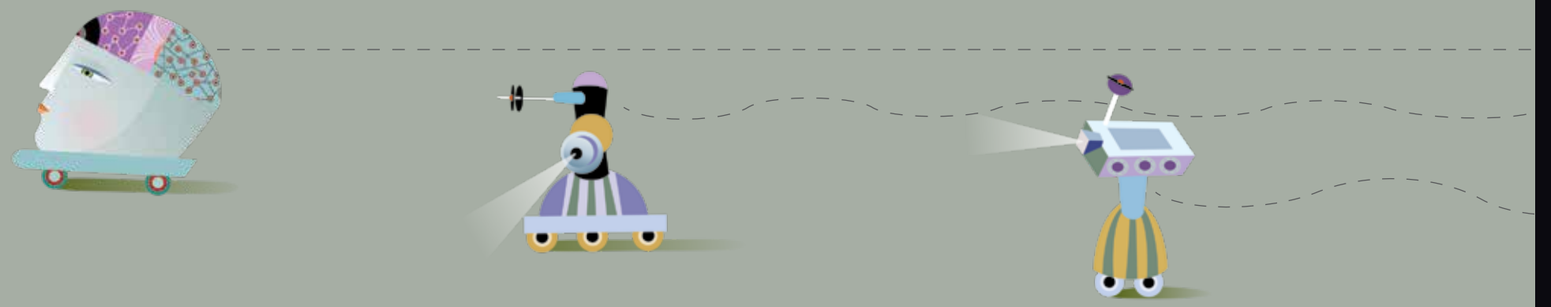
SEARCH ENGINES: Queries through search engines like Google use many different AI techniques to answer billions of questions a day.

SPEECH RECOGNITION: Personal assistants like Siri and Alexa call people, play music and find recipes among other things.

LANGUAGE TRANSLATION: Google Translate and Skype Translator enable spoken conversations between people who don't speak the same language.



Software for this SandBOX was designed by Behnam Saeedi, an OSU computer science student, and the hardware by Scott Laughlin, an OSU mechanical engineering graduate. Users can create terrain maps by physically manipulating the sand, which prompts an Intel RealSense depth camera above the box to project changing light patterns on the sand to color the resulting elevated or depressed areas, rendering them as topographic-like maps. Artificial intelligence relies on image processing and noise reduction techniques to polish the final display, and optimized computer vision and analysis estimates the profile of the sand. SandBOX was developed in OSU's Create IT Collaboratory as part of the TekBots program. (Photo: Ian Vorster)



But it also has to be tracking where all the other cars, pedestrians, bicyclists, trees, signs and the edges of the lane are, anticipate what all those things are going to do and choose actions to deal with them.

There is a fixed set of objects that those systems know about. What happens when a new object shows up? This is known as the "open category problem" because the set of objects or obstacles is an open set. There are new possibilities all the time.

This is one of the things we have studied here at Oregon State: How can we create systems that are guaranteed to be able to detect all of those new objects in addition to the things they know about?

Terra: That leads to the next logical question. What are the weaknesses of current AI systems? And what are the prospects to make them more robust and high-performing?

TD: One is what we just touched on — the open- versus closed-world problem. The other is that training data are never complete. If you visit Garmin (navigation technology company) in Salem, it has a group that develops avionics software for the airline industry. That software is incredibly, carefully engineered and tested. Garmin verifies with high confidence that it will behave correctly. We don't have a similar set of standards or practices yet for AI software in ground transportation. There's no regulatory body for general AI software like the Federal Aviation Administration that requires extreme rigor in these systems. That's an area where I think we need much more attention to figure out how to test and audit these systems.

Because these systems are part of a larger human and social system, it's important that the functional organization around the computer system is also reliable.

Terra: You spoke earlier about some major areas where Oregon State is advancing artificial intelligence. What are other key focus points for OSU with this growing technology?

TD: We have quite a large group in artificial intelligence and robotics. Our work really runs the gamut. On the AI side, we've had a machine learning group for many decades. We work on computer vision and language understanding. We have experts in automated planning. We develop AI methods for ecology, bioinformatics and genomics.

In our machine learning group, we're looking at problems of fraud detection, cybersecurity and a technique known as "anomaly detection algorithms." These algorithms look for unusual images, decisions or outliers in data that might signal fraudulent transactions or failures in a computer system — either because the computer system was compromised by cyberattack or some part of it is broken.

One of my own projects is part of the Trans-African Hydro-Meteorological Observatory (TAHMO) effort led by OSU professor John Selker. The goal of TAHMO is to create and operate a network of 20,000 weather stations in Africa. My role in the project is to detect when weather stations are broken and need a visit from a technician. My AI tools look for unusual behavior in the numbers coming out of the weather station that indicate something is wrong.

Terra: Again, there's that human element where data are looked at critically with human interpretation, which goes beyond the AI systems.

TD: Yes, exactly. We also do a lot of work at OSU in what's called "human-robot interaction." Typically, robots are kept in a separate cage because it's unsafe for them to be around people directly because if there's an error in the programming, the robot might smack you in the head if you're standing in the wrong place.

One of the big goals is to figure out how we could make robots intelligent enough and understandable enough so you can read their body language. Then you would know when it was safe to hand them something or take something from them or interact with them more directly. We're also looking at making robots out of soft materials instead of steel bars. This is known as "soft robotics."

In the robotics program at OSU, there is research on walking robots, swimming robots, spider robots, flying robots, wheeled robots, all kinds of things. There are single robots, groups of robots and combined groups of humans and robots working together.

So there is a lot of activity being pursued at Oregon State in both artificial intelligence and robotics.

Terra: There is plenty of speculation about some of the perils of AI. Are these warranted or is Hollywood influencing this thinking?

TD: In Hollywood, there are basically two main stories, it's either the *Pinocchio* story, and Commander Data wants to be a real boy. Or there is the *Terminator* story, and robots will somehow turn on us. I think the most accurate view of the future is from *2001: A Space Odyssey*. There, we have the HAL 9000 computer. HAL doesn't "go rogue." HAL was just incorrectly programmed. The programmers set up HAL to put a higher value on the mission's success than on human life. And so HAL just followed the values it had been given.

The most important thing to remember about AI software is that it is software. And we all know it is very hard to program software so it does what we want it to do. We see this every day on our phones and our laptops when we have to kill programs, reinstall apps or reboot our machines.

The big challenge is how do we define what is correct and appropriate behavior for these systems and then reliably create software that produces that behavior. That is very difficult. So the biggest risk is the HAL 9000 risk that we program the system, and then we give it autonomous control over something. I think one of the most important research areas is precisely this area of building AI systems that are robust and safe so that we can have a higher degree of confidence that they'll behave correctly. terra

OSU SYMPOSIUM FOCUSES ON AI AND ROBOTICS

Registration for free, daylong symposium now open.

A symposium focused on the future will take place at Oregon State University on Oct. 23.

"The Promise and the Peril of Artificial Intelligence and Robotics" is the culmination of OSU150, the celebration of the university's 150th anniversary. Oregon State will host this daylong symposium with faculty and national experts who will discuss the potential benefits, risks, ethics and uncertainties of the emerging technologies of artificial intelligence and robotics.

These experts will contribute their insights to the potential for AI and robotics to transform agriculture, health care, natural resource management, transportation, arts and entertainment as well as consider possible impacts on jobs, the economy, laws and privacy.

Jacob Ward, science and technology correspondent for CNN and Al Jazeera, will give the keynote address. Ward previously served as the editor-in-chief of *Popular Science* magazine and recently completed work on *Hacking Your Mind*, a four-hour series on the science and implications of bias slated to air on PBS in 2019.

The symposium, which will take place at The LaSells Stewart Center and the CH2M HILL Alumni Center in Corvallis, welcomes academia, industry, policy makers, the general public and members of the OSU community.

Although attendance at the symposium is free, registration is required. To register and learn more about the day's programming, please visit the symposium website at osu150-airobotics.org.

Robots FLEX THEIR STUFF

IN YIGIT MENGÜÇ'S LAB, ROBOTS WAVE AND SLITHER

BY LETO SAPUNAR | PHOTOS BY KARL MAASDAM

Soft robots, in their elastic and dexterous forms, could offer major improvements over their more traditional wheeled or propeller-driven counterparts.

After seeing the creations in Yigit Mengüç's robotics lab at Oregon State University, you'd be forgiven for thinking you had wandered into a sci-fi film. Mengüç, an assistant professor of mechanical engineering has tentacle-like arms waving, synthetic snakes wiggling, and an underwater hanging machine, that at first glance resembles a living octopus, all lending life to the lab. These aren't sights most people expect when they think of robots. However, they are typical for researchers in OSU's soft robotics lab. Here, on the cutting edge — although there isn't a solid edge to be found on most of these creations — the group is finding revolutionary new ways to fabricate and design machines that look and feel more like flesh than concrete.

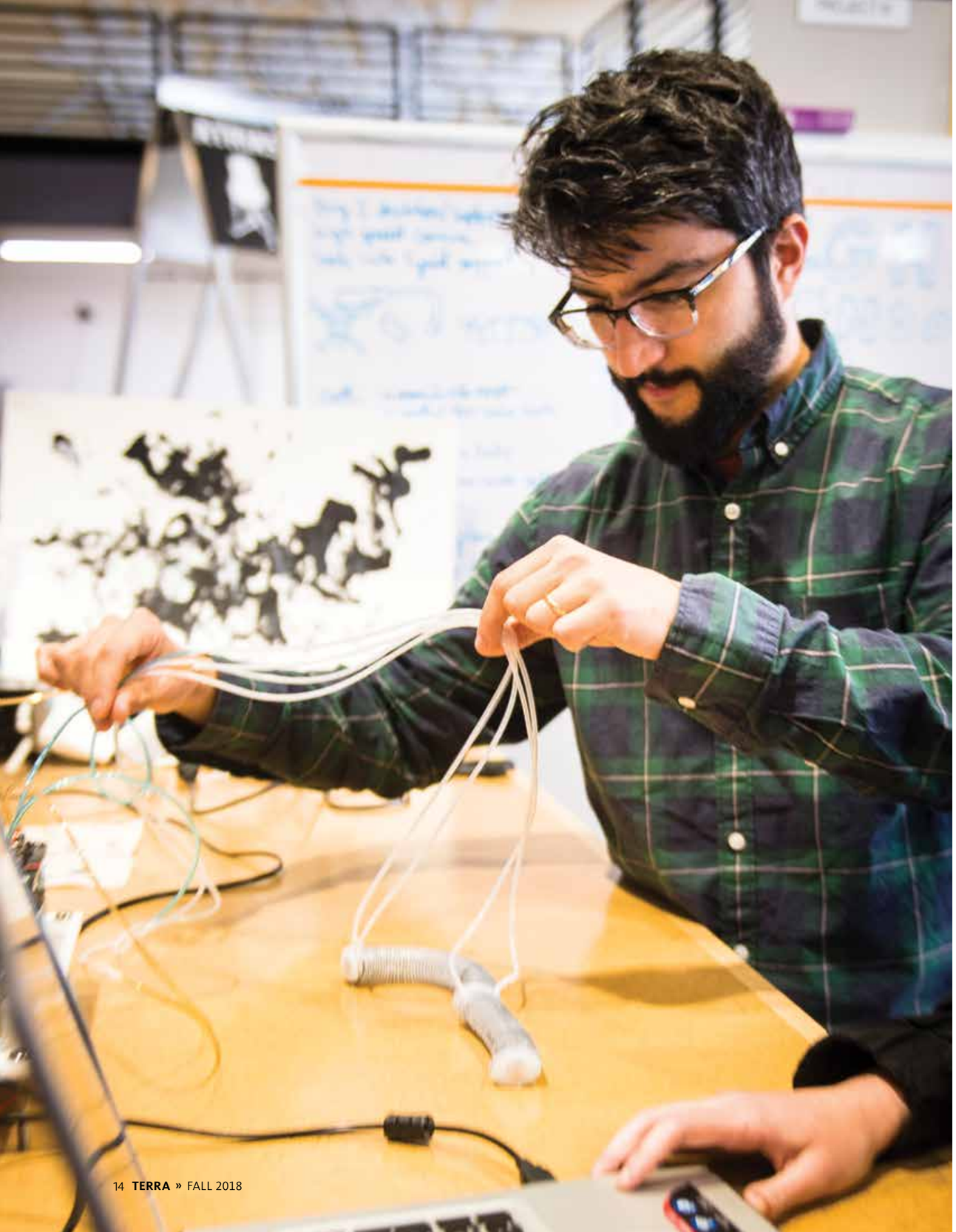
Often inspired by biomimicry — the design of practical systems modeled on living organisms — soft robotic researchers look for ways to make robots safer, cheaper and more versatile. Where a conventional rigid robot arm is difficult to program and complex and expensive to fabricate, a soft robot has the potential to perform the same tasks with none of those limitations. This kind of design is particularly useful for delicate tasks like grasping coral samples on the seafloor or handing a glass of water to an elderly person.

Liquid Metal and Hollow Chambers

Soft robots are made from silicone, similar to the kind used in soft phone cases or ice cube trays, and sometimes infused with liquid metal wires made of gallium — a rare metallic element that is liquid near room temperature and found as a trace element in coal and other minerals.

Researchers can control the motion of these soft robotic limbs by pressurizing internal channels. A tentacle with four pneumatic chambers within can flex in any direction depending on which hollow chamber is inflated. This principle also works to make soft robotic snakes, which can locomote in a variety of different snake "gaits" depending on how their air chambers are pressurized and depressurized.

Most current robots are designed to encounter specific environments — a wheeled machine for flat surfaces or a propeller-driven underwater craft. These robots can function spectacularly in the particular circumstances they're designed for but can lack the versatility to do much else.



Osman Dogan Yirmibesoglu, an OSU Ph.D. candidate, uses a massive 3D printer he built to create a meter-long octopus-like soft robotic arm.

Soft robots, in their elastic and dexterous forms, could offer significant improvements. For instance, many living snakes can swim as well as traverse flat, rocky or sandy terrain. A soft robot made to mimic that motion, like the kind OSU Ph.D. student Callie Branyan is working on, can already move across flat surfaces as well as through granular materials like millet seeds, sand and river rocks. It can also slither through a pipe and escape after being buried under the seeds. Branyan is tweaking the design proportions as well in an attempt to build thinner, faster locomoting robots. “More like a garter snake than a python, quick and small,” she says.

Currently, the snake’s component pieces are made using a time-consuming molding process, but the lab is actively working on perfecting silicone 3D printing methods, allowing for any device configuration to be made cheaply and quickly. Osman Dogan Yirmibesoglu, another OSU Ph.D. candidate, is using a massive 3D printer that he built to create a meter-long, tentacle-like soft robotic arm. “It’s actually more powerful than an octopus arm,” he says, explaining that an octopus arm doesn’t do well outside of water, whereas this arm will be able to support its weight in air. Although it won’t look much like a tentacle, the arm will be able to flex in any direction and hold its position.

The material used is, as Yirmibesoglu puts it, “radiation transparent,” meaning it doesn’t interact strongly with most types of high-intensity radiation. That could make it preferable for radiological testing or emergency response robots for nuclear incidents. In such situations, high versatility is required to face intense radiation, pass over irregular terrain, investigate underwater reactor pools and operate controls.

To find out how the material responds to radiation, Yirmibesoglu printed samples of the silicone for Tyler Oshiro, an OSU nuclear engineering master’s student, who irradiated them in the university’s research reactor. Oshiro’s goal was to study how the mechanical properties of the silicone changed with high radiation exposure for his master’s thesis. He found the samples stiffened after exposure to vast amounts of radiation but deal well with it overall. Oshiro finds soft robotics interesting because the field is the epitome of finding different ways to approach traditional problems.

Sensors and Circuits

In the lab, Yirmibesoglu demonstrates how one of the sensors deforms when he presses it with his thumb. It stretches like an octopus tentacle but pops back into place as soon as it’s released.

As the material stretches, the small channels inside containing liquid metal become warped, making the wires thinner or thicker as the material flexes in different ways. Because wires of different thicknesses vary in electrical resistance, a computer hooked up to the electrodes can measure this value and determine how distorted the sensor is from its normal shape. In this way, a robot can know the location of each of its limbs. The technology has promise in other avenues like wearable electronics. The sensors are cheap, relatively lightweight and versatile.

Building a silicone structure with internal channels of liquid metal isn’t easy. Previously, it required a complicated, multistage molding and gluing process. However, the lab has recently devised a way to 3D print freestanding liquid metal and hopes to build a dual-headed printer, capable of constructing both the silicone body of a robot limb or sensor and its liquid metal veins simultaneously.

Oregon State Ph.D. student Nick Bira is working on figuring out the design for “soft valves” to precisely control airflow used to activate the limbs of a small octopus robot. The tricky part is building smart pressure controls that don’t rely on conventional electrical valves to achieve the same end. Elegant design here is key. He says the lab space reached “peak awe factor” a few months ago when, in addition to the usual high-ceilinged workspace filled with 3D printers, squishy limbs, actuators and aquatic prototypes were floating in an underwater testing tank.

New and Growing

Back in Mengüç’s Graf Hall lab, the assistant professor of mechanical engineering puts one inspiring animal center stage writing, “Many of my colleagues and I have chosen to take inspiration from one of the most alien mascots: the octopus. As soon as we take as our goal technology that is entirely soft, squishy and stretchy, yet dynamic, agile and intensely intelligent, we are forced to reevaluate what is possible.”

In 2017, Mengüç also wrote an overview piece on the field of soft robotics, published in *American Scientist*. He describes the many avenues of a new and growing field such as electrorheological fluids — substances that can change between liquid and solid based on an electric field — and the possibility of introducing artificial muscles into future robots. Among already existing soft robot technologies, he lists other applications including maritime robots for inspection and welding; stealthy naval surveillance robots; safer industrial manufacturing robots; surgical tools like endoscopes; and prosthetics or orthotics. The future possibilities all have been inspired by a creature that has existed for millions of years — the octopus. terra

Editor’s note: Leto Sapunar was an undergraduate in the College of Science. He graduated from OSU in 2018.

Too Much of a Good Thing?

Super-cushioned running shoes provide less shock absorption

STORY AND PHOTOS BY IAN VORSTER

Out on the Trail

Anecdotal evidence carries a hefty kick in athletic circles. If a long-distance runner tries on a new pair of shoes and says that after 4 or 5 miles she notices significantly less muscle fatigue than before, her running buddy might be inclined to try a pair. But with super-cushioned running shoes, also known as maximal shoes and first produced by running shoe company HOKA ONE ONE, it's more a case of oil and water — some love them, others hate them.

Sherri Dean hates them. The OSU-Cascades undergraduate research assistant and recreational runner has completed many 5K and 10K races since relocating to Bend, including last year's Silver Falls Trail Half Marathon. Dean enters the races to remain motivated and to partake in the social side of the sport, and she enjoys the trails with her dogs and her children if she can get them to join her.

"I did try maximal shoes once, but they didn't suit my running style," she says. "I just did not enjoy them. Within a mile, I had knee pain. Never had it before, never had it since. But that's just me."

Erin Kevin loves them. She started running last year and describes herself as overweight and fast approaching middle age. She was inspired by Mirna Valerio, author of the *Fat Girl Running* blog and the book *A Beautiful Work in Progress*, because Valerio promotes running as an accessible sport for all body types.

"I used to be an active hiker, but I wanted the scenery to go by a little faster," she chuckles. "And my dog has a lot of energy so together we started running."

Kevin has run a 5K and a 10K and is now training for a half-marathon. She was introduced to maximal shoes in February after turning her ankle on a rock on the Deschutes River Trail, producing severe foot pain.

"I wanted a stable shoe with more cushioning and started running in a pair of HOKAs in March," she says. "I completed the first mile with some difficulty and then the next three without any discomfort at all." That was Kevin's first post-injury run, and she now regularly runs up to 6 miles in her maximal shoes without pain.

Undergraduate research assistant Sherri Dean stands still as JJ Hannigan attaches marble-sized reflective balls to her.

Back in the Lab

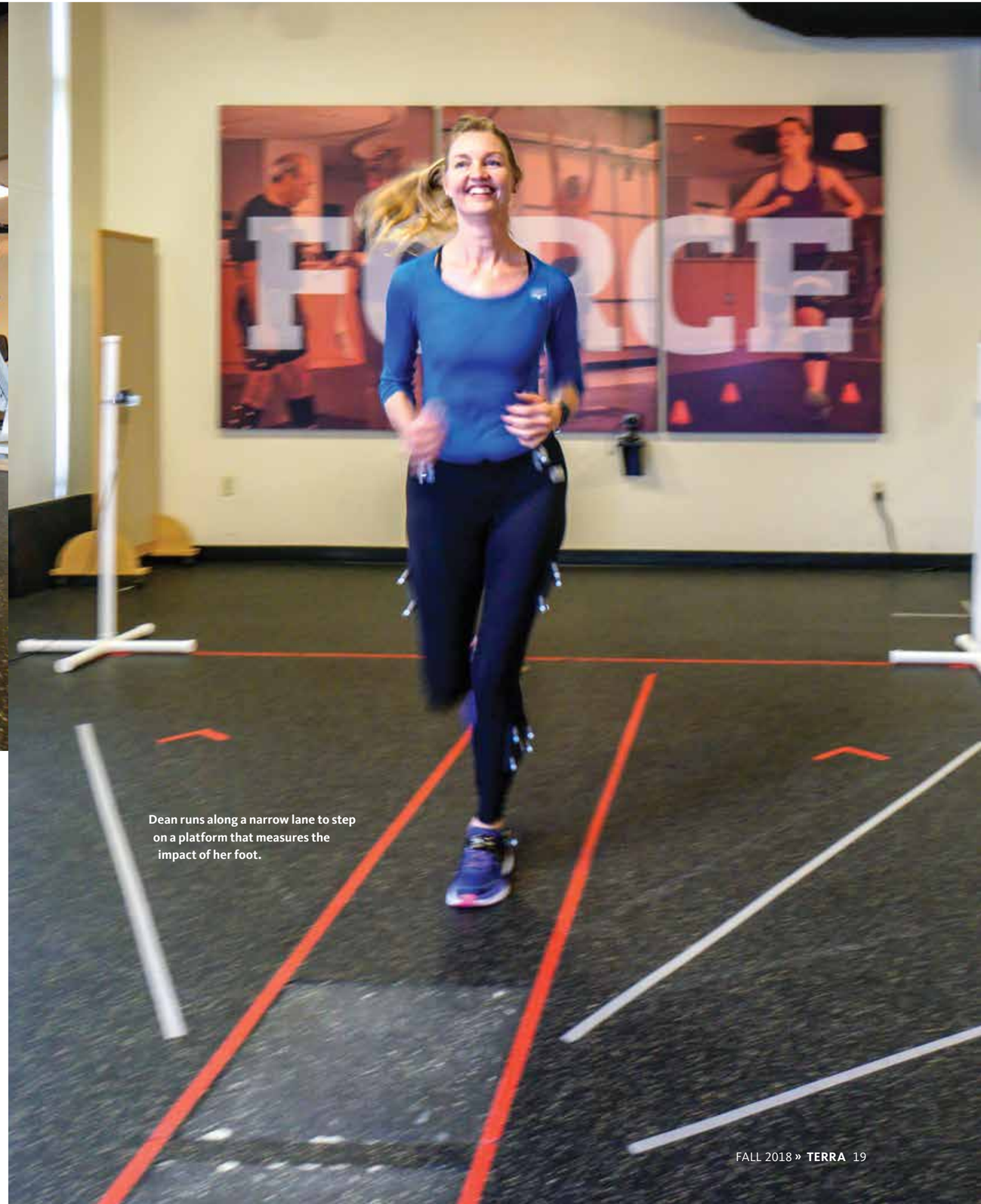
Sporting a broad smile in a lab at Oregon State University-Cascades in Bend, Dean stands with her feet placed squarely beneath her shoulders and her arms arched above her head. Christine Pollard and JJ Hannigan are attaching marble-sized reflective balls to Dean's shoes and at points on her knees, thighs and waist. Pollard is the director of the Functional Orthopedic Research Center of Excellence (FORCE) Laboratory, and Hannigan is a postdoctoral researcher.

Eight high-speed infrared cameras located on scaffolding just beneath the ceiling will project light, capture the reflections from these small spheres and transmit them to software on a nearby computer. The software will then overlay the reflective points on the skeletal system of a runner. As Dean is running along the test lane, she will step on a platform that measures the impact generated by her footfall.

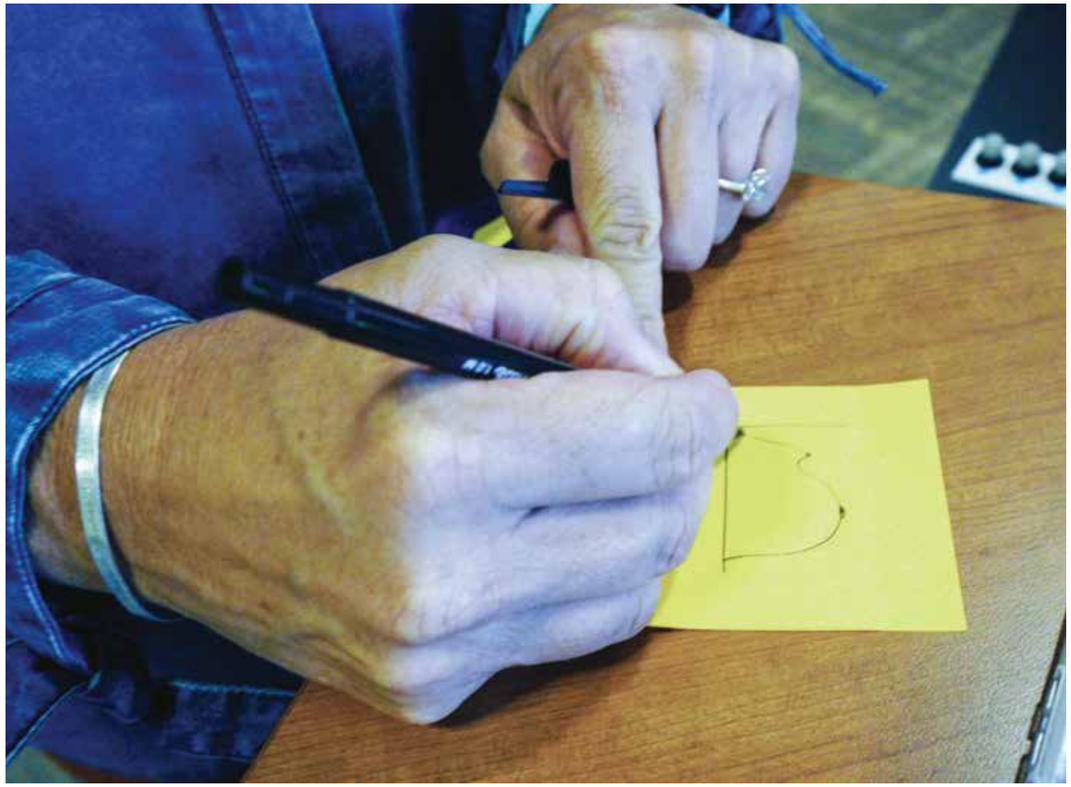
Why is Pollard so interested in this? "I started out as a physical therapist so my goal is to better understand lower extremity movement to reduce injury," she says.

Christine Pollard, the director of OSU-Cascades Functional Orthopedic Research Center of Excellence Laboratory, repositions a reflective marker on Dean's shoe in preparation for a force-platform analysis test.

Both Pollard and Hannigan are interested in exploring some of the conflicting anecdotes made by maximal shoe users. The FORCE Lab provides cutting-edge research and correction strategies for injuries, especially as related to knees, ankles and hips. Since the lab supports Central Oregon's population of elite and



Dean runs along a narrow lane to step on a platform that measures the impact of her foot.



recreational athletes, it is interested in squaring those anecdotal reports with research findings.

Hannigan, who as a competitive track and cross-country athlete struggled with injuries, echoes Pollard's sentiments and adds, "We've heard many subjective reports from runners who previously experienced knee pain several miles into their run and are now pain-free after switching to HOKA shoes. But we've also heard the opposite."

Recent History

Traditionally running shoes have had a moderate amount of cushioning, with the various brands being differentiated by how much control they provided for pronation—or inward rotation—of the feet. The heel of the majority of these shoes was at least a half inch higher than the toes — known as heel-toe drop.

"Between the '80s and about 2009, most footwear companies produced a range of running shoes that had one thing in common — all had a reasonable amount of heel-toe drop," Pollard says. "At one end of the spectrum, they had more stability, and at the other end they were more cushioned. But all had more cushioning under the heel than they did under the forefoot."

In 2009, the industry produced two innovations — minimal running shoes and maximal running shoes. Both styles had far less heel-toe drop, but the minimal shoes had less than a quarter inch of cushioning while the maximal shoes had almost an inch.

Pollard draws a graph showing the key points the team measures: The initial peak, referred to as the impact or passive peak, and a second peak, known as the push-off or active peak.

Help or Hindrance?

In this context, the science of biomechanics focuses on the effects of forces on the body when subjected to different athletic and recreational activities. More importantly for runners, it includes the study of injury prevention. Researchers focus on the relationship between force, the body and motion. The principle concerns for protecting runners against injury are the need for cushioning, rear-foot control of pronation and forefoot stability. To study these concerns, biomechanists use a device known as a force-platform along with high-speed video capture and other types of measurements.

Using force-platform analysis — a test that involves a runner stepping on a platform to measure the force exerted — scientists are able to identify the most prominent footfall pattern where the heel strikes the ground before the toe. Researchers found that there is an initial peak, referred to as the impact or passive peak, and a second peak, known as the push-off or active peak.

The body has to mitigate the shock through the bones and cartilage or by changing its geometry — in other words by compensating. It was, of course, believed that footwear should help cushion the foot-ground collision, but surprisingly it was found that a softer midsole offered no benefit over a hard midsole.

Which is why Pollard and Hannigan thought they would see these reductions in the HOKA shoes. "But we didn't, we saw the opposite," says Pollard. It may be that runners are relying too heavily on the maximal soles and are not using their internal musculoskeletal structures to dampen the forces adequately.

"And we didn't see any change in the loading rate or impact peak after six weeks of acclimating to the HOKA shoe either," says Hannigan. The average loading rate and impact peak were still significantly higher in the HOKA shoe compared to the traditional shoe.

Members of the FORCE Lab team who worked on this project from left to right are: JJ Hannigan, postdoctoral researcher; Christine Pollard, director; Sherri Dean, research assistant; and Bella Krevitz, research assistant.

In other words, the FORCE Lab has now twice found that maximal shoes actually provide less functional cushioning than the old traditional, tried and tested training treads. Could too much of a good thing be bad for runners? If runners love their HOKAs, then the answer might be a resounding no, but if they hate them, the FORCE Lab's next study might show why. terra

A Percolating Concern

What effect will warming ocean waters have on offshore methane seeps?

BY MARK FLOYD

Take a look off the Oregon coast, and you may see migrating gray whales spouting in between dives for krill or boats fishing for the Northwest's iconic Chinook salmon. But below that scenic vista lies an environment we still don't know much about – a seafloor of sand, silt and rocks from which seemingly innocuous but ubiquitous streams of bubbles rise and percolate up through the water column.

These bubbles may spell double trouble. Comprised of methane, one of the Earth's most potent greenhouse gases, they have been leaching out of the seafloor in some quasi-steady state for millions of years. If that rate increased due to some natural or manmade disturbance it could become concerning because of the potential to accelerate global warming. If the methane bubbles remain in the water column, most of them will get oxidized into carbon dioxide – the abundant greenhouse gas that has garnered the most attention from scientists – and either go into the atmosphere or remain in the water and add to the growing ocean acidification issue.

Scientists don't know a lot about the reservoirs of methane off the Pacific Northwest coast, first identified in the 1980s. But a team of researchers from Oregon State University and the National Oceanic and Atmospheric Administration (NOAA) has begun a comprehensive study to learn how widespread they may be, how much methane is stored in the deposits and, most importantly, what type of threat the methane may hold.

Race against time

Bob Embley is a geophysicist for both OSU and NOAA who has spent more than five decades studying the geology of what lies beneath the surface waters of the ocean. He estimates he has spent nearly four full years at sea, serving as chief scientist or co-chief scientist on 37 expeditions involving various ships, remotely operated vehicles (ROVs) and other submersibles. To paraphrase the old E.F. Hutton commercial, when Embley speaks, his colleagues pay attention.

His message on methane is to the point.

"We are in a race against time," he says emphatically. "Tens of millions of years ago, there was evidence of a massive methane release that shows up in the sediment core, so we know that it's possible for the methane to escape into the atmosphere. Did earthquakes destabilize the geology and create a sudden release? That's one concern. But now we have global warming and as temperatures in the ocean rise, one has to wonder – what effect might that have on methane deposits?"

It isn't an idle concern. The methane appears in two forms – either as bubble streams, or as hydrates, which is a solid form of the compound that looks like chunks of ice. Below 500 meters in depth (about 1,600 feet), the methane is often found as solidified hydrates in conjunction with gas bubble streams. Above 500 meters, the methane always appears in the gas phase as bubble stream rising from the seafloor.

"One question we need to answer is whether hydrates are formed by methane gas seeping out of the Earth and meeting the cold, deep seawater, or whether the bubbles we're seeing are a result of the hydrates breaking down and releasing gas," says John Lupton, a chemical oceanographer with NOAA's Pacific Marine Environmental Laboratory who works out of OSU's Hatfield Marine Science Center. "It's a chicken-or-egg problem, but both may be affected by rising ocean temperatures."

If the methane gas does not form hydrates as readily because of warmer water, it could alter how much methane the ocean floor sequesters and how much it releases. If the source of the methane is the breakdown of hydrates, warming temperatures may push the "melting point" or what is known as the hydrate stability zone deeper than 500 meters, leading to the breakup of previously stable hydrate, and the release more of the potent greenhouse gas.

Either way, a warmer ocean appears to be a cause for concern.

Mapped more of the moon

Three-plus decades ago, OSU oceanographer La Verne Kulm and his colleagues found a handful of methane seeps off the Oregon coast, and a decade later, another group of researchers documented a significant reservoir at a site since dubbed Hydrate Ridge.

Many of these early serendipitous discoveries were prompted by fishermen, who spotted anomalies on their fish-finders that turned

out to be acoustic reflections of bubbling methane gas. The haphazard nature of discovering methane bubbles resulted in the documentation of just a hundred or so "seep sites" along the Northwest coast by the year 2015. That all changed over the next two years, as the OSU/NOAA team began systematically hunting for sites, aided by new sonar technology aboard the Exploration Vessel Nautilus, which is owned and operated by the Ocean Exploration Trust.

The researchers were surprised to locate methane seeps all along the coast. By the time they concluded their last research cruise in 2017, they had expanded the number of documented sites to more than a thousand.

"Let's face it, we've mapped more of the moon and Mars than we have of our own ocean floor," says OSU oceanographer Susan Merle, who led the mapping portion of the expedition.

The discovery of methane in shallow water is of particular concern because it makes it more likely the gas could reach the atmosphere before microbes oxidize it into carbon dioxide. Although CO_2 is bad enough, methane is 25 to 30 times more potent. So the researchers scheduled a research expedition in the summer of 2018 to search for shallow-water sites and in hopes of retrieving pure samples of the methane to test for its origin.

The team conducted 13 dives from Northern California to the Washington border, using the ROV Hercules on the E/V Nautilus, which was supported by the NOAA Ocean Exploration and Research Program. They used the ship's multibeam sonar to locate 96 previously unknown flares that indicate bubble streams on the seafloor. They dove at three shallow sites (100 to 150 meters deep) on the Oregon coast at Nehalem Bank, Heceta Bank and Coquille Bank. All of the sites had microbial communities, known as bacterial mats, occurring in patches close to where the bubble streams entered the ocean. These bacterial mats utilize the methane to power their metabolism, forming the base of unique seafloor communities.

But it is what the team took away from the seep sites that excites them the most.

First uncontaminated samples

Months before the 2018 summer expedition was to begin, Lupton worked with an engineer in California to design a prototype hydrate sampler, which they hoped would attach to the ROV to collect samples of methane hydrate. Other researchers have collected samples, but virtually all of them had some level of contamination before having them analyzed.

Upon return from the expedition Tamara Baumberger, an Oregon State researcher and lead chemist on the project says, "To our knowledge, these are the first uncontaminated samples of methane hydrate ever retrieved from the ocean depths."

Baumberger and her colleagues collected 170 samples of methane gas, hydrates, seep fluids, seawater, sediments, fauna and rocks. The prototype sampler works by taking a small core of hydrate and keeping it sealed under pressure so no gases can escape before they can be analyzed onshore.

Baumberger said she hopes to have the results by late fall of 2018.

Drilling and mining problematic

There is another side to the methane story. The researchers say industry representatives are also interested in the new data as an indicator of deep gas and oil reservoirs. Drilling is problematic off Oregon, and direct mining of the hydrate reservoir even more so. Although they have yet to figure out how much methane is off the coast, it appears to be abundant. Could it be a benefit instead of a liability?

"That's a tricky one," Embley says. "It is very complex – and potentially hazardous – to attempt to extract methane hydrate on any kind of large scale. Mining would have all sorts of implications. Right now, our focus is on trying to determine where the methane is and how much is out there. We also need to quantify what happens to the methane that is released, and what could happen during an earthquake, or as the ocean warms.

"At this point, environmental concerns are more pressing than the potential for energy extraction." terra

Remotely Operated Vehicle Hercules works at a hydrate site. Hercules has been exploring the geology, biology, archaeology and chemistry of the deep sea since 2003. The undewater vehicle is equipped with a high-definition video camera, four lights, two manipulator arms and a variety of oceanographic sensors and samplers. It can deliver approximately 150 pounds of samples or tools to and from the seafloor. (Photo: Ocean Exploration Trust)

Remotely Operated Vehicle Hercules collects methane bubble samples. Hercules is one of a few remotely operated vehicles designed specifically for scientific purposes and is capable of descending to depths of 2.5 miles. (Photo: Ocean Exploration Trust)

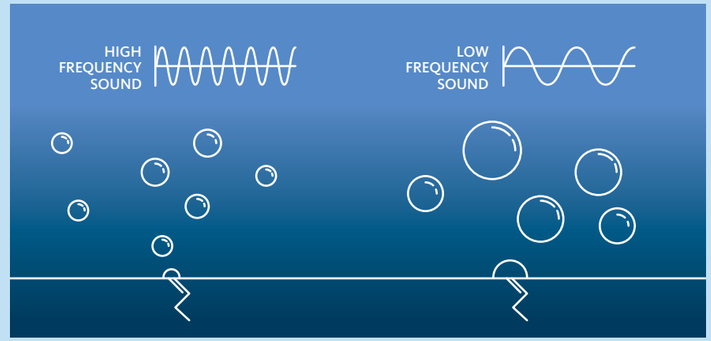
BUBBLE TROUBLE

Over the past three years, scientists have documented hundreds of sites off the Northwest coast where methane is bubbling up from the seafloor. Since methane is a potent greenhouse gas — it has some 25 to 30 times more heat-trapping effect than carbon dioxide — there is cause for concern.

If the methane reaches the atmosphere, it could accelerate the pace of global warming. If it stays in the ocean, microbes will oxidize it into CO_2, potentially increasing the rate of acidification.

The $64,000 question is: How much methane is bubbling up off our coast?

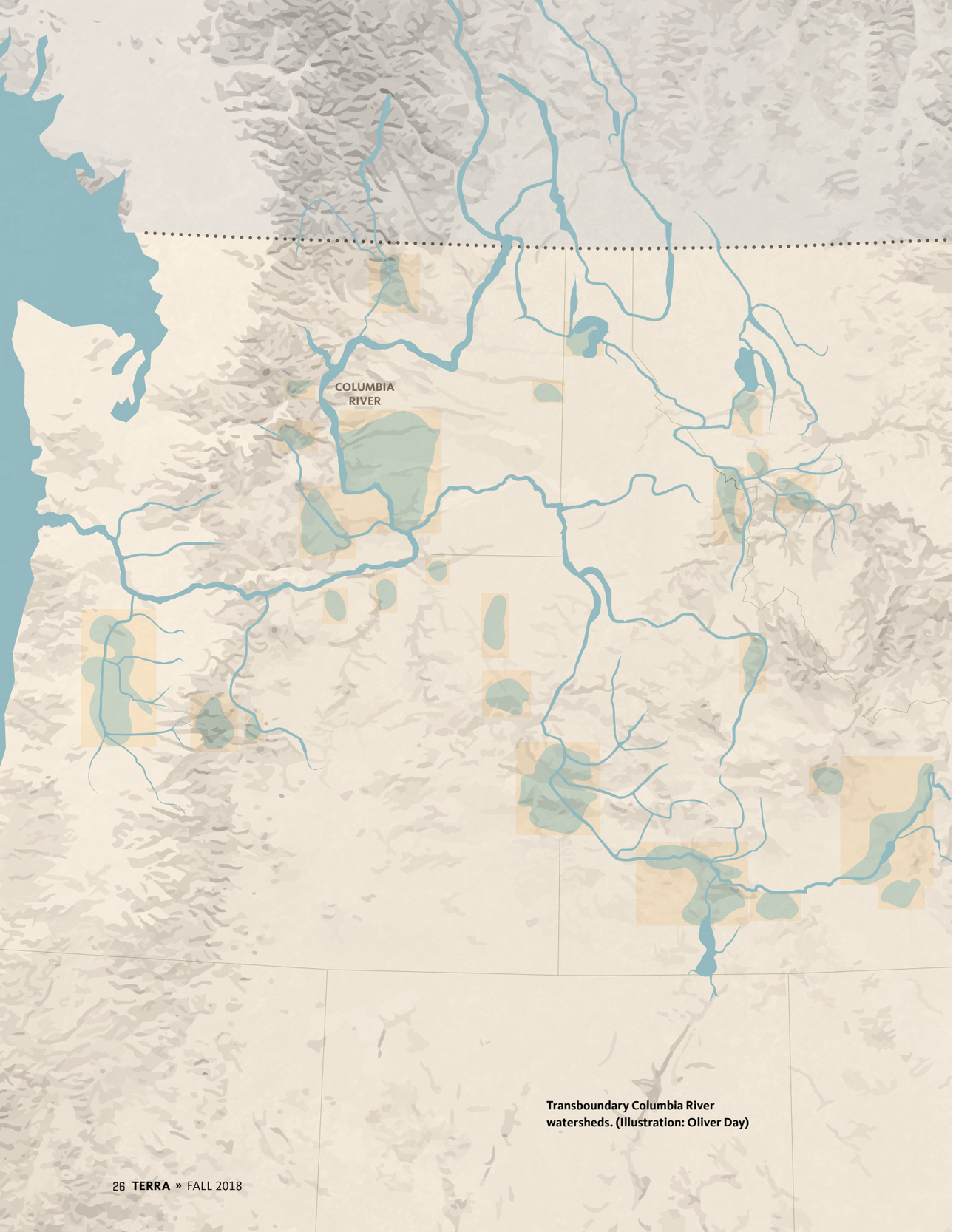
Robert Dziak hopes to find out. In a new study published this spring, the NOAA researcher based at OSU's Hatfield Marine Science Center outlines how hydrophones are not only able to detect the presence of methane bubble streams, but they may help quantify the amount of methane.



"The bubbles in the streams make sound, and the frequency of the sound is related to the size of the bubble," Dziak says. "The smaller the bubble, the higher the pitch. And the larger the bubble, the lower the sound pitch, but the more methane it contains. Our ultimate goal is to use sound to estimate the volume and rate of methane gas exiting these seafloor fields."

Dziak, who has a courtesy appointment in OSU's College of Earth, Ocean, and Atmospheric Sciences, says the acoustic signatures of the bubbles from the seep site are depicted in the hydrophone record as a series of short, high-frequency bursts, lasting 2–3 seconds. He and his colleagues then compare the sound record with still images taken from a remotely operated vehicle to match the sound off the bubbles with visual evidence.

"The acoustic data and the visual data match closely," Dziak says. "We're getting closer all the time."



Transboundary Columbia River watersheds. (Illustration: Oliver Day)

River Renewal

Renegotiating the Columbia River Treaty

BY NICK HOUTMAN

"We need to do the right thing and look after the river. It's not about the treaty; it's about taking care of the river."

— Notes from Second Annual Symposium of the Universities Consortium on Columbia River Governance

The next time you fly out of the Portland airport or sit in a restaurant within a stone's throw of the Columbia River, give a grateful nod to the Spicer family of Nakusp, British Columbia. The village of about 1,500 people sits along Upper Arrow Lake in a picturesque valley framed by the Canadian Rockies. At high water, the marina is filled with boats for exploring this nearly 150-mile long reservoir created by the Hugh Keenleyside Dam downstream on the Columbia. Nearby hot springs are a tourist attraction.

However, this idyllic spot used to support a more ecologically diverse and productive farming community. Located on rich river-bottom lands, the Spicer farm was known throughout the region for its bounty of potatoes, asparagus, corn and other produce. Then in 1969, Christopher Spicer watched waters from the newly built dam flood some of his best fields. He and his family were allowed to stay in their home, but BC Hydro had ordered that the structure was to be burned after his death (the home was later saved by a reprieve from the company president).

The Spicers were among the estimated 2,300 people in two dozen communities who lost homes and farms to the rising waters behind what are known as "the Treaty dams" — three in Canada and one in Montana. Designed to reduce flooding in the United States and generate electricity to be shared equally by both countries, the dams owe their existence to the Columbia River Treaty, the agreement between the U.S. and Canada that went into effect in 1964.

Thanks to the sacrifices made by those who lost property to the new reservoirs, development along the lower Columbia has proceeded with confidence that it would be protected from floodwaters. The likelihood of floods has been significantly reduced. Indeed, the devastation wrought by high water in 1948 may have been on the minds of negotiators as they structured the treaty. In that year, the Columbia was swollen by snowmelt in its Canadian headwaters and by torrential spring rains. The river breached a railroad embankment and destroyed the city of Vanport just north of Portland. High waters made the Portland airport unusable for several months.

The damage put a spotlight on a need unmet by the flurry of dam building in previous decades. Most of the more than 60 dams on the Columbia and its tributaries were designed to generate electricity, not to reduce floods. Indeed, the basin produces more power than any other watershed in the United States.

But the Columbia River Treaty simultaneously expanded hydropower and added capacity for managing floods. Although some provisions for managing high waters will expire in 2024, the agreement was intended to continue in perpetuity. However, either the U.S. or Canada could signal an intention to withdraw or revise it with 10 years notice. That step was taken in December 2013 when the U.S. State Department formally announced its intention to renegotiate. Formal talks began May 2017.

In the years after it was ratified, the agreement was considered a model of an effective transboundary arrangement, says Aaron Wolf, professor in the College of Earth, Ocean, and Atmospheric Sciences (CEOAS) at Oregon State University. “It allocates benefits, not water, which is a huge step forward. It shared both expenses and benefits of development, which was done collaboratively between the two countries, from the design of shared dams to how benefits would be shared. Interestingly, there’s no river basin organization. It’s a very elaborate system of coordination.”

Transboundary Waters

Wolf and Lynette de Silva, an instructor in CEOAS, co-direct the Water Conflict Management and Transformation program at OSU. They study rivers that cross international boundaries, such as the Euphrates and Jordan in the Middle East, the Nile in Africa and the Mekong in Southeast Asia. And just as on the Columbia, decisions by one nation to build a dam or manage water for other purposes such as agriculture, can have drastic consequences for countries downstream.

Top: Lands known as Spicer Garden in 1962. Bottom: By 1970, the same area had become known as Spicer’s Mud. (Photos: John Osborn)

In 2008, Wolf and de Silva became aware that, despite its landmark status, the Columbia River Treaty was about to enter a period of uncertainty. Both Canada and the U.S. could begin to renegotiate its terms as early as 2014, and yet the potential for a new treaty was attracting little attention. So the two OSU faculty members began collaborating with colleagues at other universities in the Pacific Northwest to create the Universities Consortium on Columbia River Governance.

The consortium brought together citizens, scientists, managers and governments — local, tribal, state, provincial and federal — to consider the needs of the river and the communities along its shores. The forums were informal with no legal impact on policymaking. However, they provided an opening for dialogue. There had been no opportunities throughout the basin for residents to share views about the river and to consider how the treaty might be revised.

Despite its status as an effective agreement providing clear benefits to both countries, the treaty has been found wanting. Tribal governments in the United States and First Nations in Canada were excluded from the talks that produced the agreement. Moreover, the document ignores the river basin’s rich ecological heritage. There is no mention of the abundant runs of salmon that have been excluded from much of the basin and have dwindled elsewhere. And since the 1960s, other issues missing from the treaty — such as water quality, navigation, recreation and climate change — have become significant for river managers.

Vanport City was located between the Portland city boundary and the Columbia River. Vanport was destroyed on May 30, 1948, when a section of the dike collapsed during a flood on the Columbia River. (Photo courtesy of Oregon Digital)

The consortium meetings ranged widely. “The conversations were really rich and productive. Nobody wanted to scrap the treaty,” says Wolf.

If the treaty was done away with, it would be destined for Congress and subjected to requirements that have nothing to do with water or the region. So the group started talking about modernizing the treaty, collectively saying that the modernized treaty would have to consider the environment as a third leg of treaty management goals, equal to hydropower and flood control. And that representation of both the public at large and especially the tribes should be fostered and incorporated.

“These were things we all collectively agreed to and signed onto,” adds Wolf. “And they do show up in the official negotiating positions of Canada and the U.S. Both sides sent official representatives to our meetings.”

Tribal and First Nation participation in negotiations for a new treaty were seen as especially important, says de Silva. "The tribes have a unique relationship to the federal governments, both legal and political, which surpasses what other stakeholders and individuals have," he says. "From that perspective, they need to be at the negotiating table. They weren't part of it in 1964, and it would be detrimental to find ourselves in that predicament again." At a consortium meeting held at Oregon State in Corvallis in 2010, representatives of the tribes and First Nations held formal ceremonies honoring their renewed relationships and common bonds.

Nevertheless, when negotiations began last spring, the U.S. negotiating team included agencies with official standing in implementing the treaty: The State Department, Bonneville Power Administration, Army Corps of Engineers, National Oceanic and Atmospheric Administration and Department of the Interior. On the Canadian side are representatives of BC Hydro and the Canadian federal government. The tribes and First Nations continue to be consulted in the process, but observers have expressed disappointment that they are not at the table.

"We have so much more in common with each other in the Pacific Northwest than we have with Ottawa or Washington, D.C.," says Wolf. "We have a Northwest ethic. We care about the things that have been missing in the treaty. We all care about the environment. We all care about tribal representation. And we all care about the benefits that the treaty has led to."

A Place for Students

In addition to bringing people together, the consortium provided students with an invaluable lesson in regional decision-making and politics. Students served as facilitators and helped to organize discussions. A graduate student, Julie Watson, interviewed people with a stake in the discussions and produced a film about the river (see *transboundarywaters.science.oregonstate.edu/content/student-testimonials#Watson*)

Another student, Kim Ogren, currently works on water supply issues for the Oregon Water Resources Department. In 2010, she had just started a master's program in water resources, management and policy at OSU. "The consortium was great in that it brought everyone together whose identity is tied to this place," she says. "A lot of folks came representing different interests. People in Portland benefit from flood control. They can live there and prosper because of this protection. For the people in Canada, they live along reservoirs that go up and down every year a lot. Their properties were flooded by the reservoirs."

Ogren leveraged her experience in the consortium meetings into a Ph.D. on river basin governance and an internship with the U.S. Army Corps of Engineers in Portland. She interviewed people in the U.S. and Canada about the treaty and found that people north of the border were generally more aware of the agreement. "It creates the possibility to live in Portland because of flood protection," she says. "We just take it for granted. In Canada, it seemed like everyone knew about the treaty. In the U.S., because we don't have as many negative impacts, people just aren't aware."

The informal nature of the consortium process was both a blessing and a curse, adds Ogren. On one hand, participants could feel free to speak openly without the burden of formally representing an organization or taking a position. However, neither government was required to incorporate or respond to the views expressed in the meetings. The gatherings lacked the impact of a formal process, she says.

Today, Nakusp and other riverside communities continue to see impacts from the reservoirs. Seasonal drawdowns in preparation for the spring snowmelt create mudflats and leave marinas high and dry. Winds blow dust into homes and businesses. The shorelines that used to thrive with abundant vegetation and wildlife have become all but silent.

In the hopes of restoring some of what they have lost, citizen activists are calling for limits to how much the reservoir water levels can change from season to season. Other observers are tracking the negotiations in the hope that their views will have an impact.

"Nobody will point to the universities consortium and say that's what caused peace on the Columbia," says Wolf. "But we did foster a lot of good dialogue when only universities could pick that up." terra

THE SACRED RIVER

Native Americans netting salmon at Celilo Falls near The Dalles. Celilo Falls was a traditional Native American fishing location until it was inundated by The Dalles dam in 1957. (Photo courtesy of Oregon Digital)

As negotiators discuss a new Columbia River Treaty, legal and spiritual perspectives on nature are taking hold elsewhere. In countries from India and New Zealand to Ecuador, decision-makers have recognized that rivers have a formal right to representation in legal proceedings. In the United States, 12 Catholic bishops in the Pacific Northwest signed a pastoral letter in 2001 declaring that the Columbia River is sacred and urging the public to work for its betterment.

Such endeavors, says OSU professor Aaron Wolf, can help overcome conflicts in environmental issues. In *The Spirit of Dialogue: Lessons from Faith Traditions in Transforming Conflict* (Island Press, 2017) he reflected on how religious values can help people resolve differences of opinion, especially where technical details fail to inspire agreement. "Technical is a great basis for making decisions," he says, "but it's not just about parts per million and cubic meters. It comes from ethics and spirituality, how people think differently and how they come together."

FOLLOW THE NEGOTIATIONS

To access the schedule for negotiations for a new Columbia River Treaty, see the U.S. State Department website (*state.gov/r/pa/prs/ps/2018/08/285199.htm*). The next round of negotiations will take place Oct. 17–18, 2018, in Portland.

A PINNACLE PRACTICE

Emilee Mowlds was introduced to undergraduate research in her junior year when she applied for a position counting salamanders and cutthroat trout through Oregon State University's College of Forestry Mentored Employment Program. While working in OSU's H.J. Andrews Experimental Forest that summer, Mowlds, a natural resources major, then learned about the Research Experience for Undergraduates program and applied for that as well. The Research Experience for Undergraduates is a National Science Foundation funded 10-week summer research opportunity. Students have to propose a question they want to test using the scientific method and then execute the project.

"It was kind of the next step from participating in the salamander and fish stream count," says Mowlds. "More immersive than a tech position, it felt like a mini version of a grad program where you develop your own project."

Mowlds proposed to validate a commercial instrument, the BenthoTorch, which is used to measure chlorophyll content in algae cells through fluorescence. The instrument makes it possible to look at how much synthesis of organic compounds from CO_2 (photosynthesis) occurs in the streams, as opposed to an elaborate process in the lab.

Francisco Pickens is assisting Mowlds on the BenthoTorch study. A master's student in fisheries science, he also participated in both the employment and research programs as an undergraduate. He learned a range of different research methods related to stream ecology, which, in turn, generated new questions. "At that stage, I didn't have any particular focus. I certainly didn't have grad school in mind; I was only interested in finishing my undergrad degree," he says. Transitions like Pickens' were, in part, why the undergraduate research experience was created.

Natural resources major Emilee Mowlds says that participating in the Research Experience for Undergraduates program "felt like a mini version of a grad program where you develop your own project." Here she uses the BenthoTorch to read samples on McRae Creek in the H.J. Andrews Forest. (Photo: Will Johnstone)

Ivan Arismendi, assistant professor in the OSU Department of Fisheries and Wildlife, serves as advisor for both Mowlds and Pickens. He explains that the program allows the opportunity for students to create memorable and meaningful research experiences. "Science projects are hands-on and customized for each student," he says. "They plan, conduct and report on their research. It's a bit of what a scientist lives every day."

It was the undergraduate research experience, along with an invitation from Arismendi, that propelled Pickens into the master's program, where he is now researching the effect of climate change on aquatic animals living in headwater streams. "I was planning my master's experiments in my senior year and conducting them a couple of weeks after graduation," he says.

Sophie Pierszalowski is Oregon State's undergraduate research coordinator. She says faculty who are applying for an NSF grant, or who already have an NSF grant, can request funds to design and implement the program. Those can be in any discipline and the program is open to students at universities across the nation.

Pierszalowski also notes that in the past decade or two, there's been a tremendous amount of work done to try answer the question of how research experiences benefit undergraduates. "You'll see in the research literature hundreds of papers that talk about gains that students see from participating in research with faculty mentors," she says.

These range from increased academic persistence to a higher likelihood of going on to a graduate program, increased confidence in students' academic programs and connections with faculty who can write letters of recommendation and introduce students to other talented people in their field.

Pierszalowski adds, "Undergrads who often engage in research find their academic home and become part of a more intimate community in a vast and sometimes intimidating research institution." For these reasons, undergraduate research has been referred to as a "pinnacle practice" in higher education literature. Mowlds and Pickens couldn't agree more.

One Size Doesn't Fit All

BURNING SAGEBRUSH NOW SLOWS FUTURE FIRES

Oregon State researchers modeled fire behavior to predict how fire might move through a particular study area. They found "dramatic differences" between the unburned and burned plots. Seventeen years after fire, the burned plots, with their low fuel loads, slowed the spread of the next wildfire, said Lisa Ellsworth, lead researcher for the project.

"Sagebrush steppe ecosystems that are in good ecological condition, with minimal invasive grass, can recover from prescribed fires," she notes. "There are benefits to keeping some fire on these landscapes, including fires acting as fuel breaks, which will slow the spread of fire substantially."

The results are noteworthy as federal, state and local agencies in Oregon and other western states spend millions on land management methods to conserve habitat for native wildlife, including greater sage-grouse, and when experiencing increasing summer temperatures and fires thanks to climate change.

Read more in Living with Fire at Terra online at **bit.ly/2xKt71Z**

Voices of a Warming Planet

ORAL HISTORY INTERVIEWS FOCUS ON CLIMATE CHANGE

The Voices Initiative is a multiyear effort produced by the OSU Libraries Special Collections and Archives Research Center. Voices of a Warming Planet, a category of the initiative, consists of contextualized oral history interviews with 12 OSU faculty members.

The interviews were conducted with faculty who are engaged in climate change research from multiple scholarly vantage points, including the oceanographic and atmospheric sciences, forestry, agriculture, ethics, public health and public policy. They trace each narrator's path through academia with particular attention to their research and perspectives on climate change. In addition to each video interview, the Voices of a Warming Planet website includes contextual information and interview abstracts.

For more information, please visit Voices for a Warming Planet at **bit.ly/2vvdGK3**

Two Global Warming Experts Appointed to IPCC

ASSESSING SCIENCE TO DEVELOP CLIMATE CHANGE-RELATED POLICIES

OSU faculty members Alan Mix, an oceanographer and paleoclimatologist, and David Wrathall, a human geography researcher who studies environmentally forced migration, have been appointed lead authors and will join hundreds of colleagues from 90 countries around the world to contribute to the most recent Intergovernmental Panel on Climate Change Assessment Report.

Mix is in IPCC Working Group I: Physical Science Basis of Climate Change. He is a lead author on the chapter, Ocean, Cryosphere and Sea Level Change. Wrathall is in IPCC Working Group II: Impacts, Adaptation and Vulnerability of Climate Change. He is a lead author on the chapter, Poverty, Livelihoods and Sustainable Development.

The IPCC was founded in 1988 by the World Meteorological Organization and the United Nations, and thus far has produced five climate assessments during that 30-year period. Each time a new assessment is made, expert scientists from around the world gather to review and report on progress made.

Read more in Climate Roulette at **bit.ly/2OWf3Jd**

TECHNOLOGY THAT WORKS

Engineering teams up with anthropology

BY KENDRA SHARP, RICHARD AND GRETCHEN EVANS PROFESSOR IN HUMANITARIAN ENGINEERING

Technologies developed in one place sometimes fail in another. Nowhere is this problem more glaring than in efforts to solve water problems in Sub-Saharan Africa. Over half of such projects no longer function after just a few years. Many of these failures occur because researchers don't consider how people actually use water filters, solar water purifiers and other engineered systems.

One high-profile example is known as the PlayPump, a kind of merry-go-round designed to harness the energy of children. In practice, the machine was not fun to play on but rather hard to turn. And it had to be turned round-the-clock to meet its delivery target of water for 2,500 people per day.

At Oregon State University, graduate students in the Humanitarian Engineering Program are working to ensure that the technologies they design and deploy in the developing world provide sustainable solutions that meet the needs and desires of the users. To do so, students are combining applied anthropology and mechanical engineering design into a dual-degree master's program.

Take the case of water purification. Currently, over 1.2 billion people disinfect their water by boiling it, often over an open fire. This approach uses unnecessarily large amounts of wood and other types of biomass. Fires may be located indoors, where smoke harms human health and the environment. Boiling is a very common approach to purifying water because biomass is available, and people see an obvious visual indication that the water is safe.

To develop a safer, more efficient and still effective purification process, OSU master's students Grace Burleson and Nick Moses partnered with InStove, an Oregon-based enterprise. The company's water purifier fits into a wood-fired cookstove, also designed by InStove, and can purify up to 400 liters of water per hour.

The InStove Water Purifier heats incoming cold and unsafe water to 71 degrees Celsius (160 degrees Fahrenheit) for 15 seconds, thus meeting World Health Organization drinking water standards. Previous research has shown that this device uses up to 97 percent less wood compared to the standard open-fire boiling process.

In her work, Burleson used anthropological methods to understand how people at a girls' school in Uganda used the purifier. She observed kitchen staff and measured how they allocated time with and without use of the device. She collected helpful user-based data and effectively analyzed her observations.

One efficiency-driven innovation in the pasteurizer is a simple heat exchanger. It uses waste heat from the outgoing (heated) water stream to help heat the incoming (cold) water. Burleson found that users were suspicious of the safety of the water coming out because it was cold, just like the water that went in.

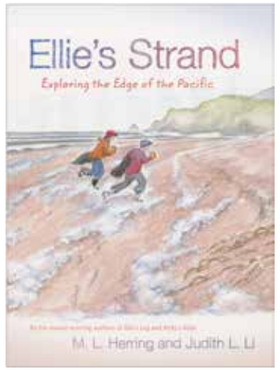
These and other observations led her to recommend that the pasteurizer be modified to allow users to draw off hot water directly as it exits the internal heating chamber. This modification gives users confidence that the machine is actually working. Moreover, users can decide if they want cold water for immediate drinking or washing, or hot water for tea or cooking.

OSU has one of only a handful of humanitarian engineering programs in the country. The dual degree option focuses on what people need and how they think. It will narrow the gap between theory and application and help more projects succeed in the long term.

Master's student Grace Burleson takes notes in Uganda during testing of the InStove. (Photo: Hyacinth Walimbwa)

BOOK NOTES

RECENT PUBLICATIONS BY OSU FACULTY



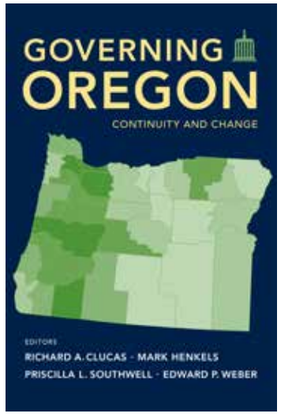
ELLIE'S STRAND: EXPLORING THE EDGE OF THE PACIFIC

M.L. Herring, associate professor emeritus of science communication and Judith L. Li, retired associate professor in the Department of Fisheries and Wildlife.

Published by Oregon State University Press

In this sequel to "Ellie's Log" and "Ricky's Atlas," Ellie and Ricky travel to the Oregon coast from their home in the Cascades to help with a one-day beach cleanup. Hoping to find a prized Japanese glass float, they instead find more important natural treasures and evidence of an ocean that needs its own global-scale cleanup.

With charming pen-and-ink drawings and a compelling story, "Ellie's Strand" makes coastal science exciting for upper elementary school students.



GOVERNING OREGON: CONTINUITY AND CHANGE

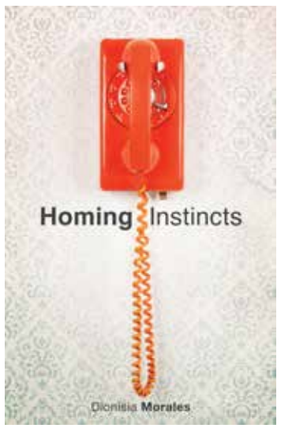
Edited by Richard A. Clucas, Mark Henkels, Priscilla L. Southwell and Edward P. Weber

Published by Oregon State University Press

At the end of the 20th century, the state government of Oregon was routinely entangled in intense partisan conflict, with opposing sides waging bitter battles in elections, the legislature and the courts. Many of the most important state laws were decided through the initiative process rather than by lawmakers in Salem.

As the 21st century began, this political dynamic began to shift. Partisan conflict in the capitol grew less rancorous, legislative gridlock eased and ballot initiatives lost their central role in defining Oregon politics.

With contributions from 27 leading experts and political insiders, *Governing Oregon: Continuity and Change* offers insight into the people, political practices, governing institutions and public policies of Oregon.



HOMING INSTINCTS

Dionisia Morales, Publications Manager, OSU Extension Service

Published by Oregon State University Press

As a native New Yorker who now calls Oregon home, Dionisia Morales knows how moving and resettling can spark an identity crisis relative to geography, family and tradition. The essays collected in "Homing Instincts" explore how Morales' conception of home plays out in her daily life as she navigates the gap between where she is and the stories she tells herself about where she belongs.

As issues of migration and social integration play out in national and international politics, Morales provides a personal lens through which readers can appreciate that at one time or another everyone has been in the process of arriving.

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.

OUTFOXING THE FRUIT FLY

Vaughn Walton, a professor in Oregon State's Department of Horticulture, points at net-covered cages containing fruit flies, blueberries and what he calls artificial fruit — a chemical concoction that attracts the flies. "We place little disks of attractant in the middle of each cage, cover them with nets and release flies inside," he says. "After two days, we collect the fruit, and we look at the infestation."

The particular pest Walton is referring to is the spotted-wing drosophila (Drosophila suzukii), and it can have a negative annual economic impact of up to $500 million on soft fruit such as blueberries, raspberries, peaches and strawberries. The researchers have been working for a number of years to develop an artificial attractant that encourages the flies to lay their eggs on or near it rather than in the fruit. In this particular experiment Walton's team found up to 76 percent reduction in egg laying on the blueberries using their synthetic fruit matrix. They are showing similar results on strawberries, which make up about 70 percent of all susceptible fruit worldwide. That efficacy is comparable with pesticides, but it has no insecticide in it at all. "That opens up industry markets significantly because it's environmentally friendly," he says.

The fly buzzed onto Walton's radar in 2009 when he and colleagues from as far afield as Italy started working on the creation of an attractant. In 2017, Walton, together with OSU horticulturist and extension fruit expert Clive Kaiser and visiting Italian graduate student Gabriella Tait, were finally able to develop the first prototype of the product.

The team is now in the advanced developmental stage as they work on the most optimal commercial application — a means to spread it near the fruit so that the attractant can outfox the flies. With the help of OSU agricultural entomologist, Valerio Rossi Stacconi and Jennifer Field, a chemist and professor in the Department of Environmental and Molecular Toxicology at Oregon State, the scientists are refining an organic product that allows the chemicals to release at a slow and sustained rate. "We are essentially producing an economic benefit because of the combined lower cost of labor, and we are increasing its effectiveness," says Stacconi. The longer the product remains active, the less that needs to be applied.

Net-covered cages containing fruit flies and attractant comprise an experiment being conducted to beat a pest that has enormous impact on soft fruits such as blueberries and strawberries. (Photo: Vaughn Walton)

Brian Wall, assistant vice president for research, commercialization and industry partnering, in the OSU Research Office, sees great potential in this synthetic fruit solution to a pervasive pest problem. His team is committing $60,000 in support through the University Venture Development Fund, has filed a patent application, provided OSU Advantage Accelerator training, and is connecting with local entrepreneurs and investors who may be interested in supporting the work as is emerges.

"This is an outstanding example of how OSU research plays a key role in driving economic impact in Oregon and beyond," Wall says.

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**

Oregon State University

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This past summer the Oregon State Robotics Club won the Canadian International Rover Challenge. The event was held in the Canadian Badlands in Alberta. Below is a photo of the rover performing a task in the competition. (Credit: Dylan Thrush)

The team's point total was nearly double the second-place score posted by a crew from Poland's Bialystok University of Technology, and it bested Harvard Univeristy and the University of Washington. Oregon State instructor Matthew Shuman said the robotics team and the Mars rover participated in various tasks similar to what astronauts do on a daily basis.

The OSU Robotics Club is a student group affiliated with the Collaborative Robotics and Intelligent Systems Institute in the College of Engineering. The CoRIS Institute includes faculty across multiple disciplines, who advance the theory, design, development and deployment of robots and intelligent systems able to interact seamlessly with people.

Taking advantage of that expertise in robotics, on Oct. 23 OSU will host a free, daylong symposium, The Promise and the Peril of Artificial Intelligence and Robotics. (See Page 11.) Registration is now open: **osu150-airobotics.org**.