

terra

DISCOVERY | CREATIVITY | INNOVATION · Fall 2015



WHO'S STEERING YOUR HEALTH?

How gut microbes drive human well-being

Oregon State
UNIVERSITY

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Small World

*The chestnut-backed antbird, like other ground-nesting species of tropical Panama, loses many eggs and chicks to bird-eating snakes, Oregon State researchers have observed via hidden video cameras. See "The Mystery of the Disappearing Birds," Page 20.
(Photo: Christian Ziegler)*



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Oregon State is Oregon's leading public research university with more than \$308 million in research funding in FY2015. 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. Oregon State comprises 11 academic colleges with strengths in Earth systems, health, entrepreneurship and the arts and sciences.

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

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On the cover: Illustration by Lisa Haney

Stirrings of the Soul

My friend Lorraine, email moniker “ecoeditor,” walks the talk of environmental consciousness. Her energy-efficient windows, her drought-tolerant garden and her rooftop solar panels are visible emblems of her commitment. She eats local, organic and free-range. She composts religiously. And I have never, ever seen her put a disposable plastic bottle to her lips.

So one evening as our women’s reading group was discussing several Earth-themed poems, I was stunned when Lorraine’s face suddenly contorted in pain, and her voice, rising a few decibels above her usual measured tone, wailed: “Climate change is my fault! I’m responsible!” We had just turned to a 2014 composition by Oregon poet Kim Stafford, *In My Name*. As Lorraine read the poem aloud, one stanza struck me as especially damning. “I touch the thermostat, open the fridge, turn my Volvo key, tap my Mac space bar for email — and the Pacific surges over Fiji, the Ogallala aquifer sinks away, the Sahara’s green rim withers, Greenland glaciers calve and crumble, Peruvian children thirst, fiery trees explode in Greece, Brazil, and Malibu.”

When she finished, we all sat still for a moment. Finally, someone asked, How does the poem make you feel? “Guilty,” one woman said. Everyone nodded. That’s when Lorraine’s longstanding distress over the planet’s plight, fanned by her chronic, wearying thoughts about her own complicity, burst out. I knew exactly how she felt. I’d been carrying around my own eco-guilt for years. But as I scanned the troubled faces of the warm-hearted, Earth-loving women sitting there that night, a nub of defiance took hold. Are my fridge and my furnace *really* drowning Fiji? I asked myself. Am I *really* supposed to shoulder the blame for the disappearing Ogallala aquifer and the thirsty Peruvian children?

I was still taking the measure of my personal guilt when, a few weeks later, I wandered over to the OSU Center for the Humanities to hear assistant professor Tim Jensen lecture on the “rhetorics” of social movements. When he pointed out the “collective guilt” that so many of us absorb, unconsciously, from corporate PR messages, my ears pricked up. Those messages, he told us, are often designed to deflect our anger away from the real bad guys.

Environmentalism and other social movements, he explained, are driven by feelings and emotions, “stirrings of the soul.” These motivating emotions are prompted first by love and then by rage. “Collective guilt,” he warned, “can become a paralyzing force” that short-circuits large-scale activism, leading us to seek atonement in individual acts (recycling water bottles and yogurt containers, for example) instead of demanding sweeping reforms. Read more about Tim Jensen’s compelling scholarship in this issue of *Terra*.



Lee Sherman
Associate Editor



A Life of Discovery

The “contagion” of research begins with caring mentors

BY CYNTHIA SAGERS, OSU VICE PRESIDENT FOR RESEARCH

My first scientific experiment happened by chance during a childhood ramble in eastern Iowa. I was 7 or 8, exploring the woods around rural Maquoketa with my grandmother, who loved the outdoors. I picked up a small brown nut and asked, “Granny, is this the kind of nut that’s good to eat?” “Well,” she said with just the slightest twinkle in her eye, “why don’t you tell me?” I bit into the pale kernel and winced, spitting it out as fast as I could. It turned out to be the aptly named bitternut hickory (*Carya cordiformis*), not poisonous but not exactly palatable, either. (Early settlers fed them to their pigs, inspiring their other common name, pignuts.)

Maybe it’s a coincidence that I went on to become a botanist who studies the chemical, genetic and evolutionary science behind the tastes and scents that protect plants from animals and insects that would eat them. Maybe, but I doubt it. More likely, those early wildland explorations forged some deep, synaptic connection in my young brain between nature’s mysteries and a grandmother’s love. By the time I got to college, plant ecology was in my bones.

So what could feel more fitting when, as an undergrad at the University of Iowa, I got the chance to lead a field crew taking a census of tropical tree species at the Smithsonian Tropical Research Institute in Panama? My experience in the jungles of Panama — doing my first fieldwork; meeting my Ph.D. mentor, botanical “rock star” Phyllis Coley; hanging around with geoscientists, ecologists, ornithologists — was absolutely seminal in my journey as a scientist. To have these brilliant people sitting across the table from me at breakfast or on the sofa beside me after dinner, talking about their ideas, their questions, their passions, had a really strong impression on me.

So imagine my surprise at the latest coincidence in the trajectory of my professional life: Shortly after arriving on campus late this summer, I learned that the fall issue of *Terra* magazine — the first issue to appear on my watch as Oregon State’s new vice president for research — would feature a story about OSU scientists conducting avian ecology studies at the very same Smithsonian institute in Panama where I cut my teeth as a scientist (see “The Mystery of the Disappearing Birds,” Page 20).

Living for a year in that community of people so committed to research was contagious. In my role at Oregon State, I want to pass on that contagion with every tool at my disposal, to students in particular. OSU’s undergraduate research program is growing fast. As for grad students and post-docs, I want to make sure they know the Research Office is here to give them what they need for their own journeys of discovery.

We are poised to grow OSU’s \$308.9 million research enterprise to ever greater heights. I can’t wait to work with all of you at this great university and, in the spirit of discovery I inherited from my grandmother, to explore the forests and waters of this beautiful place.

Before being named vice president for research at Oregon State in May, Cynthia Sagers was associate vice provost for research and development at the University of Arkansas.



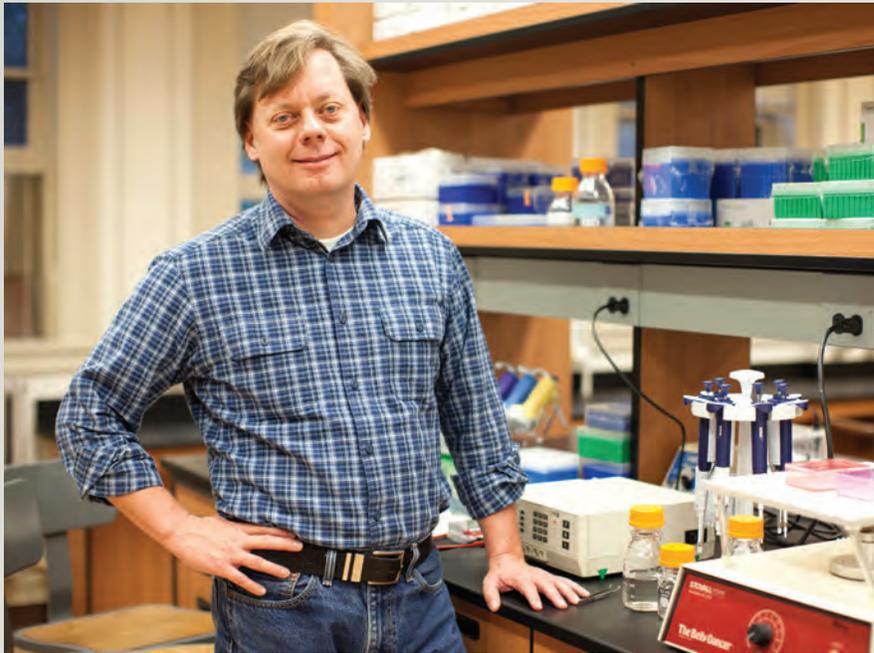


Diet and the Microbiome

Building evidence toward dietary recommendations



BY NORMAN HORD, COLLEGE OF PUBLIC HEALTH AND HUMAN SCIENCES



The gut microbiome — a teeming mass of bacteria, fungi, viruses, archaea and protozoans that live in our lower gastrointestinal tracts — has captured the attention of health-conscious consumers. Through controlled studies with mice, scientists have learned that by manipulating the microbiome, we can induce weight loss, affect pain perception and decrease hormonal responses to stress, among other fascinating outcomes. We know that the microbiome interacts with the immune, neuroendocrine and cardiovascular systems to affect health.

By providing a warm, nourishing environment for microbes, we sustain the microorganisms that help maintain good gut and immune function. Based on these observations, it may seem intuitive that scientists can recommend foods to nudge the microbiome to promote health, right? The answer is an emphatic “no.” Here’s why.

Nutrition is a team sport. In many cultures, foods fermented and fresh provide all the nutrients necessary for a vibrant life. And we’ve known for more than a century that what we eat profoundly affects our microbial residents. Awarded the Nobel Prize in Medicine in 1908 for his cellular theory of immunity, Élie Metchnikoff inspired generations of scientists and food product developers with his proposal to transform the “toxic” flora or microbiota of the large intestine into a host-friendly colony of *Bacillus bulgaricus* through the consumption of yogurt. In spite of research on conditions from ear infection to colon cancer, the only proven effects of probiotic bacteria (like those in yogurt) are for the prevention of *Clostridium difficile*-associated diarrhea.

We do know that a diet dominated by vegetables or meats can dramatically alter “who” populates an individual’s gut

microbiome and “what” these organisms are doing there. In fact, we can significantly shift the composition of the microbial community with dramatic changes in dietary patterns from one day to the next.

It’s clear that short- and long-term variation in the gut microbiome is vast, even in healthy individuals. This microbial community comprises a diverse ecosystem in which organisms compete for resources, occupy niches and produce metabolites with myriad consequences for other microbes and for human health.

However, we are still learning to identify all the bugs that populate our guts, how they function and how they interact with each other and with the human body.

Research at Oregon State (in this issue of *Terra*, see “Gut Check,” Page 6) and elsewhere merges basic nutritional sciences with genomics, bioinformatics and other disciplines to interrogate when shifts in the microbiome occur and why. OSU researchers study a variety of topics, from diet and interactions with the immune system to exposure to chemicals in the environment. But simply put, scientists don’t yet know enough to make specific statements with confidence about how we might promote a healthy microbiome through diet.

Scientists are excited to know that biological processes in early development, cognition, aging, disease prevention and treatment involve the microbiome in our gut and other organs. Nevertheless, research is needed on many fronts. We need to increase our understanding of individual variations in the gut microbiome, the impact of diet and physical activity and the mechanisms by which the gut microbiota and their metabolites impact host physiology and the development of disease.



Stormy Waters

Joe Kemper helps solve a local dispute over flooding and ditches

BY LEE SHERMAN

Running whitewater in a kayak is not that different from steering a group of feuding neighbors through the shoals of local water conflict. Ask Joe Kemper. He's done both.

An avid paddler who has attacked Class V rapids from Colorado to Costa Rica, Kemper concedes that maneuvering a tiny boat over thundering ledges in places like Oregon's Opal Creek Wilderness presents obstacles no more dodgy than those he faced when facilitating a series of community meetings in the tiny Coast Range town of Falls City.

"It's the people who are the really complicated part," observes Kemper, a graduate student in Water Resources Engineering at Oregon State University. The "ubiquitous, quintessential need" for water, he says, can rip communities apart as well as knit them together.

Turning Corners

That fraught intersection of humanity and nature has drawn Kemper in with the force of a narrow chute in a deep canyon. How he arrived at that spot is itself a story of intersections. From Portland's Jesuit High School, Kemper headed east to Georgetown University where he studied psychology. But always, the "steep creeks and rivers" of the West pulled him back. While fellow students interned in the halls of Congress, he guided raft trips in the wilds of Colorado and California. At loose ends after college, he took a job at a small renewable-energy startup in Washington, D.C.

"That experience reset my life," he says.

Driven by a new sustainability ethos, Kemper determined to make the environment his workplace as well as his playground — to meld his passion for water with his knowledge of human behavior to become a defender of natural resources. About that time, he traveled to Central America to kayak Panama's legendary "jungle rapids." In a little town called Boquete, he witnessed the devastating,

river-altering impact of hydroelectric dams. It came as a sobering jolt. Then one day while "Googling around," he chanced upon Oregon State's programs in Water Resource Engineering and Water Conflict Resolution. His path appeared.

Digging Deeper

We tend to think of "transboundary water conflict" as an international problem, something that happens on the parched

the Institute for Water and Watersheds at OSU. Jarvis was invited to study the problem. The first thing he noticed was that the ditch water ran clear, not muddy. This suggested that the flooding source could be groundwater, not surface water. If that was the case, the ditches were tapping into the city's aquifer, making things wetter not drier.

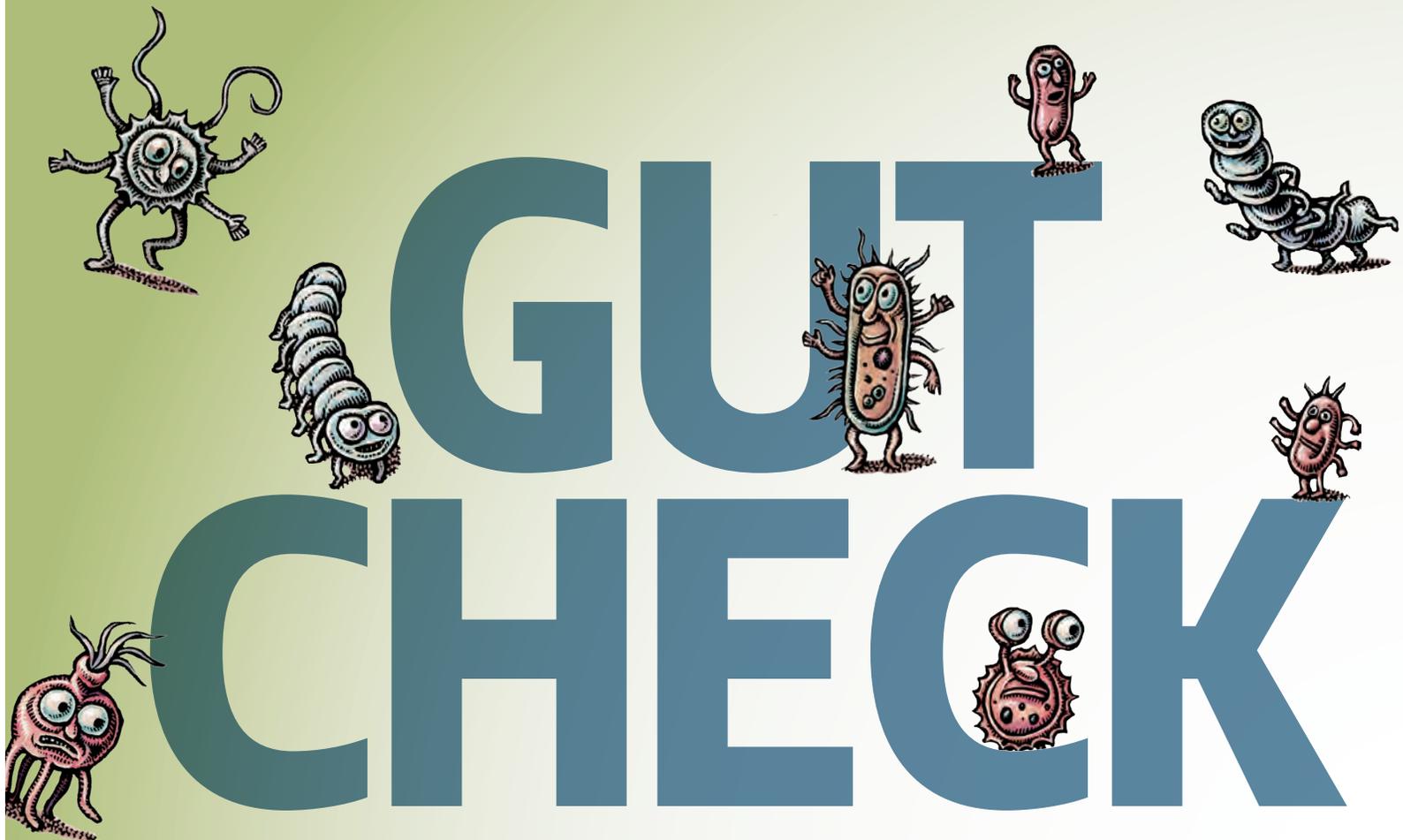
By then, Kemper was looking for a research project for his thesis. Under



landscapes of Africa or the Middle East. But the boundaries that divide people can be much more parochial, notes OSU researcher Todd Jarvis, author of the 2014 book, *Contesting Hidden Waters*. In Falls City on the edge of rural Polk County, for instance, the boundary in question is the one between the historic city (population just over 900) and the timbered county. Across that line, a fight festered for years over seasonal flooding. That's because landowners often dig ditches to divert unwanted water. One person's ditch can create a pond in his neighbor's yard or basement.

By the time a local citizen contacted OSU for help in 2012, "people wouldn't talk to each other," recalls Jarvis, a groundwater hydrologist and director of

Jarvis's mentorship, he set out to study whether the Falls City aquifer "supercharges" (fills the soil's pores to overflowing) during winter's wetness. A test well jointly funded by the city and the U.S. Geological Survey confirmed their hypothesis. But that was just the science — the "straightforward part" of the town's dilemma, according to Kemper. To solve the trickier equation, the frayed relationships among neighbors, Kemper facilitated a series of public forums convened by city residents. Several solutions have emerged to quell the floods and, at the same time, mend the rifts. Meanwhile, Kemper is designing an engineered solution to support the locally generated plans for flood mitigation.



GUT CHECK

Intestinal microbes affect our health

“Microbiome research is poised to transform society: It has captured public imagination, ushered in new industrial opportunities, and potentiated changes in how we manage health and natural resources.”

— *The Oregon State University Microbiome Research Faculty in a June 2015 letter to the Office of Science and Technology Policy*

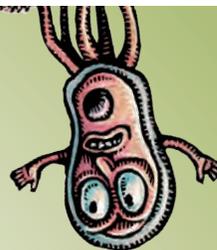
BY NICK HOUTMAN
ILLUSTRATIONS BY LISA HANEY



We’ve all gone through it and wished we hadn’t: growing discomfort, a stomachache and nausea, maybe vomiting and diarrhea. For most of us, symptoms pass in a day or two. We call it “stomach flu” or “food poisoning.” But for Pat (not her real name), the symptoms did not improve, so she went to her doctor. He concluded that she had picked up a parasite during a recent vacation and prescribed an antibiotic. That might have been the end of it. But the 35-year-old woman’s debilitating struggle with intestinal distress and bacterial infections was just starting. Before it was over, she landed in the hospital twice and lost so much weight and became so weak that she had to walk with a cane. Her hair fell out. Her doctor told her he might have to remove part of her colon.

“He said, ‘It’s not so bad,’” Pat recalls. “‘You wear a little bag. Lots of people live with one.’”





In the late 1990s, when Pat was in the throes of her illness, antibiotics and surgery were the major medical options for people with inflammatory bowel disease, colitis, Crohn's disease and related illnesses. Scientists and physicians knew that microorganisms played a role in digestion, the immune system and other bodily functions, but there was little understanding of the diversity and ecology of this community — nor of its complex relationship to human health.

At that time, microbiologists needed to grow an organism in the laboratory in order to study it. “No one in the field thought we were doing comprehensive surveys of microbial diversity by culturing microorganisms,” says Thomas Sharpton, assistant professor in the Oregon State departments of Microbiology and Statistics. “We were doing the best that we could.”

It turns out that most of a body's microbial residents won't grow in a laboratory culture dish. And the idea that organisms could be identified through genome sequencing was still a dream.

Microbe vs. Human

In 1907, Élie Metchnikoff, a Russian microbiologist, proposed that microbes in our gut could exert a powerful influence on health (see “Five Facts About the Microbiome”). But it wasn't until 1972 that

a University of Missouri scientist estimated that, based on analysis of a single gram of feces, microbes in the body outnumber human cells 10 to one. That simple ratio has been passed along in scientific papers, lectures and news media and is now considered crude at best. Still, the point remains: When it comes to our health, we may be as much microbe as we are human.

Pat and thousands of people like her learned this lesson the hard way. What if, rather than using radical surgery or broad-spectrum antibiotics, intestinal health could be restored with simplicity and precision, perhaps by getting a vaccination or by following a strict diet? What if physicians could diagnose and treat illnesses in the gut on the basis of a deep understanding of this dynamic system?

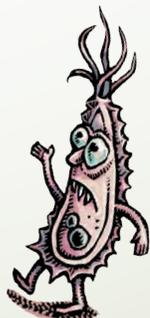
The new picture that is emerging through research is not for the squeamish. Thousands of species of bacteria, viruses and fungi live on and in our bodies. Microorganisms teem in every pore and crevice, from mouth to stomach to intestines to colon — all along the alimentary canal, which, if removed and stretched end to end, would measure about 30 feet. Microbes deploy chemicals in an ongoing competition for resources, and the full picture is just coming into view.

“It's a little like being Dr. Livingstone and walking around in the jungle and saying, ‘What's

that?’ and ‘Oooh, what's that?’” Sharpton says. Researchers are discovering that the biologically active compounds produced by these microbes likely play a role in diabetes, obesity, atherosclerosis (hardening of the arteries), mental function and vulnerability to infections.

In 2001, Joshua Lederberg, a Nobel Prize-winning molecular biologist, proposed a term for these microbial communities: the “microbiome.” The word stuck. The National Institutes of Health launched the Human Microbiome Project. A new nonprofit research organization opened its doors: the American Microbiome Institute. In the grocery store or online, you can buy products — probiotics and prebiotics — that claim to boost your microbiome. You can send stool samples to at least two organizations — American Gut and μ Biome — to have your personal microbiome analyzed.

Through growing collaborations at Oregon State, Sharpton and his colleagues are delving into connections between the microbiome and human health. They are looking for clues in large datasets of microbial DNA and conducting experiments in a lab that maintains — ironically — a colony of germfree mice. Natalia Shulzhenko (College of Veterinary Medicine) and Andriy Morgun (College of Pharmacy) established the facility





Thomas Sharpton,
College of Science

in 2014 to study the role of microbes in disease and what happens when they are buffeted by antibiotics and dietary changes.

At the Sinnhuber Aquatic Research Lab and in the Department of Microbiology, teams of scientists are studying the microbiomes of zebrafish (*Danio rerio*). “What we’re really interested in using zebrafish for is understanding changes in the environment of the host (be it a fish, a mouse or a human) — whether they’re due to exposure to drugs, toxicants or diet. How do they alter the established communication with the host and how do they affect the physiology of the host?” says Sharpton.

of DNA sequences with computers. As he came to understand the potential of this new field, he got hooked.

“I had never done anything like this before,” Sharpton says. “I thought it was the coolest thing in the world. This guy (John Taylor, fungal biologist at Cal) turned me toward this field that I didn’t even know existed.”

At the same time, the emerging technology of rapid DNA sequencing (led in part by OSU scientist Steve Giovannoni) was revealing the presence of a microbial universe in seawater, soils and plants.

During a postdoctoral research fellowship at the Gladstone Institute in San Francisco, Sharpton developed new ways to analyze microbiome data. “We take DNA from an entire consortium of cells that comprises the microbial community and sequence them all simultaneously. What we get is an alphabet soup,” he explains. “We use the computer to determine what DNA came from what organism.”



Natalia Shulzhenko,
College of Veterinary
Medicine

It’s a Microbial World

As an undergraduate at Oregon State, Sharpton studied microbes in sea anemones with OSU zoologist Virginia Weiss. Later, as a Ph.D. student at the University of California, Berkeley, he delved into the field of bioinformatics — the analysis



Andriy Morgun,
College of Pharmacy



More Microbiome Studies at Oregon State

Researchers explore impacts on cognition, disease and immune function

Your Brain on Microbes

Chemicals produced by microbes in our intestines may affect the brain. In a study with laboratory mice, Kathy Magnusson and her colleagues have demonstrated that adaptability, short-term memory and learning for long-term memory are related to the microbiome and what we eat. “This suggests that it’s not just about the food itself, but that the food is having an effect on the bacteria that live in our gut, and that can influence our behavior,” says Magnusson, a professor in the OSU College of Veterinary Medicine and the Linus Pauling Institute.

Infection Conversation

As food moves through the digestive tract, the immune system stands guard against foreign microbes. Interactions between diet and the immune system may also shape our microbiome. Adrian Gombart and his colleagues in the Linus Pauling Institute are investigating this possibility with an emphasis on vitamin D. They have shown that knocking out an antimicrobial gene in immune cells can make animals more susceptible to infection. And they know that vitamin D regulates the same gene. “We’re interested in the cross talk that goes on between diet, the immune system and the microbiome,” says Gombart.



Kathy
Magnusson



Adrian Gombart



Emily Ho



Aleksandra
Sikora



Norman Hord



David Dallas



By combining statistical reasoning with hyper-fast computers, he and his colleagues are gradually putting the microbiome puzzle together. However, their work would not be possible without catalogs of genes that scientists have already assembled through DNA sequencing.

Sharpton explains it with an analogy right out of the machine shop. “Imagine you’ve gone to the junkyard and brought me an array of parts from cars, bicycles and skateboards and dumped them on the floor. If I’m a smart mechanic, I can tell you which pieces go to automobiles, which go to skateboards and bicycles.”

Similarly, scientists are learning which genes are most likely to work together to make a microbe function. They are creating the molecular equivalent of a parts catalog that can be used to map genes that belong together.

And as DNA sequencing labs such as Oregon State’s Center for Genome Research and Biocomputing churn out data by the barrel, Sharpton

and his colleagues sort, categorize and annotate their parts lists into a web of microbial life. They are finding surprises.

“Those that we might think of, *E. coli* for example, are known because they can be cultured in the lab, but in a typical healthy microbiome, they make up less than 0.1 percent of the microbial species present,” says Sharpton. “Thanks to DNA sequencing, we are realizing just how many different types of organisms are out there.”

Three-Way Conversations

As Sharpton was developing his skills, two scientists at the National Institutes of Health were using gene data to explore a three-way chemical conversation between the microbiome, the human immune system and disease-causing organisms. The wife and husband team of Natalia Shulzhenko and Andriy Morgun were investigating the possibility that the balance between health and disease — obesity, diabetes, cancer — could be tipped



Thousands of species of bacteria, viruses and fungi live in what amount to our internal ecosystems – nose to throat to lungs; mouth to stomach to small and large intestines.



The Zinc Connection

Microbes grab zinc as it passes through the digestive tract, but what happens if there isn’t enough of this micronutrient? Emily Ho is leading studies to understand how zinc-deficient diets change the microbiome and may compromise the immune system. “Our central hypothesis is that age-related alterations in gut microbial composition contribute to age-related deficits in cellular zinc levels and enhanced inflammation,” says Ho, a professor in the College of Public Health and Human Sciences and the Linus Pauling Institute. Ho directs the Moore Family Center for Whole Grain Foods, Nutrition and Preventive Health.

Microbes and Diabetes

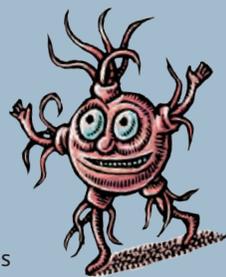
Among the risk factors for Type 2 diabetes (the most common form of diabetes) are family genetics, obesity, heart disease and lack of exercise. Natalia Shulzhenko (College of Veterinary Medicine) is working with Andriy Morgun and Aleksandra Sikora (College of Pharmacy) to understand how the microbiome might affect metabolism and contribute to the disease. Knowing which microorganisms are associated with it could make it possible to identify the microbial genes at work behind the scenes. The researchers’ long-term goal is to prevent Type 2 diabetes before it takes its toll.

Diet Drives the Microbiome

Changing the microorganisms in your gut requires a shift in diet, but scientists are still learning how such changes affect overall health. Norman Hord and his colleagues in the Moore Family Center are studying the influence of whole grains on microbiome composition. Studies with oats, wheat and other grains are underway to investigate impacts on disease processes such as insulin resistance, a factor in Type 2 diabetes. “When it comes to making health claims about how foods may improve health by changing the microbiome, it’s still the Wild West,” says Hord, co-director of the School of Biological and Population Health Sciences.

Too Much of a Good Thing

Humans need proteins to survive. Most of these critical nutrients are digested in the small intestine, but when some escape into the colon, inflammation can follow. When he arrives at Oregon State in December, David Dallas will continue his studies of microbiome response to proteins in infants, the elderly and people with gut inflammation. “My plan is to develop diagnostics to monitor protein digestion in the gut to guide nourishment in these vulnerable populations,” says Dallas, assistant professor in Public Health and Human Sciences.





“It’s a little like being Dr. Livingstone and walking around in the jungle and saying, ‘What’s that?’ and ‘Oooh, what’s that?’”

Thomas Sharpton,
Oregon State University microbiologist

by the ways in which microbial and human cells communicate. Their goal was to understand who was talking, what they were saying, what could go wrong and how it could be corrected.

“We now know that microbial cells and microbial genes are a central part of our (human) organism,” says Shulzhenko. “We need to understand what they do to us.”

Not surprisingly, there are problems in studying a three-way conversation among thousands of microbial species: Who’s talking to whom? What messages are being received? What do they mean? Now at Oregon State, Shulzhenko and Morgun conduct experiments in a lab equipped with facilities that house germ-free mice. Without a microbiome, these animals rely entirely on their innate ability to digest food or develop immunity against infection. By selectively planting specific microbes — or groups

of microbes — into the guts of the mice, the researchers can essentially turn down the volume and listen to parts of the conversation.

In addition, like detectives who have developed a new way to track criminals, they are teasing clues out of large genetic datasets through the use of “transkingdom network analysis.” In short, they consider how human and microbial genes affect each other. “The focus is on networks of genes,” says Morgun. “How do different parts of the system talk to each other?”

The scientists are particularly interested in conversations gone wrong. For example, why are some women who have been infected with the human papilloma virus unable to clear it from their systems? And why do some develop cervical cancer?

They also have turned their attention to Type 2 diabetes (also called adult-onset and obesity-related diabetes): How does the immune system interact with the microbiome



Five Facts About Our Microbiome

to affect our blood-sugar levels? Could the conversation between the microbiome and the host affect metabolism in a way that contributes to diabetes and obesity?

And what about broad-spectrum antibiotics? Do these miracles of 20th century medicine disrupt the microbiome or directly affect an animal's own cells? How do antibiotics pave the way for resistant microbes such as *C. difficile*, one of the scourges of hospital-acquired infection, which can turn a healthy colon into a painful canker sore?

With funding from NIH and the Medical Research Foundation of Oregon, Shulzhenko, Morgun and colleagues are starting to find answers to questions about antibiotics. In collaboration with Martin Schuster's lab at Oregon State, they have found evidence pointing to the effects of antibiotics on whole suites of immune system genes. They have shown that one member of the human microbiome — a microbe known as *P. aeruginosa* — can be

turned into an antibiotic-resistant pathogen that damages the cells of the gut.

Shulzhenko and Morgun continue to work with collaborators at NIH and the University of Sao Paulo in Brazil, where they conducted clinical research before coming to the United States. "We want to identify interactions between the host and the microbiome, to define who are the causal players," says Shulzhenko. "What genes and microbes are responsible? We are one of the few groups using transkingdom networks to do this."

Such knowledge — and the medical treatments that could follow from it — might have helped Pat when she was suffering from bacterial infections and severe colitis 20 years ago. Feeling at the end of her rope and facing the possibility of colon surgery, she talked to friends, visited Internet chat rooms and scoured the shelves of local bookstores.

Pat credits her eventual recovery to a diet, The Specific Carbohydrate Diet, described in a self-help book by Elaine Gottschall, *Breaking the Vicious Cycle*. In the 1950s, the New Jersey mother was struggling with her 4-year-old daughter's debilitating colitis. Gottschall found a New York physician who had developed a dietary approach to the condition. After her daughter got better, Gottschall went back to college, became a scientist specializing in inflammatory bowel disease and wrote her book to share what she had learned about diet and intestinal flora.

Pat didn't have her gut microbes analyzed and doesn't advocate this approach for everyone. Still, based on her own experience, she knows that tending to the microbiome through diet is a key to health. "It saved my life," she says. **terra**



UNKNOWN PROTEINS

As scientists sequence DNA in microbiome samples, they are discovering new building blocks of life. About 30 percent of the genes in genomes sequenced in large-scale studies code for proteins that are new to science.

MICROBES IN HUMANS

Estimates of the number of nonhuman cells in our bodies range from 30 trillion to 400 trillion. The human body contains about 37 trillion human cells.

SECOND BRAIN

The gastrointestinal tract contains so many nerve cells that it is known as the "second brain." Phrases such as "gut feeling," "butterflies in the stomach" and "trust your gut" are thought to reflect the mind-gut connection.

THEORY IGNORED

In 1907, Élie Metchnikoff, a Nobel Prize-winning Russian microbiologist, suggested a connection between longevity and fermented milk. He proposed that lactic acid bacteria "could normalize bowel health and prolong life." Medical researchers ignored his theories for most of the 20th century.

PREBIOTICS VS. PROBIOTICS

Online or in the health-food aisle at the grocery store, you can buy probiotics and prebiotics that claim to support digestive health. Probiotics are living microorganisms that have been shown to exert a beneficial impact. Prebiotics are compounds (such as dietary fiber) that may promote the growth of beneficial microbes.

THE LANGUAGE OF THE SUBLIME

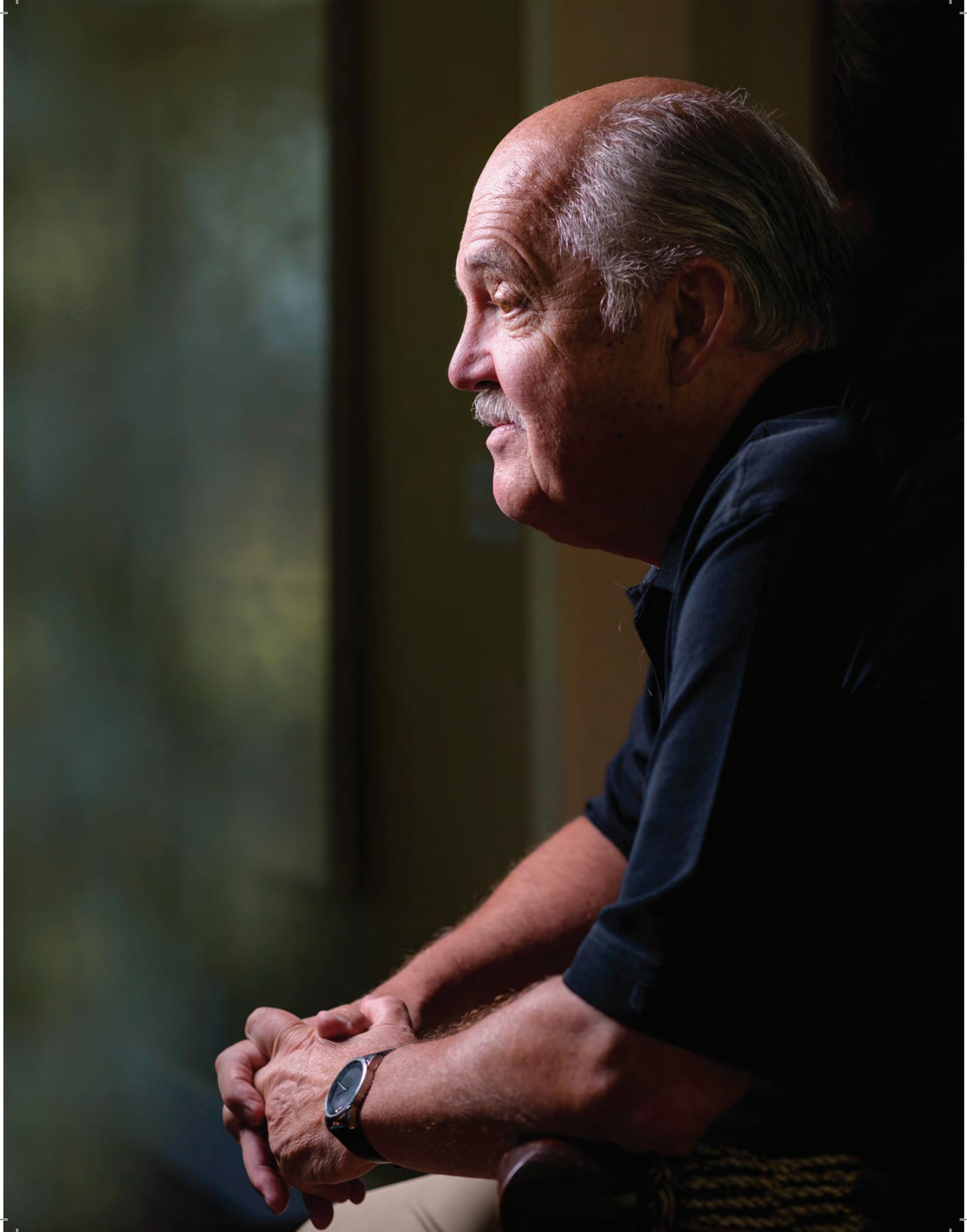
Henry Sayre's written and spoken stories about art have opened countless students' eyes

BY LEE SHERMAN | PHOTOS BY JOE KLINE

One day teenaged Henry Sayre was roaming the Flatirons above the mesas southwest of Boulder, Colorado, when he looked across the valley and saw a thunderstorm forming high on a distant ridge. He watched it sweep down the foothills, a mass of moisture roiling toward the northern edge of town. After it blew through, the far side of the valley was shimmering with hailstones. The other half — the half where Henry's family lived — was clear and dry, untouched. Sayre has held that image in his mind's eye for 50-plus years, the thunderheads casting long shadows across the landscape of his childhood, where he knew "every little trail, every little cave." He can hear the thunder rumbling through the canyons still and feel the electricity prickling the air.

"It was one of the most amazing things I've ever seen," he says.

That's a strong statement from a man whose deepest driving force has been the seeing of amazing things — not only the sublime and luminous wonders of the natural world but also the inspired creations of human hands. On a family trip abroad when Henry was 13, the Sayres toured France in an "old, worn-out station wagon" and, in Paris, "looked at art all day" in museums like the Jeu de Paume and Orangerie, where Monet's water lilies wrapped around him in a visual embrace. Since then, he has traveled to Europe dozens of times, not simply as a tourist, but as a scholar — or, more precisely, as a pilgrim. Over and over, he has visited virtually every great museum in the world (the Louvre and the Musee d'Orsay in Paris, the Museum of Modern Art in New York, the Gallerie dell'Academia in Venice, the Museo Nacional Centro de Arte Reina Sofia in



Madrid, to name a few). He calls them “pilgrimage places.” They pull him in, again and again, to stand before the most acclaimed artworks by the most gifted artists ever to put brush to canvas or chisel to stone (Michelangelo and Manet, Rubens and Rembrandt, David and Ingres, Picasso and Pollack are a mere handful).

Hundreds of these creations of the human spirit he has shared with students, face-to-face in physical classrooms as well as virtual ones, and in the pages of his voluminous written works, which include his bestselling textbook, *A World of Art*. More than a million students



Henry Sayre's personal library includes works about the great French Impressionist Edouard Manet, who is the subject of Sayre's current book research.

have read and studied his art appreciation textbook since it was first released by Prentice-Hall in the 1980s. Now in its eighth edition, it helps students tease out the interwoven threads — social, cultural, historical, political, personal — from which artworks emerge.

Now, after 35 years as a Distinguished Professor of art history at Oregon State University — 13 of them at OSU-Cascades — Sayre has taken on the emeritus mantel. But for him, retirement from the classroom doesn't mean a chaise lounge by the seashore. It means more time to write. Working from his book-stuffed study in the art-filled Bend home he shares with his wife Sandra Brooke, a painter and associate professor at OSU-Cascades, he's already well into his next project, a provocative book about the racial overtones and economic undertones of Manet's masterpiece, *Olympia*, which has him scouring the archives of the Bibliotheque nationale de France for source materials. “It's very exciting!” he says with the zeal of a gourmet about to fork into a plate of coq au vin.

Views from the Summit

The panoramic Colorado landscape — the thunder and lightning, the mountains jutting shardlike to the sky, the palpable wildness — helped form Sayre's aesthetic sensibility. It's not a fluke, for instance, that one of his most-loved paintings is George's *The Tempest*, a 16th-century masterwork that bristles with electricity and earthly mystery; you can practically smell the ozone as you gaze at the white-hot bolt splitting a portentous sky. In a fascinating essay on the influence of landscape

on American art, “The Great Interior Basin: Western Landscape as a Container,” which he produced for a Smithsonian exhibition catalog, he writes: “The symbolic language of the sublime dominates American landscape imagery usually associated with altitude — with peaks, pinnacles, spires, buttes, promontories, and the views from such lofty vantage points. ...Sublime is the word we have created to name the incomprehensible and the unknowable, the very condition of which leaves us, paradoxically, dumb-struck — literally, without words.”

But nature was just one of his muses. The allure of literature matched the magnetism of mountains, woods and rivers in Henry's imagination. His dad, the city attorney, had made him a deal in the fourth grade: For every book Henry finished on the required reading list for Phillips Exeter, a prestigious prep school on the East Coast, he could buy a book of his own choosing. One by one, Henry checked off the titles on the Exeter list (which his “ever-ambitious-for-her-children” mother had found somewhere and thought was a good idea).

It was after reading *The Catcher in the Rye* that Henry — in constant conflict with his parents and intrigued by J.D. Salinger's fictional boarding school, Pencey Prep — proposed a deal of his own: If he could get into famed Exeter, would they let him go?

“They looked at each other and said, ‘Sure,’” he recalls with a wry smile. “They probably thought I wouldn't get in.”

On October 22, 1962, the day of Henry's interview with an Exeter recruiter at the swanky Brown



Palace Hotel in Denver, the Cuban Missile Crisis was reaching a scary crescendo. Waiting in the hotel lobby, Henry and his dad listened to President Kennedy's speech to a worried nation.

Henry got into Exeter, one of the first kids from the then-small town of Boulder, he says, to attend a private boarding school in the East. Like some scene out of *Dead Poets Society* or *The Emperor's Club*, the rebellious Westerner from the Flatirons arrived at the storied New Hampshire campus, suitcase in hand, and donned the required sports jacket and tie along with several hundred other nervous

At a production studio in Bend, Sayre records the e-book version of his bestselling textbook, *A World of Art*, now in its eighth edition.

14-year-olds. The first year was tough. But once he got used to the East Coast jargon and the academic rigor, he was in his element, sitting at oval tables with his teachers and classmates, discussing history, literature, philosophy and art in the Socratic style. It was a heady place for a boy from Boulder. When he graduated, President Eisenhower gave the commencement address. Dwight's grandson David was one of Henry's classmates.

The Left Coast

He loved Exeter. But the East Coast didn't hold him. For college he bounced back west to Stanford, where a storm of another kind was brewing. It was the late '60s. Antiwar activist David Harris, husband of folk singer Joan Baez, was student-body president when Sayre enrolled for his freshman year. It wasn't long before Henry was burning his draft card at the federal building in San Francisco while Baez sang *The Times They Are*

A-*Changin'* live on the front steps. Across the bay at UC Berkeley, he marched in the infamous People's Park protest, which ended in riot and bloodshed. He demonstrated at the Stanford Research Institute — an event that took a quirky twist some 30 years later when Sayre was viewing an exhibit called "Evidence" at the San Francisco Museum of Art.

"I turn a corner, and there's a photograph of the big demonstration at Stanford Research Institute, and there I am," he says. "There's a black Magic Marker circle around my face and a question mark next to it."

It's not surprising then, given his Vietnam-era activism, that another of Sayre's most beloved paintings is *Guernica*, Picasso's antiwar depiction of devastation in Spain during the Spanish Civil War. Sayre draws a straight line, in fact, from early political pieces like *Guernica* to the contemporary works of dissident Chinese artist Ai Weiwei, who challenges his nation's Communist regime by, for example, painting a Coca Cola logo on an ancient Han Dynasty urn, and to today's young artists in New York City whose content is both political and environmental.

"The number of them who are working in ways that are about climate change is extraordinary," Sayre says. He offers an example. A few years after Hurricane Katrina and shortly before Superstorm Sandy, the Museum of Modern Art held an "architects-in-residence" exhibition called "Rising Currents," displaying ecologically sound designs for protecting New York City from climate-driven sea-level rise.

Making conscious connections between art and politics, art and science, art and the environment

is a relatively new direction in the field of art history, according to Sayre. "When I was first taking art history, art was over here (he points to the south wall of his comfortable living room) and life was over there (he points to the opposite wall). Scholars, critics, collectors and curators tried to isolate art from the world. The museum was something of a sacred space where you could go to retreat from the urban reality — and maybe get a good cocktail at the bar. That thinking started to change in the '60s with the Vietnam War and civil rights movements. People realized that art could be, and almost always was, political."

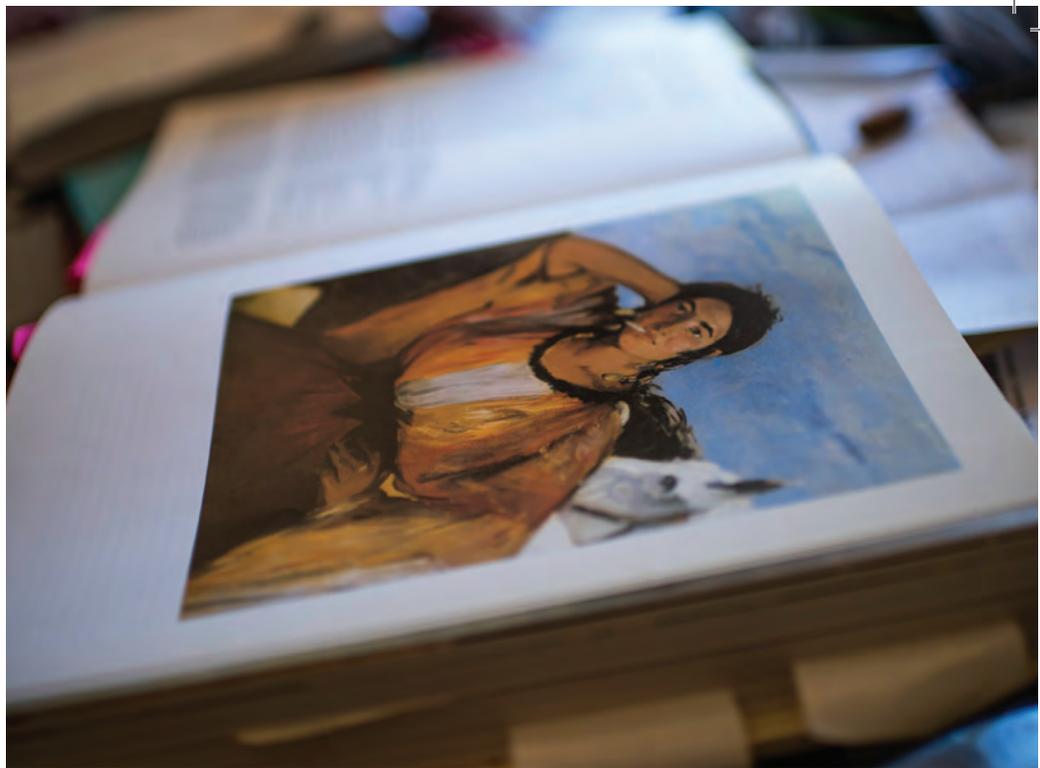
Rites of Passage

Political activism was exciting for Sayre. So was rock 'n' roll (he wrote music criticism for a small arts magazine called *Chaparral*, and once even booked the just-emerging rock bands Jefferson Airplane and the Grateful Dead to play at a freshman dorm party). But these '60s-era rites of passage didn't keep him from his intellectual pursuits. Two classes, in particular, gripped him and led him toward his eventual embrace of the humanities en masse (and later to write another bestselling textbook, *The Humanities: Culture, Continuity, and Change*). One seminal course, "The Epic," explored foundational Western literature. He can still tick off the required readings: *Epic of Gilgamesh*, *The Old Testament*, *The Iliad* and *The Odyssey*, *The Aeneid*, *Paradise Lost*, *The Inferno*, Shakespeare's history plays, *The Faerie Queene*, *Paradise Lost*, *Tristram Shandy*, *War and Peace*, *The Brothers Karamazov*, *The Magic Mountain*. "I was blown away," he says.

The other course, "The Existential Quest in the Continental Novel," was taught by Walter Sokel, an eminent intellectual who had fled his home in Austria before World War II to escape the scourge of anti-Semitism that was infecting Europe. Even though Sokel lectured in a 450-seat auditorium, the course always filled up in a nanosecond. When Sayre finally got his chance in his junior year, he sat transported by Sokel's stories about such Existentialist writers as Kafka, Kierkegaard and Nietzsche, stories whose weft was richly woven into the warp of events and ideas of 19th- and 20th-century Europe (the rise of Marxism, the aftermath of World War I, the psychology of pre-Hitler Berlin).

"To be honest," Sayre reveals with a confessional laugh, "I wanted to be Sokel."

Armed with his English degree, Sayre started casting about for a Ph.D. program. By then he was tilting strongly toward art history. But in those days, academic disciplines were straitjacketed, leaving little-to-no room for overlap. That was doubly true for art history, which Sayre characterizes as "the most conservative of the humanities disciplines." His English degree might as well have come with a deadbolt; it locked him out of art history departments left and right. But he found a portal through which he could slip. At the University of Washington was an English professor named Roger Stein who was working on a book called *Seascape and the American Imagination* (published in 1975). "Rather like myself," Sayre says, "Stein started off in English and transformed himself into an art historian."



Sayre's art collection includes a Madoura ceramic plate by Picasso (top left) and a painting titled Kerouac from Pat Passlof's American writers series (at left). Full-color plates of thousands of other works, such as Manet's *Bohémienne à la Cigarette* (shown above), fill the shelves of his library.

Sayre was admitted to the UW American literature department “to explore landscape artwork as an idea.” By the time he enrolled, however, Stein had moved on. Undeterred, Sayre shifted gears. His dissertation on writer Gertrude Stein, poet William Carlos Williams and the rise of American modernist painting eventually led to his first book, *The Visual Text of William Carlos Williams*. He had dipped his professional toe into art history scholarship.

East Village Chronicles

Serendipity brought Sayre to Oregon State University in 1980. It was the year Mount St. Helens blew volcanic ash all over the Northwest. He had been teaching part-time at the University of Washington and — frequently stopping to change the ash-clogged filter on his Dodge Charger — driving back and forth from Seattle to Corvallis, where his first wife, Laura Rice, was on the English faculty.

When their 2-year-old son was diagnosed with kidney cancer, Sayre quit teaching to care for him. During the little boy's convalescence, Sayre had lots of time to write. One of his pieces, a review of a “gorgeous” exhibit of scientific photographs of coastal estuaries, ran in the *Salem Statesman-Journal's* Sunday

magazine. One of his sources for the article was Mark Sponenburgh, then chair of OSU's art department. Sponenburgh — a sculptor and one of the celebrated World War II “Monuments Men” who recovered priceless artworks stolen by the Nazis — loved Sayre's article. As it happened, the piece's appearance on newsstands coincided with the sudden, untimely resignation of one of Sponenburgh's faculty members. There was no time to conduct a search. Sponenburgh asked if Sayre could fill in. “I could do that,” Sayre responded.

“Filling in” led to a yearlong, \$25,000 fellowship from the National Endowment for the Humanities to study and write about performance art. Hanging out in Greenwich Village, New York City's hotbed of artistic talent and experimentation, seemed like the best place to research his topic. By then, Sayre's little boy was healthy, so the family took a flat in New England and Sayre made the scene in the East Village every other weekend or so. He saw Andy Warhol — the pop icon of the mid-20th century — painting in the studio known as The Factory, where the “Warhol Superstars” (described in Wikipedia as “a ménage of adult film performers, drag queens, socialites, drug addicts, musicians, and free-thinkers”) helped screenprint famous images like the Campbell's Soup cans and portraits of Marilyn and Mao. Sayre soaked it all up that year, and then came back to Oregon State to accept a tenure-track position teaching art history.

Illustrators of History

To Sayre, artists like Warhol, one of the most notable visual chroniclers and cultural critics of the modern era, play a powerful role as illustra-

tors of human history. As he writes in *A World of Art*, “Artists make a visual record of the people, places and events of their time and place.” He spells out other roles, too: helping others see the world in new ways, imbuing functional objects with beauty and meaning, and giving form to “the immaterial” (universal truths, spiritual forces, personal feelings). At the end of each chapter, Sayre poses a series of questions, challenging students to think critically about works such as Warhol's 1963 piece, *Race Riot*, a four-panel representation in red, white and blue of African-American demonstrators beset by attack dogs and fire hoses in Birmingham, Alabama. The book also includes works like *Charles the First*, an homage to the great jazz saxophonist Charlie Parker by black artist Jean-Michel Basquiat, and *The Liberation of Aunt Jemima*, described by Sayre as “an icon of the civil rights movement,” by Bettye Saar.

But not that long ago, broad inclusion was outside the norm. When Sayre first came to OSU, the typical art appreciation book was limited to Western artists, mostly white, mostly male. These glaring gaps were brought home to Sayre in the fall of 1990 when he was teaching Art 101. There was an incident on campus — a white student shouted a racial slur at black student Jeffrey Revels, coordinator of the university's Black Cultural Center, and then almost ran him down with his car — that sparked a campuswide conversation on race. For Sayre, that conversation proved pivotal.

“This black kid in class said, ‘Well, Dr. Sayre, you know, this textbook we're using doesn't have any black artists in it.’ And I said, ‘That's true.

That's true of almost all the books.’ And he said, ‘Besides that, every time you talk about value’ (light and dark) if something is high in value, it's white. If something is low in value, it's black. Do you ever think about that?’

“And I thought, ‘Oh, geez.’”

That's the day Sayre decided to accept Prentice-Hall's offer to publish an art appreciation book if he was willing to write it. The book ultimately spanned all spheres of human diversity, from ethnicity to gender, culture to nationality, featuring artists from around the globe, a daring leap from the norm.

“It broke new ground,” Sayre says.

He broke new ground, too, in the late 1980s and early 1990s when he helped lead the development of OSU's “Bacc Core” curriculum, and again with the production of a multimedia teaching package for art appreciation, funded by a \$1.2 million grant from the Annenberg Foundation at the Corporation for Public Broadcasting. The project included a 10-part TV series, *Works in Progress*, co-produced with Oregon Public Broadcasting. It first aired on PBS in 1997.

East of the Cascades

At the turn of the millennium, Oregon State began looking toward Central Oregon to site a satellite campus. About the same time, Sayre was elected president of the Faculty Senate. He quickly jumped into the front seat to help steer the Central Oregon effort. When he moved to Bend the following year, it was as academic vice-provost of OSU-Cascades.

“We opened the doors on 9/11, 2001,” he recalls. “The first thing I did was gather everybody out in the

circle in front of the administration building to sing *God Bless America*. It was pretty weird.”

Settling in Bend felt like returning to the landscape of his youth. “Bend is Boulder back in the 1960s but without the big university, only the burgeoning one,” he says. “There’s something about the dryness, the altitude, being on the eastern slope of mountains, on the very edge of the wilderness, that is exactly the same. My body is simply happier above 4,000 feet.”

A Narrative Arc

In the end, Sayre says, everything comes down to story. The human story, which he calls the “grand narrative” — the emergence of *Homo sapiens*, the birth of civilization, the sweep of history, the progression of ideas, the power of culture, the hegemony of technology — is the container that holds the context for our own time, our own tale.

“We’ve got all this information exploding around us,” he says. “If it comes to us in isolated flecks, we have no place to store it. But if we’ve got some understanding of the history of thought, then we have cubbyholes we can tuck it into and remember where it goes.”

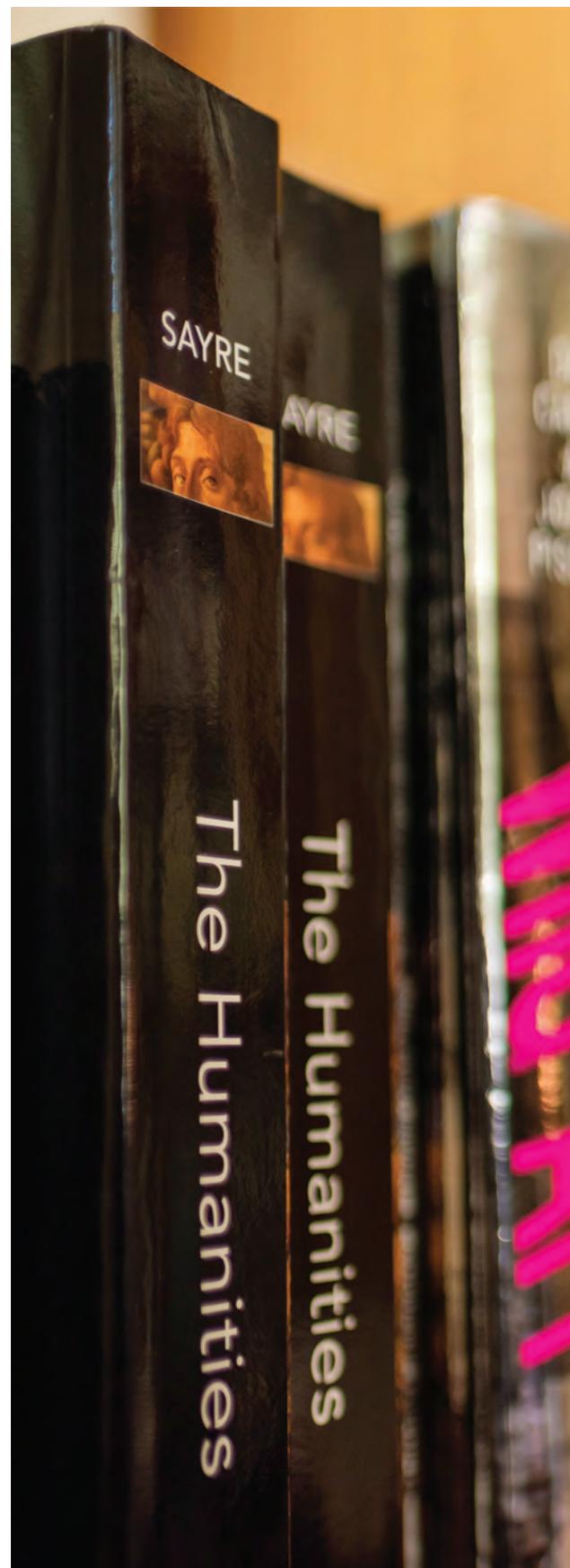
His notion of “grand narrative” plays out in his textbooks. Take Chapter 1 of *A World of Art*, sixth edition, for example. He guides the reader from *The Gates*, Christo and Jeanne-Claude’s massive saffron-fabric art installation in New York’s Central Park in 2003; to the Torii gates of the Fushimi Inari Shrine in Kyoto, dedicated to the Shinto God

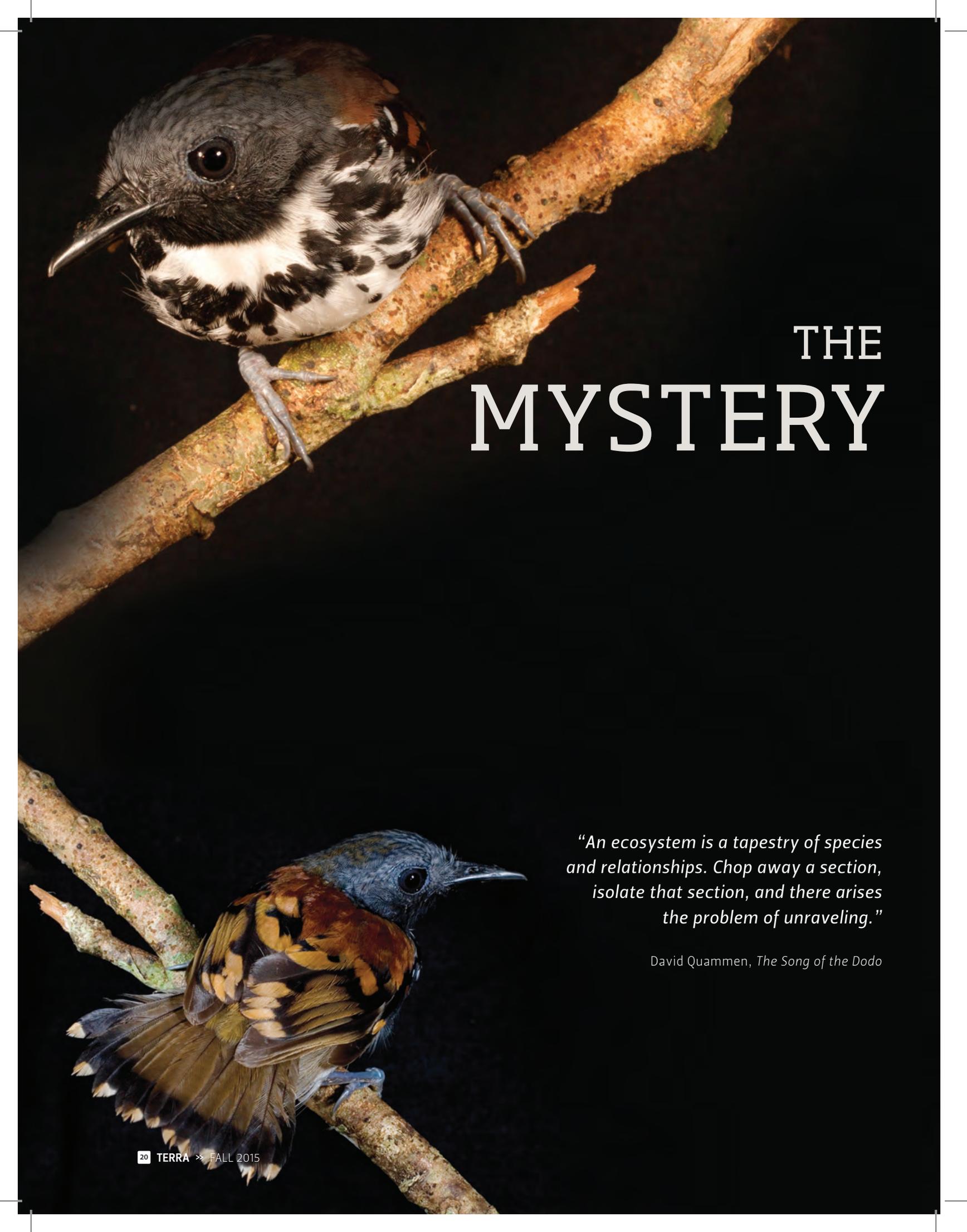
of Rice; to the U.S. refusal to ratify the 1997 Kyoto Protocol aimed at lowering greenhouse gas emissions worldwide. At the same time, he brings in the 9/11 terrorist attacks on the Twin Towers, the original Central Park architects Olmsted and Vaux, and the reactions of critics and residents to the Christo installation. And that’s just in the first three pages.

“Students often think of art appreciation as something like a maraschino cherry on top of their education sundae, kind of pretty, maybe poisonous — at least when it was red dye No. 2 — but pretty much useless,” Sayre says. “But it’s just the opposite. That’s the reason we emphasize critical thinking so much. I mean, it’s no accident that the detectives in New York City go to the Morgan Museum and look at art as part of their forensics training. They’re asked to notice things — ‘What did you see in the painting?’ They learn to put two and two together, to notice detail, to understand that even the smallest things matter.” **terra**

AUTHOR’S NOTE: For additional details about Henry Sayre’s life and career, read an in-depth Q&A by Janice Dilg, whose reporting contributed to this piece, and visit the Oregon State University Sesquicentennial Oral History Project at <http://scarc.library.oregonstate.edu/oh150/sayre/index.html>.

As an undergraduate at Stanford, Sayre fell in love with the humanities, a lifelong passion that later led him to pen the hugely popular textbook on the subject.



A photograph of two birds perched on branches against a black background. The bird at the top is a small, dark bird with a white breast and a long, thin beak. The bird at the bottom is a larger bird with a blue head, a long beak, and brown and black patterned wings. The title 'THE MYSTERY' is written in large, white, serif capital letters on the right side of the image.

THE MYSTERY

“An ecosystem is a tapestry of species and relationships. Chop away a section, isolate that section, and there arises the problem of unraveling.”

David Quammen, *The Song of the Dodo*

OF THE DISAPPEARING BIRDS

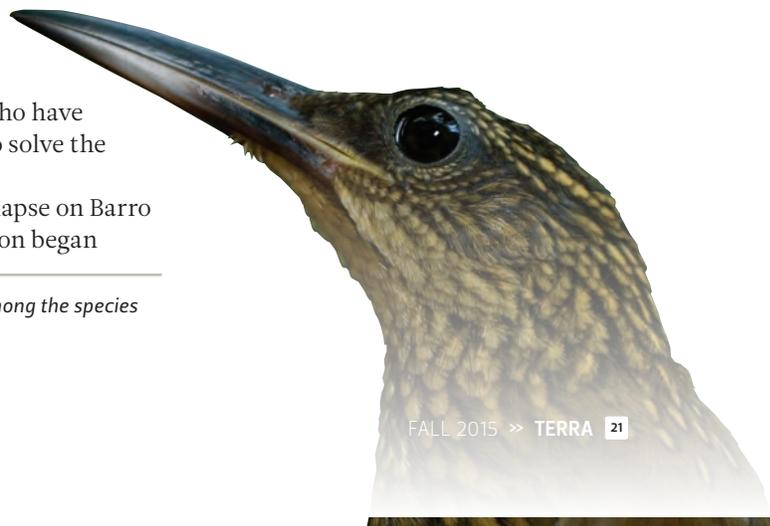
How a mountaintop became an island and what it teaches us about biogeography and fragmentation

BY LEE SHERMAN | PHOTOS BY CHRISTIAN ZIEGLER

The mystery of the disappearing birds of Panama's Barro Colorado Island holds all the elements of a detective story. The "victims" are 45 avian species, once common, now gone. The prime suspects are monkeys, coatis and other mid-sized furry omnivores whose numbers boomed after the big cats and raptors vanished from the island (another piece of the mystery). Possible accomplices include cramped habitat, shrinking gene pools, geographic isolation, climatic changes and unforeseen predators. The investigators are Oregon State University wildlife ecologist Douglas Robinson and Ph.D. student Randall Moore, who have painstakingly collected and analyzed a wide array of evidence to solve the scientific whodunit.

To sleuth out reasons for the rapid and widespread species collapse on Barro Colorado (meaning "red clay" for its russet-colored soil), Robinson began

The spotted antbird (left-hand page) and the cocoa woodcreeper (at right) are among the species that have so far survived on Barro Colorado Island.





(Above) Every year, hundreds of scientists travel to Barro Colorado Island in the Panama Canal to study the fragile, fast-evolving ecosystem. (Below) Avian ecologist Doug Robinson has studied birds on the island for two decades.

making research trips to the island in 1994. Just two years earlier, he couldn't have imagined his long-term presence there. A brief island stopover with some other scientists



had left a bad impression. "I hated it," he says, sitting in his office in the OSU Department of Fisheries and Wildlife. "Being in the lowland tropics means you're

hot and sweaty continuously. The trails were steep and slippery; I fell down multiple times. And there were no birds there, it seemed. It was, like, dead. I didn't really have an interest in Barro Colorado then because it was so depauperate for birds. It just

seemed like a really boring place."

But that boringness, that emptiness where birds should be bountiful, soon struck him as an intriguing research question: Where were the birds, anyway? What was driving their demise? He dug into the literature. The prevailing idea was the 1980 Terborgh-Winter hypothesis, suggesting that the island's medium-sized mammals (coatis, howler monkeys, possums, armadillos and sloths, among them) were flourishing after the last pumas and jaguars faded away (big predators need big territories and 3,700 acres wasn't big enough). This so-called "mesopredator release" means that midsized mammals whose populations once were held in check by bigger carnivores, are feasting on eggs and nestlings in ever-larger numbers. This imbalance in turn spells doom for such species

as the great curassow, the marbled wood-quail, the rufous-vented ground cuckoo and the black-faced antthrush, all of them now extinct on Barro Colorado.

The ecological puzzle, however, turns out to have far more intricacies than a single hypothesis can explain. After two decades of collecting and analyzing all sorts of data from population surveys, catch-and-release experiments and time-lapse videotapes, Robinson and his team have turned up some compelling clues that point in unexpected directions.

Flooding a Forest

Barro Colorado didn't start out as an island. Once upon a time it was a mountaintop, rising from the trackless rainforest that carpeted the Isthmus of Panama. Its deep-green slopes hosted pumas and jaguars and more than 200 species of birds — long-tailed birds with comical yellow pantaloons; green-crested birds with blue and purple feathers

shimmering with iridescence; diminutive birds with gigantic eyes adapted for foraging in the sunless forest (what Moore calls the under-story's "eternal twilight"). But commerce demanded a shortcut for shipping between the Pacific and the Atlantic. So nearly a century ago, the Panama Canal was dug, the Chagres River was dammed, and Gatun Lake rose up to flood the watershed's lush valleys. The former hilltop became the largest island in an archipelago of remnant peaks dotting the blue waters, plied day and night by container ships and oil tankers.

Two things happened very quickly on the newborn island. One, species began to go extinct. And two, scientists began flocking there to study tropical flora and fauna. Today, 900 scientists a year conduct studies at the Smithsonian Tropical Research Institute headquartered on Barro Colorado Island. As science writer David Quammen notes in his celebrated 1996 book, *The Song of the Dodo: Island Biogeography in an Age of Extinctions*: "For most of its insular history, biologists have been on it like flies on a picnic buffet. It has been one of the most closely scrutinized patches of landscape in the American tropics."

Island biogeography, sometimes called "insular biogeography," is the study of biodiversity within patches or fragments of land isolated from larger landmasses and habitats. First put forth in the 1960s by eminent Princeton biologists Robert MacArthur and Edward O. Wilson, the theory of island biogeography provides researchers with a model for studying the ways in which island (or patch) size and distance from the mainland can predict the colonization and extinction of organisms — and, ultimately, the biodiversity and species richness of the place.

Because islands and fragments are self-contained, they make perfect study sites for biologists and ecologists like OSU's Robinson and Moore. It's like putting a microscope on evolution and watching it in real time. As Quammen explains, "Islands are natural laboratories of extravagant evolutionary experimentation ... because their limited area and their inherent isolation combine to make patterns of evolution stand out starkly." An island gives "clarity" to evolution, he says, because it's a simplified ecosystem, "almost a caricature of nature's full complexity."

Sunken Stumps

When the caretaker at the Barro Colorado field station first saw OSU's Panamanian research vessel, he chuckled and said, "*Parece que la cascara de aguacate*" ("It looks like the husk of an avocado") — in other words, small, thin-walled, as insubstantial as the peel of a tropical fruit. The tiny fiberglass skiff, thereafter dubbed *La Cascara de Aguacate*, has survived some near-disasters. One day when Moore was at the helm, the boat suddenly plunged into a 3-foot "canyon of water" generated by the "brutal" wake of a passing tugboat. Swamped, the little vessel started to sink. Moore jumped into the lake and grabbed the bow to counterbalance the motor. Then he "frog-kicked" to shore dragging the boat with him. Not until that evening in the dining hall did he learn that Gloria, the island's resident 12-foot crocodile, was jealously guarding her nest just a few yards down the shore from where he was swimming.

Another time, Moore had motored to one of the smaller islands to survey

Randy Moore, a researcher at Oregon State University, steers his team's research skiff, nicknamed La Cascara de Aguacate.





To test different species' ability or willingness to fly across water, the researchers designed a release box and documented each bird's success or failure to reach the shore unaided. This black-crowned antshrike makes a clean getaway.

birds. As he tied up, a troupe of white-faced capuchins rained out of the trees onto the boat. The monkeys were former pets that had been rescued and released on the island. “This is trouble,” Moore thought as the animals scampered around his fragile vessel, chittering excitedly. So he changed his plans. He motored to a nearby islet, tightly secured the boat and equipment against monkey marauders, and returned the next day. After surveying birds inland for several hours, he returned to shore to find that “one of the little rascals” (he didn’t actually use the word “rascals”) had pulled out the boat’s stopcock valve (the drain plug that keeps water from filling the hull). The boat was all but sunk. Moore managed to save it with some furious bailing, stuffing one of his socks into the drain hole for the six-mile chug back to Barro Colorado. Mourning his shredded dry bag and stolen sunglasses, he cast one last glance ashore to see a monkey in a tree chewing on Moore’s red bandana while looking at him with maddening indifference.

Crocs, tugs and monkeys are only some of the hazards the researchers face in the Gatun Lake archipelago. Another one is stumps. Thousands of old-growth trees, the remnants of towering tropical hardwoods now submerged in Lake Gatun, poke up just under the water’s surface. “There’s a tremendous minefield of tree trunks out there,” says Moore.

Besides transporting the researchers among islands, the fiberglass skiff has served as a launch pad for flight experiments. Robinson and Moore wanted to test the idea that certain tropical, understory birds can’t (or won’t) fly across water. So they strung up finely woven nets, called “mist nets,” in the undergrowth to

capture low-flying species on the wing. The captives (10 species in all) ranged from probable good fliers to suspected poor fliers.

One at a time, each bird was placed into a carefully designed, shaded box secured in the bow of the boat. Then, at varying distances from shore, the researcher would open the box and watch what happened. Some birds, like the red-capped manakin and the stripe-throated hermit, flew to land, no problem. Others, such as the spotted antbird, made a short aborted flight and plopped into the water, where they were quickly rescued. A few birds even refused to leave the boat, hunkering down in the relative safety of the box.

The experiment showed that “the ability to fly even short distances between habitat fragments varies dramatically and consistently among species of forest birds,” Moore and Robinson write in the journal *Ecology Letters*. “This variation correlates strongly with species’ extinction histories and current distributions across the archipelago.” In other words, the birds that can’t or won’t fly from the island to the mainland are the same birds that are failing to thrive on their water-bound patch of land.

Caught on Camera

The grainy black-and-white videos, fuzzy as they are, tell an unambiguous and universal story: Ground-nesting birds lose many eggs and nestlings to predators. But Robinson’s research has revealed a surprising twist on the nest raiders of Barro Colorado: They aren’t necessarily the hairy, clawed species the scientists had expected. Instead, the most common culprits in one recent study had scaly skins and forked tongues.

A series of time-lapse videos, captured by cameras hidden in the jungle foliage, show shadowy figures nabbing eggs and chicks from the birds' carefully camouflaged nests. On their initial viewing of Tape No. 1, Robinson and Moore watched as the skinny arms of a white-faced capuchin reach into the video frame and, with dainty hands, pilfer a pair of pinkish, speckled eggs from a Chestnut-backed antbird's bowl-like nest. In Tape No. 2, it's a white-nosed coati (something like a small raccoon) that steals the clutch of eggs. These first two tapes lent credence to the widely held hypothesis that small to medium-sized mammals were the major culprits in the island's crashing bird populations.

But then came the surprise. The third video revealed a nest robber that wasn't a mammal at all. It was a snake. The next video, too, showed a snake. So did the next. Eight of the 10 videos, in fact, documented predation by colubrids or "bird-eating" snakes rather than mammals.

"We were the first ones to figure out that snakes were really important predators on the island," says



Moore prepares to gently extract a spotted antbird from a "mist net" strung across the forest floor to capture low-flying species.

Robinson. "Since then, a couple of other studies have shown exactly the same thing — 80 percent predation by snakes in Central America. Based on our video work, we didn't find any evidence that supported the classical view of mesopredator release."

Designing Deforestation

More evidence is needed to close the case of Barro Colorado's disappearing birds. But the investigations of Robinson and Moore (who has finished his Ph.D. and now teaches at OSU), lend further support to worldwide conservation efforts aimed at

reconnecting fragmented forests by creating wildlife corridors — or, better yet, avoiding fragmentation in the first place.

"Our work is one piece in a whole body of evidence showing that many organisms — even birds, considered the iconic organisms for mobility — often won't cross even absurdly small gaps, like a few meters of water or narrow roads and trails," says Moore. "It's yet another rock in the massive and growing mountain of evidence that we need to maintain connectivity of fragmented patches of tropical forests." **terra**

CEREBRAL SONGS

Doug Robinson never forgets a warble, chirp or twitter

Douglas Robinson's brain is wired for bird sound. He discovered his uncanny talent — a seemingly genetic ability to recognize and remember hundreds of songs and notes — growing up in the Ozarks of southern Illinois, where he made his first ornithological field notes at age 10. This gift lets him survey and study even the most elusive avian species in the world. Before heading to Barro Colorado Island, he spent six months tramping through the jungles of central Panama to learn the sounds of the local species. Finding birds solely by sight, he says, is all but impossible in the tangled foliage of tropical rainforests. Once he hears a song, he never forgets it. As his Ph.D. student Randy Moore explains: "Doug has some kind of filing system in his brain that lets him readily access bird vocalizations even when he hasn't heard them in years. They're always right at his cerebral fingertips."



As a kid in southern Illinois, Doug Robinson made careful notes and detailed drawings to document his field observations in the Ozarks.



Installed to protect public health, wells provide 97 percent of the potable water in Bangladesh. Other health problems arose when it was discovered that groundwater in many parts of the country is naturally contaminated with arsenic. (Photo: Molly Kile)

A POISON IN SMALL DOSES

Public health scientists investigate arsenic

BY NICK HOUTMAN

In 1971, a country where rural people ride rickshaws to work and where millions live just above sea level jumped into global consciousness with help from a group of musicians. The Concert for Bangladesh featured the likes of George Harrison, Ravi Shankar, Bob Dylan and Ringo Starr and raised \$12 million for the South Asian country beset by war, natural disaster and disease. But in the wake of the aid that poured into the densely populated and impoverished nation, a massive tragedy unfolded. The World Health Organization (WHO) called it the “the largest case of mass poisoning in the world.”

Public health officials discovered that thousands of wells installed to provide safe drinking water were contaminated with arsenic from groundwater aquifers. “If you put a hand pump in an area where you’ve said the water is unsafe and tell people it’s now safe, people will go there. You’ve just created infrastructure,” says Molly Kile, an environmental epidemiologist at Oregon State University.

“We know that arsenic levels in the hundreds of parts per billion are bad. No one argues about that,” says Kile, an assistant professor in the College of Public Health and Human Sciences. “But what about 5 or 15 or 20 parts per billion? Understanding the health consequences of low-dose exposure is an emphasis of our work.”

Arsenic is a well-known poison with a colorful history. The Medicis of Renaissance Florence were famous for feeding it to their enemies. In the 1800s, it was used in medicine, agricultural chemicals and rat poison. Dr. Campbell’s Safe Arsenic Complexion Wafers promised smooth, velvety skin “to all women who desire beauty.” Paris green, a lustrous pigment containing arsenic, was used in paint, wallpaper, clothing and even children’s toys.

In drinking water, it takes very little arsenic to cause trouble. Concentrations of hundreds of parts per billion (an amount equivalent to a few minutes in 32 years) can lead to skin lesions and bladder and skin cancer.

Since 2002, Kile and her partners — students and physicians at the Dhaka Community Hospital and the Harvard T.H. Chan School of Public Health — have turned Bangladesh into a laboratory for arsenic toxicology. With the help of people in rural communities, what they are learning could do more than address a crisis in South Asia. A 2007 study estimated that about 137 million people worldwide are exposed to water that exceeds the WHO’s arsenic limit of 10 parts per billion.

Arsenic-containing minerals are common in the bedrock of North America. In Oregon, testing by the Oregon Health Authority and county health departments has found well water with arsenic concentrations over that standard in communities such as Tualatin, Sweet Home and Ontario.



Molly Kile

(Above) In her research, Molly Kile collects blood samples. Here, she tests for lead, another metal with a big public health impact. "Lead exposure in these rural populations is very high," she says. (Right) One of Kile's colleagues, Aminal Islam, holds the 1-month old baby of a woman who participated in a reproductive health study. Islam and his team member work for the Dhaka Community Hospital. (Far right) The task of carrying water falls largely to women in Bangladesh. "We need to educate women on safe water because they are the ones who actually select the water source and provide the water to the family," says Kile. (Photos courtesy of Molly Kile)



Out of Place

Kile began her research as a doctoral student at Harvard looking at dietary sources of arsenic and biomarkers of exposure and disease in rural Bangladesh. "I was visiting places that had never seen Westerners," she says. "Here I was, an unmarried woman traveling without a husband or father, asking personal questions. And I'm 6 feet tall. I'm big. When I walk through a village, people notice," she laughs. "I can empty a school in seconds when the kids crowd around to look at me.

"And yet," she adds, "they are the warmest, most hospitable, welcoming people. In the beginning, the whole situation was totally foreign to my Western eyes. But I loved it and wanted to understand their point of view."

Kile had important allies. Through her Ph.D. adviser David Christiani at Harvard and Quazi Quamruzzaman, the visionary founder of the Dhaka Community Hospital, she was paired with Bangladeshi partners who have become steadfast colleagues in her research. During her annual trips, she lived with a family with whom Kile had a personal connection through art: Her grandmother and the family's father were both artists.

Community members who valued health care and understood the importance of reducing arsenic exposure helped Kile and her research partners recruit subjects. "We were welcomed everywhere we went," she explains. "We were never chased out of town or harassed. There's always been a lot of respect," which she attributes to the Dhaka Community Hospital's approach

"The largest case of mass poisoning in the world ..."

- The World Health Organization (WHO)

to community partnerships. "We couldn't do what we do without them," she adds.

In rural villages, Kile and her team collect tissue samples (toenails, hair and urine are reliable indicators of arsenic concentrations in the body). They monitor people with arsenic-induced skin lesions, interview pregnant women and track the health of children.

Arsenic and Disease

What they are finding is generating a new view of the venerable poison. For example, in the journal



Environmental Health, they reported that higher arsenic concentrations in women were associated with more frequent vomiting, diarrhea and abdominal cramping during pregnancy.

The researchers are investigating the possibility that arsenic may compromise the immune system in utero, leading to a lifetime of increased risk for infectious disease. They are also studying whether arsenic exposure may also make vaccinations less effective.

In a separate study using data collected by the Centers for Disease Control and Prevention in the United States, Kile and Ellen Smit, an Oregon State colleague, have already shown that higher levels of arsenic in urine correlate with a reduction in antibodies to the varicella virus. Varicella causes chickenpox in

children and shingles in adults. “We interpret that as increasing risk for shingles. While we don’t know how it actually causes infection, we do know that arsenic modulates the immune system,” says Kile.

In Bangladesh, Kile and her team, including Oregon State Ph.D. student Andres Cardenas, are collecting data on the health of children to look for relationships between arsenic and the frequency of illnesses from colds to diarrhea. “Our hypothesis,” says Kile, “is that respiratory and other illnesses in the first five years of life are correlated with the mom’s arsenic exposure. We are focusing on this early exposure period because the immune system begins to be programmed in utero, and this might be a particularly vulnerable time.”

If that turns out to be true, public health policies may need to be

revised. “We need to be removing the exposure from mom’s world as adults, which means creating policies and interventions that protect women of reproductive age from harmful exposures,” she says. “But that does not have the same policy traction. Somehow we’re bad at that. We put efforts into protecting babies, but what if the toxic exposure has already happened (prenatally)? This puts more emphasis on protecting the entire population, looking at drinking water, dietary exposure and other types of pollution.”

Despite these gains in knowledge, the origins of the crisis in Bangladesh haunt Kile and her colleagues. “This was totally preventable,” she says. “People just didn’t look at the whole picture when these wells were being installed. We can’t let this happen again.” **terra**



SWALLOWING THE GUILT PILL

Tim Jensen explains how consumers are led to internalize environmental degradation

BY LEE SHERMAN | PHOTO BY FRANK MILLER





“Rhetoric is the study of how we use language and how language uses us.”

—Krista Ratcliffe, Marquette University

It was Earth Day 1971. Across America, millions of TV viewers were settled on their sofas, bathed in the blue light of *Columbo* and *Ironside* and *The Mary Tyler Moore Show*. At the commercial break, between ads for Dial soap, True cigarettes and Ragu spaghetti sauce, they watched as an actor in buckskins and braids paddled a canoe through a landscape blighted by industrial pollution and trash. Just as the actor beached the canoe, a bag of half-eaten fast food, hurled from a passing car, splatted at his feet. A tear trickled from his eye while a voiceover admonished: “People start pollution. People can stop it.”

As they watched, John and Jane Doe shifted uncomfortably on their sofa. The implied accusation in the ad, sponsored by the public-private consortium Keep America Beautiful, clearly was directed at them.

Fast forward four decades. In the spring of 2010, Americans sat riveted in horror as the Deepwater Horizon oil spill unfolded on their TVs. One evening, even as thousands of barrels of sticky brown crude gushed from the seafloor into the Gulf of Mexico, Captain Ed Stanton of the U.S. Coast Guard looked grimly into a bank of network cameras. “If you drive a car, you own part of this spill,” he told the viewing public. Blame for the tar-spoiled beaches, the idled shrimp boats and the oiled pelicans was being laid at the feet of harried parents who haul their kids to music lessons in minivans and weary workers who commute to offices and factories in hatchbacks and pickups. Stanton’s remark echoes the so-called “Crying Indian” strategy, now a ubiquitous means of steering public emotion on issues of environmental degradation, according to Tim Jensen, an assistant professor at Oregon State University.

In exploring the rhetorics of social movements, including environmentalism, local foods and Occupy Wall Street, for an upcoming book, Jensen has delved into the

societal impact of the Crying Indian. Critically acclaimed by Madison Avenue as one of the best ads ever made, the Crying Indian was one in a series of public service announcements sponsored by Keep America Beautiful, a nonprofit consortium founded by beverage behemoths Anheuser-Busch, PepsiCo and Coca-Cola, and tobacco giant Philip Morris along with private philanthropists and government agencies. Messages developed by the ad agency, like “Every Litter Bit Hurts” and “Don’t Be a Litterbug,” which started airing in the early ’50s, chided American consumers to take personal responsibility for pollution. The Crying Indian amped up the stakes — from encouraging a sense of civic duty to instilling a sense of self-reproach.

It was no coincidence, Jensen says, that Keep America Beautiful was organized in 1953, the same year Vermont first sought to legislate point-of-purchase deposits on aluminum cans (advertised then as “throw-aways”), which were blighting roadsides and waterways across the nation. To head off the growing anti-disposables mood and any laws that might threaten revenue, the big beverage companies contrived the Crying Indian to refocus the public’s attention on litter (and their own complicity as consumers) instead of on the companies that make, fill and sell the bottles. “The single tear at the end of that influential commercial orients us toward guilt and away from indignation,” Jensen says.

“Our emotions are being targeted by corporate interests to internalize the wrongs that have been done to the environment,” he explains. “At the end of a long production chain, consumers are left holding the plastic bottle, so to speak. We’re made to feel that we’re primarily responsible instead of the companies that manufacture and sell those bottles.”

Paralysis Through Purity

It was a “bunch of crusty punks” in Colorado who gave Tim Jensen his first front-row seat into social movements, which he sees as “substantial shifts in collective discourse and emotional orientation.” The green anarchists and ecowarriors he hung out with in Denver’s bike-courier subculture after earning his undergraduate degree in English provided an insider’s view on the dynamics of such movements as Occupy Wall Street and Deep Green Resistance.

The son of a judge, Jensen had grown up “thoroughly middle-class” in a cloistered suburb of postindustrial Toledo, Ohio, a rustbelt town that to him “feels like it’s been taking its last gasp for a long time, yet fights on.” But Jensen never claimed privilege as a birthright. A fierce climber of rocks, paddler of rivers and trekker of trails, he found himself chafing inside the “tiny bubble” of his upbringing. So after college, he headed west with “a sleeping bag and a tub of peanut butter” to round out his education in a grittier setting. He became a bike messenger.

One day when Jensen was at a “peak oil” demonstration, he overheard an anarchist he knew talking to a young woman activist. The anarchist was incensed when he realized the woman had arrived by car. “You drove here?” he asked in a withering tone.

“She looked like she was folding in on herself,” Jensen recalls. “She completely deflated.”

This kind of guilt-driven deflation has helped fuel a phenomenon Jensen calls “paralysis through purity,” and it illustrates how, he argues, guilt is frequently leveraged by both corporate entities and activists alike. Contending that a “virulent strain” of the zero-impact ethos infects environmentalism today, he deplores peer pressure that demands “moral purity” among activists. As he points out, zero-impact implies that any human impact — eating food, drinking water, heating or cooling houses or apartments, wearing clothes — is inherently bad. The logical extension is that human existence itself is bad. Jensen rejects this conclusion along with the rigid attitudes that drive it. “It’s a potent reminder of guilt’s tremendous persuasive power, the fact that it has many shades and functions in complex ways.”

Fridge Buzz

Just as guilt can erode an individual’s will to join the fight (“I’m unworthy to take a stand because I’m complicit in harming the planet”), it also can undermine the potential for activism among entire communities and societies. Individual guilt stems from a person’s own actions (like driving a car instead of riding a bike), while collective guilt stems from being part of a group whose actions as a whole can be seen as blameworthy. So even when a person’s own lifestyle is super-green, he may feel guilt for being part of an extractive society.

“Unlike intense feelings of direct guilt,” Jensen says, “collective guilt often exists at low, steady levels in the background of everyday actions, frequently escaping the focus of our emotional lens. Like a kitchen ‘fridge buzz,’ it fades from notice precisely because it is constant.” This white noise of collective guilt can become another “paralyzing force,” he says, enervating social movements before they can even take their first wobbly steps by directing anger inward instead of outward. Jensen sees this collective guilt emerging from our “common sensorium” — that is, the emotional equivalent of common sense.

“The notion of a common sensorium provokes us to consider the historical conditioning that shapes the experience of a particular emotion,” Jensen explains. “How has our contemporary understanding of guilt and its relation to personal action been shaped culturally and historically — say, by the tenets of classical liberalism or fascinations with rugged individualism? How long has my environmentally related guilt for driving an SUV been in the making?”

Our “collective guilt” often redirects our anger and distress, turning it back on ourselves and away from big polluters and powerful policymakers, according to Jensen. Too often we substitute small-scale acts of atonement-via-consumerism for large-scale political action.

Take the ubiquitous “eco-friendly” label, for example. The eco-friendly slogan, with its “rhetoric of guilt and atonement,” has infiltrated the environmental movement by giving consumers a “safety valve” for releasing anger and easing guilt, Jensen says. By stamping consumer items — everything from drain cleaners to paper towels to pesticides — with the slogan



“Unlike intense feelings of direct guilt, collective guilt often exists at low, steady levels in the background of everyday actions, frequently escaping the focus of our emotional lens.”

“eco-friendly,” manufacturers have given consumers a handy outlet for their guilty feelings, what Jensen calls “a ready-made guilt-redemption cycle.” You buy compact fluorescent light bulbs, unbleached TP and cage-free eggs to make amends for your impact on the Earth. You feel better about yourself and the planet. The trouble is, eco-friendliness won’t stave off the worst effects of climate change unless accompanied by meaningful political action and corporate accountability.

“By no means am I saying that recycling or living simply aren’t important — they are,” Jensen says. “It’s just that they don’t have the scale of impact that we tend to assign to them.”

Wearing the green-tinted glasses of eco-friendliness encourages one to see the marketplace as the only driver of change, rather than political action, and deflects blame for pollution toward individual consumers and away from the producers of harmful products.

“The rhetorical strategy of coupling collective guilt with the offer of immediate, individualized atonement through consumerism is uniquely effective,” says Jensen. “Positioning individual consumer acts as the solution for ecological ills, however, attenuates desire to join collectives of resistance that strive for significant, structural changes to an unsustainable way of life.”

Decode and Encode

After a few years zooming around the streets with Denver’s punks and Peter Pans, Jensen took his fresh-off-the-streets insights to his studies of rhetorical theory, including the classics of Aristotle, Cicero and Quintilian, when he began work on his Ph.D. at Ohio State. “The rhetorical arts are a thousand years older than Christ —

it’s a durable discipline for good reason,” notes Jensen, a founder and editor of the interactive digital magazine *Harlot: A Revealing Look at the Arts of Persuasion*. “An education in civics and democracy is inherently bound up with an education in rhetoric — one’s ability to decode and encode communication.”

At Oregon State, where he directs the university’s first-year composition program, Jensen challenges his students to think critically and rhetorically about the language that surrounds them, to analyze the emotional impact of rhetorical choices, and to situate their observations within a larger cultural conversation. “I want students to be deeply curious about the persuasion in and about their everyday environment,” he says. “I want students to ask and pursue tough questions about how language has a profound impact on our beliefs and behavior. I want them to consider how a phrase like ‘habitat loss,’ for example, subtly steers attention away from issues of human agency.”

Jensen contends that being emotionally aware is one critical component of being rhetorically aware. “The ways in which we experience and express emotion have been significantly shaped by social forces,” he explains. “Becoming interested in and attuned to how our feelings are calibrated by culture is not just an academic exercise, but at times a necessary act for effective activism.”

At a time when extinction rates are soaring, yet oil companies view melting Arctic ice as an opportunity for more drilling, and when slimmer plastic caps on water bottles get billed as progress, Jensen suggests that some emotional adjustments are warranted. “What we need,” he says, “is less guilt and more righteous indignation.”

terra





Sequencing the Beaver

Researchers will do the first whole-genome analysis

It has orange teeth that grow throughout its lifetime. It chews relentlessly on trees and builds dams that shape habitats across the continent. In earlier centuries, its fur was the currency of empires. While a lot is known about the North American beaver (*Castor canadensis*), the animal's complete genome has never been sequenced. Until now.

In partnership with the Oregon Zoo in Portland, researchers in the Oregon State University Center for Genome Research and Biocomputing (CGRB) are planning to analyze a complete set of beaver DNA to better understand how the continent's largest rodent fills its role as an ecosystem engineer.

DNA will be retrieved from a blood sample collected last summer during a routine physical of Filbert, a 4-year-old male who was born and raised at the zoo. Researchers will analyze the chemical building blocks that comprise genes and other parts of his genome. "Sequencing all of the beaver's DNA will improve our understanding of the entire beaver species, including their amazing engineering and dietary feats and their contributions to stream and forest ecosystems," says Brett Tyler, CGRB director.



In a partnership with the Oregon Zoo, Oregon State scientists are sequencing the beaver genome. (Photo: Kristine Torres, courtesy of the Oregon Zoo).

The Beaver Genome Project is the subject of a crowd-funding campaign managed by the OSU Foundation. To contribute to the \$30,000 goal, see create.osufoundation.org. The campaign is scheduled to run from September 16 to October 30.

More than 120 Oregon State researchers are affiliated with the CGRB, which performs rapid genome sequencing and analysis for studies of human and animal health, plants, microbiology and other purposes.

Biology Through Numbers

Hiring initiative combines science and information technologies

The generation of huge data sets in gene-sequencing and computer-modeling labs challenges scientists to develop new approaches to information. "Genomics and biocomputing are important areas for the university, and we have invested in faculty in this area in the past two hiring cycles," says Provost Sabah Randhawa.

Through the Biological Informatics and Genomics (BIG) initiative, Oregon State is building expertise to apply the latest research results to human health, agricultural crops and other pressing needs. Each new faculty member combines experience in biology, math and computational science.

Researchers brought to OSU include:

- David Hendrix, Biochemistry and Biophysics and Electrical Engineering and Computer Science
- Patrick De Leenheer, Mathematics and Integrative Biology
- Thomas Sharpton, Microbiology and Statistics
- Stephen Ramsey, Medical Biology and Electrical Engineering and Computer Science

In addition, an undergraduate program (Bioinformatics and Data Science) and a graduate program (Biological Data Science) are in development.



New Record for OSU Research, \$308.9 Million

Private-sector growth leads the way for Oregon’s largest public research university

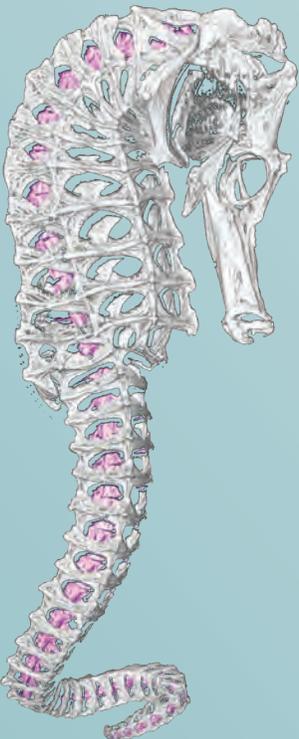
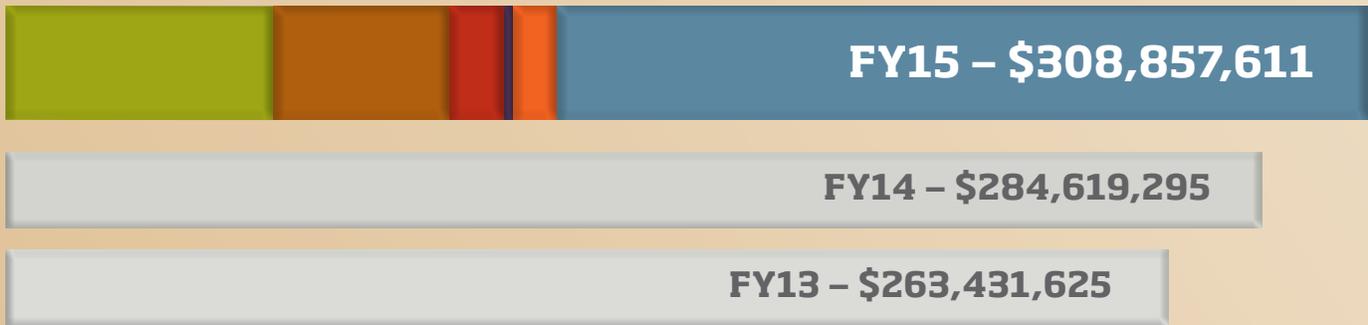
Oregon State University research funding reached \$308.9 million, its highest level ever, in the fiscal year that ended on June 30. A near doubling of revenues from licensing patented technologies and an 8.5 percent increase in competitive federal funding fueled OSU research on a range of projects including advanced ocean-going research vessels, the health impacts of pollution and sustainable materials for high-speed computing.

Oregon State researchers exceeded the previous record of \$288 million, which the university achieved in 2010. Since then,

total private-sector funding from sponsored contracts, research cooperatives and other sources has risen 60 percent — from \$25 million to more than \$40 million in 2015.

“OSU’s performance in the last year is phenomenal, given that federal funds are so restricted right now,” says Cynthia Sagers, OSU’s vice president for research. “This translates into economic growth for Oregon and the region.”

Land-Grant Formula Funding \$60,879,153	Industry \$40,067,733	Nonprofit \$12,388,688	Foreign Government \$388,514	State/Local Government \$9,969,644	Federal Agencies \$185,163,879
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Seahorse Inspires Robotics

Engineers find resilience in square structure

One of the ocean’s oddest little creatures, the seahorse, is providing inspiration for researchers as they learn from nature how to build robots that have capabilities sometimes at odds with one another — flexible, but also tough and strong.

Their findings, published in the journal *Science*, outline the virtues of the seahorse’s unusual skeletal structure, including a tail in which a vertebral column is surrounded by square bony plates. These systems may soon help create technology that offers new approaches to surgery, search-and-rescue missions or industrial applications.

“Human engineers tend to build things that are stiff, so they can be controlled easily,” says Ross Hatton, an assistant professor in the College of Engineering at Oregon State University and a co-author on the study. “But nature makes things just strong enough not to break, and then flexible enough to do a wide range of tasks.”

Although technically a fish, the seahorse has a tail that provides a grasping mechanism to cling to things such as seaweed or coral reefs. “This could be very useful for robotics applications that need to be strong, but also energy-efficient and able to bend and twist in tight spaces,” adds Hatton.



Supersinks for Carbon

Saving mangroves can mitigate climate change

As the United Nations gears up for its global climate change conference in Paris in November, the “blue carbon” message is gaining ever-more traction in the debate. Keeping greenhouse gases sequestered in the tangled roots and soggy detritus of mangrove forests could be vital to keeping the planet cool enough for habitation, scientists say.

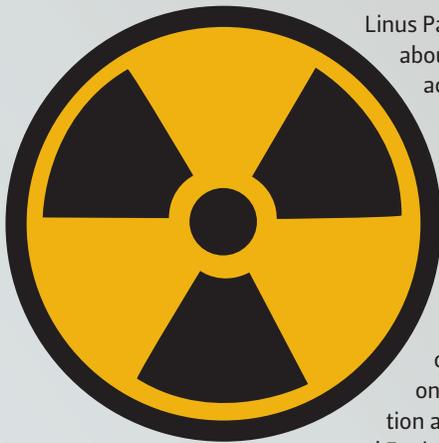
“High rates of tree and plant growth, coupled with anaerobic, waterlogged soils that slow decomposition, result in large, long-term carbon storage,” Oregon State University researcher J. Boone Kauffman and colleagues explain in a new study published in *Nature Climate Change*. (See “Blue Carbon,” *Terra*, Fall 2014.)

Arguing that mangroves, especially those in the vast archipelago of Indonesia, are the world’s richest supersinks for carbon dioxide, Kauffman and an international team of researchers make a case for preserving these vital ecosystems. “Preventing mangrove loss would be an effective climate change adaptation strategy,” the researchers say. “Conservation of carbon-rich mangroves ... should be a high-priority component of strategies to mitigate climate change.”



Seventy Years of Peril and Hope

View the sweep of nuclear history at the Valley Library



Linus Pauling, Oregon State’s most famous alumnus, spent the latter years of his life warning the world about the humanitarian and environmental threats posed by nuclear weapons. His international activism earned him the Nobel Peace Prize in 1962. (See “Like Looking Over His Shoulder,” *Terra*, Summer 2008.)

Now, Pauling’s alma mater is again raising nuclear history in the public consciousness. An exhibit called *The Nuclear Age: Seventy Years of Peril and Hope* recently opened at OSU’s Valley Library to mark the 70th anniversary of the bombing of Hiroshima in 1945.

Tapping into the university’s rich collection of historical materials on nuclear science and technology (including the Ava Helen and Linus Pauling Papers), the exhibit gives viewers a panoramic sweep across time and space. Starting with the bombs nicknamed Little Boy and Fat Man that were built in secret and dropped on Japan, the display tracks the wrenching questions of war and peace, radioactive fallout, nuclear testing, waste disposal and reactor core meltdowns on the “peril” side. On the “hope” side, it looks at promising medical technologies, energy production and scientific advances (including those under way in Oregon State’s School of Nuclear Science and Engineering).

“The exhibit is designed to reflect not only the horror of Hiroshima and Nagasaki, but also many other issues that have defined the nuclear age over the past seven decades,” says history professor Jacob Darwin Hamblin, who helped curate the show with a team of librarians and scholars in OSU’s Special Collections & Archives Research Center.



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.

Small World

Device could disrupt a \$3 billion industry

Game-changing technology sometimes comes in small packages. For example, with two magnets and a lightbulb filament — a package thinner than a deck of cards — Joe Beckman and a team of Oregon State University collaborators may revolutionize the mass spectrometry (aka, “mass spec”) industry. Their device amplifies the sensitivity and precision of technology that is the workhorse of chemistry labs. And it requires minimal retooling of existing equipment.

“We’ve been developing this approach for more than 12 years. We not only break molecules into fragments effectively, we do it so gently that it gives you entirely new insights into how molecules such as proteins work. It reduces noise (spurious data), and you can turn it off and on in less than a millisecond,” says Beckman, Distinguished Professor in biochemistry and biophysics and holder of the Burgess and Elizabeth Jamieson Chair in Healthspan Research in the Linus Pauling Institute.

Based on advances achieved in Oregon State’s mass spec lab, Beckman and his team (Valery Voinov, Yury Vasel’ev, Douglas Barofsky and Nathan Lopez) formed a company known as e-MSion. They are demonstrating their device with major mass spec equipment manufacturers, part of a global industry that generated more than \$3 billion in sales last year.

However, it wasn’t until they participated in commercialization training through the Oregon State University Advantage Accelerator/RAIN Corvallis that they began to grapple with the realities of finding a market and starting a business. The company was one of six in the Accelerator’s immersive commercialization training program last spring. Among them were Northwest Research Laboratories (quality control in commercial cleaning services), Pure Living (news aggregator and e-commerce website for families), Danio Discovery (zebrafish lab for rapid chemical testing) and Core Vitality Clinic (regenerative medical treatment).

At the end of the program, each business had clarified its product, the market and the messages it needs to reach potential buyers and investors.



As an affiliate of the Regional Accelerator and Innovation Network (RAIN), the program helps new businesses move from idea to market. “Five years ago,” says Beckman, “if we told people we wanted to start a company, they would say, ‘Where’s your business plan?’ The idea here is that you start with minimum viable product (a description of the technology) and you find out who your customers are. For a scientist, that process is just like doing an experiment, but you’re interacting with people and finding out if they will pick up your product.”

To discover what the **Oregon State University Advantage** and the **Advantage Partnerships program** can do for your business, contact Brian Wall, Assistant Vice President for Research, Commercialization and Industry Partnering, 541-737-9058. oregonstate.edu/advantage



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"When I walk through a village, people notice," says Molly Kile. The 6-foot-tall Oregon State University epidemiologist is an unusual sight in rural Bangladesh communities where she studies the health impacts of low-level arsenic exposure. See "A Poison in Small Doses," Page 26. (Photo: Molly Kile)

