

SPECIAL ISSUE: HUMAN HEALTH

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WAGING Wellness

THE ART AND SCIENCE OF PREVENTING DISEASE,
PROLONGING LIFE AND PROMOTING HEALTH

Oregon State
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Oregon's leading public research university

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Oregon State is Oregon's leading public research university with more than \$285 million in research funding in FY2014. Classified by the Carnegie Foundation for the Advancement of Teaching in its top category (very high research activity), OSU is one of only two American universities to hold the Land-, Sea-, Sun- and Space-Grant designations. OSU comprises 11 academic colleges with strengths in Earth systems, health, entrepreneurship and the arts and sciences.

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Squinting at a Diagnosis



The wind blew unseasonably bitter the day my sister and I took Mom to her first oncology appointment. As Mom leaned into the gale, her jaunty hat flew up suddenly and whirled away. The hairstyle she'd arranged with such care was defeated.

"I'm nervous," she said as we sat waiting for the doctor at OHSU's Center for Health & Healing on Portland's South Waterfront. We scrunched close, three narrow-hipped women sharing two chairs. Mom's shoulders were tense beneath her brave blue sweater. At 84, she'd been the picture of health. Then, one painful night her appendix burst. Post-surgery, the pathology report revealed abnormal cells in her abdomen.

The oncologist strode in, a confident young woman with warm eyes. She asked Mom what the surgeon had explained about her condition. "Well, the surgeon found some, um, well, some *cells* when he took out my appendix," Mom said. I was puzzled. My sister and brother had been at that earlier meeting and had phoned me, distraught, about a finding of cancer. Yet there in the oncologist's office, Mom seemed to dodge. Maybe saying the word out loud would confer power on the disease that she was unwilling to grant.

The oncologist went on to describe Mom's diagnosis as a "low-grade neoplasm." I'd never heard of a low-grade neoplasm, but it sounded better than "cancerous tumor" by a mile. I turned it over in my mind, tried it on for size and then latched on. I relaxed a little. Another surgery might be needed, the doctor was saying, but no chemo.

As we buttoned up our coats and walked back into the wind, the prognosis seemed bright. We celebrated with a glass of wine. But later on I looked up "neoplasm." It means "tumor." I called my brother. "Hey, I'm confused. Did the surgeon tell you that Mom had cancer or not?" Well, the doctor didn't exactly say cancer, my brother reported. But when he referred Mom to an oncologist, "We assumed it was some type of cancer." More talking and more Googling broadened our vocabularies (mucous tumor, pseudo-cancer, precancerous cells with malignant tendencies). Still, it felt vague.

Since then, I've talked to friends whose doctors and families also skirted the "C" word. A scary diagnosis has fewer sharp edges when cushioned in euphemisms, those handy linguistic foam peanuts for emotions. Besides, as I've come to learn, cancer is exceedingly complicated. And so we fumble to name and to characterize, even as we struggle to accept.

In this special issue on health research, you'll meet Oregon State scientists who not only investigate cancer, but also study infectious disease, childhood obesity, environmental toxins and aging. We promise you'll be as amazed as we are.

Lee Sherman
Associate Editor

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The Future of Health Care

Effective strategy demands a holistic approach

BY RON ADAMS, INTERIM VICE PRESIDENT FOR RESEARCH

A

As planning for this issue of *Terra* got underway, the Ebola outbreak was capturing attention in medical journals and news reports and across the Internet. There were fears of a pandemic. Previously known only in Africa, the disease had appeared in the United States and Spain. Public health specialists struggled to cut the rate of new infections as scientists worked to fast-track potential therapies.



This unfolding tragedy underscores the complex nature of 21st century health care. Deeply held cultural practices — for example, how we treat the bodies of people who have died — can create a path for infection from person to person. Meanwhile, people unwittingly carry disease overnight from one country to another. A growing and increasingly urban human population increases stress on public health systems in the world's poorest countries. And a warming climate is expanding habitats for pathogens and contributing to destructive weather events (storms, heat waves, floods) that put people at risk.

So it shouldn't be surprising that human health — one of Oregon State's three signature areas of distinction — encompasses a diversity of initiatives across disciplines. At OSU, the Division of Health Sciences fosters collaboration among researchers in the colleges of Veterinary Medicine, Pharmacy, Science and the state's only accredited school of public health, the College of Public Health and Human Sciences. They are joined by colleagues in Engineering, Agricultural Sciences, the Linus Pauling Institute and the Environmental Health Sciences Center. Extension faculty, long a powerful resource

in agriculture and nutrition, are ramping up their activities in community health.

A review of FY14 research funding at OSU concluded that health accounts for a share of grants and contracts that is roughly equal to each of four research thrusts addressing global challenges: marine studies to enhance the health of ocean and coastal systems; climate change and adaptation; food and water security and safety; and sustainable energy and the built environment.

Moreover, effective solutions to problems require more than science and technology. Unless innovations are accepted by people and communities, they will fail to achieve desired impacts. We must engage the social sciences and humanities as well.

Oregon State researchers have already made significant contributions to a healthy society. They have developed cancer therapies, advanced the science of antioxidants, identified candidates for new prescription drugs, taken measures to reduce antibiotic resistance and developed exercise programs and technologies to benefit the elderly. Our scientists are tracking airborne pollutants, some of which are known carcinogens, and evaluating their consequences for human health.

OSU is also contributing to Ebola control. One of the leading drug candidates has emerged from collaboration between an Oregon State scientist and the pharmaceutical company Sarepta Therapeutics, which traces its roots to OSU. Ebola is only the latest chapter in the ongoing story of Oregon State's drive to address the health-care challenges of the future.

TOWARD OPTIMAL HEALTH ON OUR BORDERLESS ORB

On a lonely planet beset by toxic chemicals, animal-to-human infections, cancers of all kinds, rampant obesity and a looming Centenarian Boom, the “One Health” concept just makes sense

BY LEE SHERMAN

“One Health is the concept that the health of humans, animals and the environment are directly linked, and that the condition of one can affect the health of the others.”

— *Position statement of the OSU College of Veterinary Medicine*

When America's first Ebola case turned up in Texas last fall, the oneness of our world clicked into our consciousness with new clarity. In less time than it takes to clean out your garage, a lethal virus traveled across the Atlantic Ocean on a commercial airliner. Suddenly, Ebola wasn't just a problem to observe from a distance. It was in our backyard.

“We now have the conditions under which we could create some kind of pandemic very quickly that we would not be able to resolve,” says Princeton sociologist Miguel Centeno, an expert in global systemic risk.

Viruses living in blood or saliva, bacteria growing in rivers or burgers, toxics spewing from smokestacks or tailpipes — these threats honor no boundaries, municipal, state or national. In even the poorest regions at home and abroad, obesity undermines wellness when fast foods and sugary drinks edge out traditional diets. The miracles of modern medicine extend our lifespan, yet those extra years can exceed our capacity for eldercare. Cancer invades the lives of just about everyone sooner or later — a friend, a relative, you. And then there's global climate change, which the *British Medical Journal* calls a “public health emergency” that will eclipse Ebola as a worldwide threat if carbon emissions don't decline soon.

All Tangled Up

Inextricable problems require integrated solutions. “Nowadays, you cannot be successful if you work on your own,” remarks Oleh Taratula, a cancer researcher at Oregon State University. “You need people to work with you, from basic scientists all the way to the clinicians.”

That’s why OSU researchers are sloughing off old allegiances to disciplinary silos and joining forces for a healthier humanity. More than 300 investigators in fields such as microbiology, bioengineering, gerontology, veterinary medicine, nutrition, early childhood, exercise physiology, nanotechnology, rural studies, pharmacology and drug discovery are sharing labs, equipment and brainpower to diagnose, treat and prevent existing and emerging illnesses.

They are reaching across institutional boundaries, too. From the OSU “mothership” (Corvallis campus) as well as from state-of-the-art labs in the new Collaborative Life Sciences Building on Portland’s South Waterfront, they are working with researchers and clinicians at Portland’s Oregon Health & Science University and the Knight Cancer Institute. Another Portland-based partner just down the river, OTRADI (Oregon Translational Research and Development Institute), is a key OSU collaborator in drug discovery and marketing.

And even state and national health-care policies are under scrutiny. The Centers for Disease Control and Prevention, for instance, recently granted \$1.25 million to a team from OSU and the Oregon Health Authority to study Medicaid expansion, data that will help inform states and communities undergoing sweeping changes under the Affordable Care Act of 2010 (widely known as “Obamacare”).

GEMs (genetically engineered mice), zebrafish (“the new lab rats”) and complex mathematical models are essential tools for studying everything from epigenetics to “superbugs” to environmental toxics. Dogs and cats are partners, too, their common biology revealing clues to

human illness through veterinary medicine. Novel “gerontechnologies” such as step-training apps to prevent falls and wearable electronic sensors to monitor gait promise more independence for elders. Creative ways to encourage kids to eat their veggies and do more exercise are on the drawing board in rural communities with funding from the U.S. Department of Agriculture.

Transnational Action

Astronauts, viewing Earth from far away, comment on the absence of lines partitioning our fragile sphere, as it hangs like a “big blue marble” in the void. That wide-angle, holistic perspective is what spurred OSU’s College of Public Health and Human Sciences — Oregon’s only public health college accredited by the Council on Education for Public Health — to launch a new international “think tank,” the Center for Global Health.

“Global health today faces many challenges shaped by a world that is increasingly interconnected,” notes center director Chunhuei Chi. “From improving the health of mothers and children to promoting environmental sustainability, these challenges transcend regional and national boundaries.

“We need collaborative solutions that involve transnational research and action.”

HEALTH RESEARCH NETWORK

Collaboration and connection across the Oregon State campus

The science of human health is a collective enterprise at Oregon State. It encompasses:

- » More than 300 faculty members in seven academic colleges, Extension Service offices and 10 centers and institutes
- » Thousands of students, research assistants and post-doctoral scientists
- » Partnerships with agencies, businesses, public health departments and universities

The work is interdisciplinary. Engineers strategize with social scientists. Biologists deliberate with physicists. Veterinary doctors collaborate with oncologists. Chemists ponder with pharmacologists.

A few highlights:

ENVIRONMENTAL HEALTH SCIENCES CENTER

With funding from the National Institute of Environmental Health Sciences, the center delves into the human health impacts of chemical exposure. The center's researchers focus on diseases such as cancer and ALS (amyotrophic lateral sclerosis) and the developmental impacts of nanomaterials, pesticides and PAHs (polycyclic aromatic hydrocarbons).

HALLIE E. FORD CENTER FOR HEALTHY CHILDREN AND FAMILIES

Established through a generous gift from Oregon philanthropist Hallie Ford, the center brings researchers together around four themes: healthy development in early childhood; youth and young adults; healthy lifestyles and obesity prevention in children and families; parenting and family life.

LINUS PAULING INSTITUTE

Through the study of micronutrients, aging and disease, the institute seeks to optimize the "healthspan." The institute's research is driven by the potential for proper use of phytochemicals, vitamins and other dietary compounds to contribute to longer, healthier lives.





CHILD OBESITY

Solving the weighty matter of kids' health

BY LEE SHERMAN


Back in the 1950s, stay-at-home moms cooked meals from scratch while kids ran and played outdoors till dinnertime. Fast-forward to the dual-income or single-parent families of the 2000s. Bone-tired at the end of a workday, parents now are more likely to nuke a frozen pizza or open a box of mac 'n' cheese than create a square meal from fresh ingredients. And latchkey kids munch on Doritos and Mountain Dew while playing Grand Theft Auto or texting friends, in contrast to their last-century counterparts who snacked on milk and homemade oatmeal cookies before hopping on their bikes or grabbing their baseball mitts.

"Obesogenic" is how the Centers for Disease Control and Prevention (CDC) tags the phenomenon. In other words, American society itself promotes obesity. "We've become enamored with making things comfortable," observes Oregon health and P.E. teacher Jason Hardrath. "You can order a pizza and have 3,000 calories knock on your door without even getting off the couch."

Patty Case, an Oregon State University Extension professor, chalks it up to human nature. "We're human beings, so we take the easy route," she observes. "Packaged foods, videogames — those are the easy route."

The route may be easy, but it can pave the way to some really hard knocks later on: obesity, diabetes, heart disease, even depression and low self-esteem. Everyone knows that Americans are too fat and getting fatter. Fully two-thirds of adults and one-third of children tip the scales at unhealthy weights. But figuring out what to do about a problem so tightly stitched into the cultural fabric is a big unknown.

Finding answers is a research priority at OSU's Hallie Ford Center for Healthy Children and Families. An example from the center's "obesity research core" is a five-year, multistate study led by OSU researchers Deborah John and Kathy Gunter in the College of Public Health and Human Sciences. The \$4.8 million project, funded by the U.S. Department of Agriculture, targets schoolchildren ages 5 to 8 in rural towns, places where distances are vast and resources are scarce, where fresh produce is hard to come by, where roadsides give way to dust and mud rather than sidewalks and bike paths and where families struggle to make ends meet as local economies shift and jobs vanish. The states of Colorado, Idaho, New Mexico, Nevada and Washington are project partners along with Oregon.



“Exercisers outperform couch potatoes in long-term memory, reasoning, attention, and problem-solving tasks.”

— John Medina, *Brain Rules: 12 Principles for Surviving and Thriving at Work, Home, and School*

Double Trouble


In Southern Oregon on the eastern slope of the Cascades, the town of Chiloquin huddles at the confluence of two rivers, the Sprague and the Williamson, renowned among fly-fishermen for trophy-sized trout. These high-elevation streams run fast and clear through an eclectic mix of ecosystems: ponderosa pine forests, rangelands scented with sage, lakes and marshes alive with migratory swans, geese and long-legged wading birds.

This land is beautiful and bountiful. Yet the children who live here are among Oregon’s most challenged. Struggling families, many of them descendants of the first peoples to hunt and forage in the timbered hills and teeming wetlands — the Modoc, the Klamath, the Yahooskin Band of the Snake Paiute — are scattered across hundreds of acres. Round-trip bus rides to school can steal an hour or more from a child’s day. Jobs are scarce now that logging has slumped. Unemployment tops 25 percent.

On the edge of town sits little Chiloquin Elementary School, neat as a pin. The linoleum floors are polished, the classrooms are cheery with primary colors, the cafeteria clanks with pots and pans, homey and comforting. But scratch the surface and the picture is less idyllic. Low scores on statewide tests rank Chiloquin in the bottom 5 percent statewide for academic achievement. And there’s another troubling number: Students here are some of Oregon’s most overweight. As measured by “body mass index” (BMI) — the ratio of height to weight — 40 percent of Chiloquin’s first- through sixth-graders are overweight or obese, compared to the statewide average of 25 percent.

“Research tells us that children living in rural places are less likely to have healthy weights than their urban counterparts,” says Deborah John. “Commuting ‘seat’ time and long school bus rides, isolation from grocery stores and limited options for daily exercise are some of the biggest barriers to healthy living.”

Oregon State’s project, dubbed “Generating Rural Options for Weight-Healthy Kids and Communi-



ties” (GROW-HKC for short), brings together researchers from multiple disciplines (public health, nutrition and exercise sciences, human development and family sciences, education and Extension) in partnership with schoolteachers and administrators, students, parents and community members in three Oregon counties — Klamath, Clackamas and Columbia — to study obstructions and opportunities for better nutrition and physical patterns.

The approach hinges on its participatory nature. Case and her Extension colleagues don’t just teach about healthy lifestyles. Rather, they partner on multiple levels (in the cafeteria, on the playground, at the community rec center) with a circle of constituents (local leaders, community groups, parents, school principals, P.E. teachers) to change

the environment and make healthy choices the easy option.

“Our premise is that lasting change happens when the community or school helps figure out what stands in the way of healthy living and then takes part in crafting the solutions,” says John. “It’s what the CDC calls a ‘social-ecological model’ of prevention — understanding the complex interplay among individuals, families, communities, even society at large — collecting data through measurement and assessment tools, and mobilizing change with action teams, using photo mapping and other participatory strategies.”

The OSU researchers, then, have embraced the broadest context for obesity, a context that includes neighborhood infrastructure, local policies, community awareness and cultural attitudes. Is there a readiness to change? Is there a capacity to follow through?

“The readiness to change has been fairly low here in Klamath County,” Case says, a note of disappointment in her voice. “But we know that community-based participatory research takes time and a persistent presence. We can’t be the cornerstones of change. Instead, we have to create those cornerstones in local people and institutions. Otherwise, things will slide back as soon as the project ends, and we go away.”

Within that broad context, childhood obesity is only one health factor. Yet it’s one that can feed into other risks, such as school failure. Kids fidget and their minds wander when their bodies are hungry and their muscles are idle. “There are countless scientific articles that link fitness to academic achievement,” says Jason Hardrath. “Our




Patty Case



Deborah John



Kathy Gunter



brains need enormous amounts of energy when we're thinking. Physical motion improves blood flow to the brain and boosts neural activity."

Nutrition Heroics

One day in mid-December, Case steers the Klamath Basin Extension office's Ford Explorer into Chiloquin and unloads a stack of boxes and tote bags at the school's front door. Her mission: Get third-graders excited about whole grains. If that sounds like Mission: Impossible, you haven't seen Case work a classroom.

"Hello!" she greets the 20 little learners, calling their attention to the phrase "Eat Smart to Play Hard"

projected on the screen at the front of the room. "Students, have you ever eaten the whole thing?" she asks, striding between the miniature desks and emphasizing the word "whole." She repeats the question until they get the joke.

"Today, we're talking about whole grains," she says. "What's the magic word?"

"Whole grains!" the students chime with energy.

After tying on her black canvas "Food Hero" apron, Case quickly gets the kids moving as she guides

Opening a Dialog About Food Insecurity

Pediatric practitioners learn to tackle tough questions

There's a paradox in Oregon's hunger picture: Families who are short on food may end up overweight. That's because dollars stretch farther on "high-energy" foods (noodles, bread and other carbs) than on "high-nutrient" foods (fresh fruit, fish, poultry and other vitamin- and protein-rich items).


Trouble is, when people struggle with "food insecurity" (spotty access to regular meals), their needs can fly under the radar when they visit a clinic or a doctor's office. Shame often keeps them silent about their predicament. As for physicians and nurses, they may be hesitant to broach such a sensitive subject.

That's why OSU Extension faculty member Anne Hoisington recently led the design of a survey that was taken by 200 doctors and nurses as part of the Childhood Hunger Coalition. "It was an eye-opener," says Hoisington, a nutrition education

specialist based in Portland. "Many pediatric practitioners are not sure about how to ask questions, discuss the issue and then intervene."

Those survey findings have led to an online, self-paced course for medical professionals. Developed in partnership with OSU's Ecampus, Oregon Health & Science University and others, the free course — accredited for continuing medical education (CME) — guides practitioners toward a better understanding of household food status and provides them with practical scenarios and screening tools to open up a dialog with patients.

Course content focuses on how to identify food security; how food insecurity is connected to health and development; prevalent issues; and intervention strategies. The course, Childhood Food Insecurity, is available in the catalog at pace.oregonstate.edu.



them through the lesson: Name the five food groups (“Clap once for each group!”). List as many kinds of whole grains as you can (“Hop on one foot and pick a grain!”). Explain how whole grains help your body work better (“Tell why grains are good for you and give a friend a high-five!”). Describe how food labels help you make better choices at the grocery store (“Leap like a frog and find the first ingredient on this package of honey-oat bread!”).

Then, like a magician drawing her audience’s gaze to the stage, she waves her arm above the intriguing jumble of mixing bowls, measuring spoons and baking ingredients assembled on the front table.

“Today,” she announces, dramatically placing a white chef’s hat on her head, “we’re going to make whole-wheat carrot pancakes!” Even the most fidgety kids are suddenly all ears and eyes. In clusters, they take turns measuring with precision, mixing with enthusiasm, and flipping with anticipation before at last chowing down on the golden-brown flapjacks. They jostle for Dixie cups of fresh-cucumber-infused water to wash down the whole grains. Then each child gets a copy of the pancake recipe to take home. This is, in part, where the larger community comes in: kids sharing their newfound

knowledge with parents in pursuit of a ripple effect for healthier eating.

“Kids,” says Case, “are the message carriers to home.”

After Case packs up her bag of tricks, she checks in at the office with principal Travis Fast about plans for a teacher training on building physical-activity breaks into classroom time. Next she pops into the cafeteria to talk with food manager Melanie Shelton about tactics for getting kids pumped up about eating right. One example: giving cool names (like “X-Ray Vision Carrots”) to menu items. Other examples: holding tastings where students vote on their favorite nutritious recipes, and creating posters and bulletin boards that nudge kids toward better choices. Finally, she heads to the gym to firm up plans with P.E. teacher Norm Barney for a springtime “walking challenge” where kids earn points for the miles they stride.

Last year, with her camera at-the-ready on the passenger seat beside her, Case drove hundreds of miles across Chiloquin’s immense enrollment district to help map the area’s local “health environment.” Parents and other community participants in GROW-HKC traveled the highways, too, photographing convenience stores and cafes, rec centers and playgrounds, farmers markets and food pantries, clinics and churches, hunting grounds and fishing holes.

The idea is to identify plusses and minuses, the aspects of community

infrastructure that encourage, as well as discourage, healthy living. The photos not only paint a picture of strengths and needs in Chiloquin, they’re also part of a growing database documenting the challenges facing rural towns around the region.

Climbing the Wall

The elementary gym at Bonanza Schools is a storm of action one Tuesday in December. On the main floor, kids are throwing themselves into pushups, jumping jacks and other vigorous calisthenics, their voices echoing in the cavernous space. At the back of the gym, other students are kicking off their sneakers and stepping onto a set of scales as OSU Extension research assistant and GROW-HKC “interventionist” Janet Rojina records their latest body-mass data.

Here in this quiet town on the wide-open rangelands of Klamath County, students have recently acquired an unlikely amenity: a rock-climbing wall. As P.E. teacher Jason Hardrath gathers the kids for a game of “pinball hockey,” they have trouble keeping their hands off the gleaming yellow fiberglass wall, its

smooth surface pocked with brightly colored footholds and handholds.

The wall was the brainchild of Hardrath, a triathlete and ultra-marathoner whose extreme athleticism and fitness fanaticism clearly has infected his students. Installed in the fall of 2014, the wall is a boon for Bonanza, a hub for the scattered ranches, dairies and farms spread across this far corner of Klamath County. Besides benefitting upper-body strength, agility and overall fitness, the chance to climb can be foundational to kids' lifelong pursuit of movement.

The boost to fitness began, in fact, even before the wall arrived. That's because students turned out in huge numbers for a run-a-thon to raise matching funds for the \$8,000 structure. The balance was seeded by a GROW-HKC grant.

It's only been a few months, but the anecdotal results are encouraging. "We have a third-grader named Ellis who's caught the vision," reports Art Ochoa, Bonanza's principal. "He's been running in road races, lifting weights, trying to eat right. He really looks up to Jason, who's a great model for teaching healthy habits."

Adds Rojina, "What makes the program work is the relationships we have." **terra**

Mining the Micronutrient Mother Lode

Millions visit LPI website to learn about vitamins

The nutrition aisle of your local supermarket can make you dizzy. Row upon row, bottle after bottle of tablets and capsules promise health, youth, vigor, longevity, energy, regularity — even better sex. How do you choose one from another? How much should you take? Should children take a daily multivitamin? Do supplements even work?

To help sort the science from the hype, consumers and health professionals by the hundreds of thousands visit OSU's online Micronutrient Information Center at the Linus Pauling Institute (lpi.oregonstate.edu/infocenter). Each year, the free, easy-to-navigate site gets 3 million page views from 1.5 million unique visitors across the planet, according to LPI director Balz Frei. These information seekers can find the latest evidence-based data on nutrients in fruits, vegetables, legumes, nuts, whole grains, coffee and tea. They can get the lowdown on synthetic versus natural vitamins. They can learn the science of such "phytochemicals" (plant-based chemicals) as carotenoids, flavonoids and resveratrol. And all the articles are peer-reviewed by leading experts in the field.

The center's most visited pages include vitamin C, magnesium, vitamin B12, essential fatty acids, L-carnitine (a lysine derivative that helps turn fat into energy), iodine and curcumin (a substance in turmeric that may have anticancer and anti-inflammatory activities).

Some of the science on the site stems from the Linus Pauling Institute's own labs. As international leaders in nutrition research, LPI scientists study the effects of micronutrients and other dietary factors on cancer, aging, cardiovascular disease and metabolic syndrome.



HUMAN HEALTH AND THE ENVIRONMENT

Public Exposure

BY NICK HOUTMAN

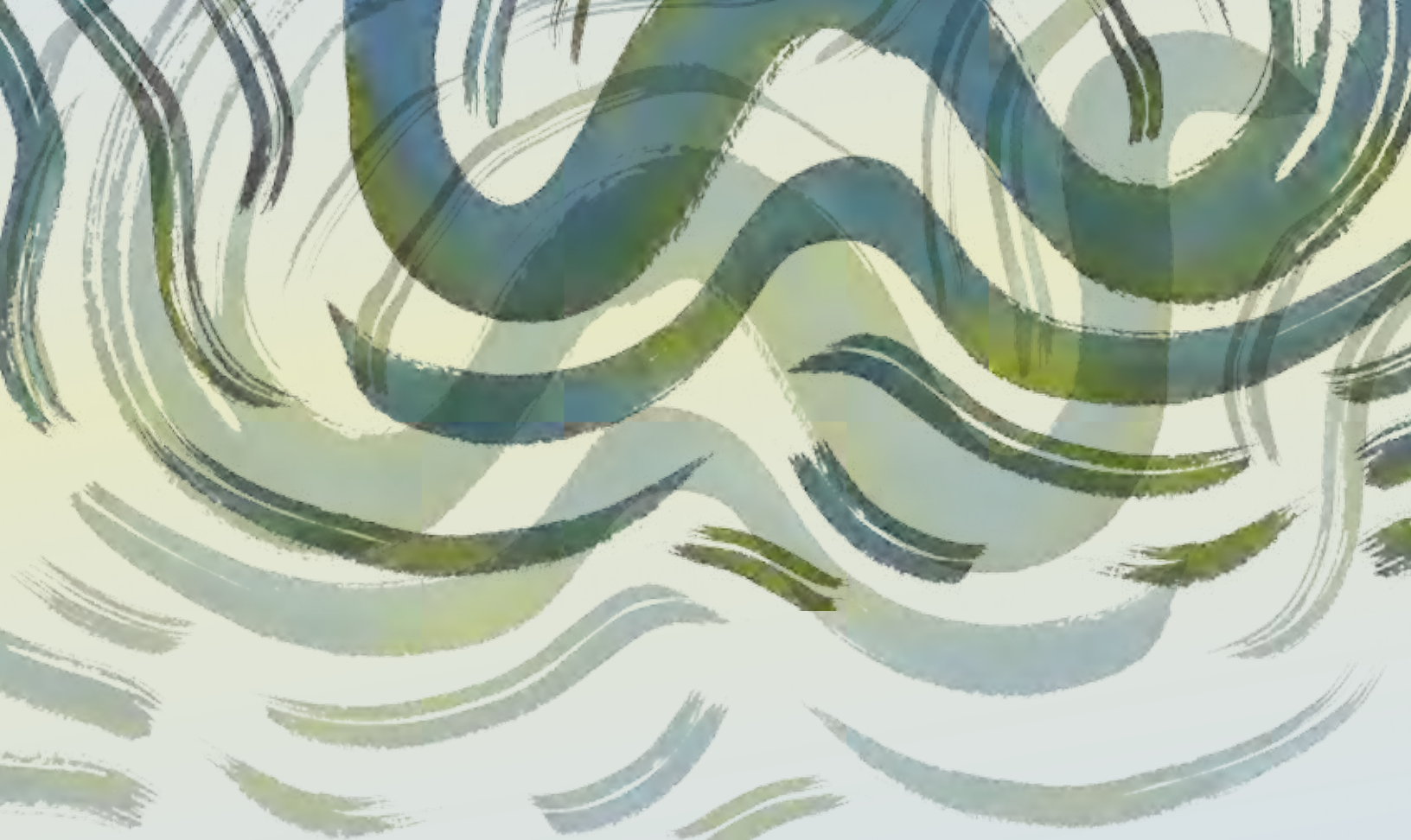
In 2010, the President's Panel on Cancer reported that, in the course of their lives, about 41 percent of Americans will be diagnosed with cancer and 21 percent will die of the disease. And, making a connection between cancer and the wide distribution of potential carcinogens in the environment, the panel added that only a few hundred of the more than 80,000 chemicals on the market have been tested for safety.

Oregon State researchers are cutting into that knowledge deficit. Using robotic systems and rapid assessment in zebrafish, they have assessed the toxicity of more than 5,000 compounds in the U.S. Environmental Protection Agency's ToxCast (a chemical evaluation program) and National Toxicology Program. Another 100,000 chemicals and nanomaterials — synthetic particles about 100,000 times smaller than the width of a human hair — have been evaluated as well. With partners at the Pacific Northwest National Laboratory, they are comparing zebrafish assays with data from mouse models, cell cultures and other testing methods.

Exposure to potentially harmful chemicals is commonplace. And pesticides and industrial pollutants aren't the only sources. Wood smoke, leafy green vegetables and grilled steak contain PAHs (polycyclic aromatic hydrocarbons), some of which are known to cause cancer in laboratory animals.

The goal is to identify the “really bad actors,” says Joe Beckman, director of the Environmental Health Sciences Center at Oregon State. “This could change the way we do public health.”

New knowledge is also emerging from Oregon State's program in radioecology, the study of radioactivity in the environment. And researchers are beginning to tackle what some experts consider the most serious public health threat of the future: climate change.



Tracking the Wind

Following pollutants from exposure to impact

“Except for the original blueprint of our chromosomes, all the material that is us — from bone to blood to breast tissue — has come to us from the environment.”

— Sandra Steingraber,
*Living Downstream: An Ecologist's
Personal Investigation of Cancer
and the Environment*

If you live near a chemical plant or by a freeway, there's more than fresh air in the breezes that waft across your yard, through open windows and under doors. The wind carries volatile compounds used in manufacturing and byproducts of fossil fuel combustion as well.

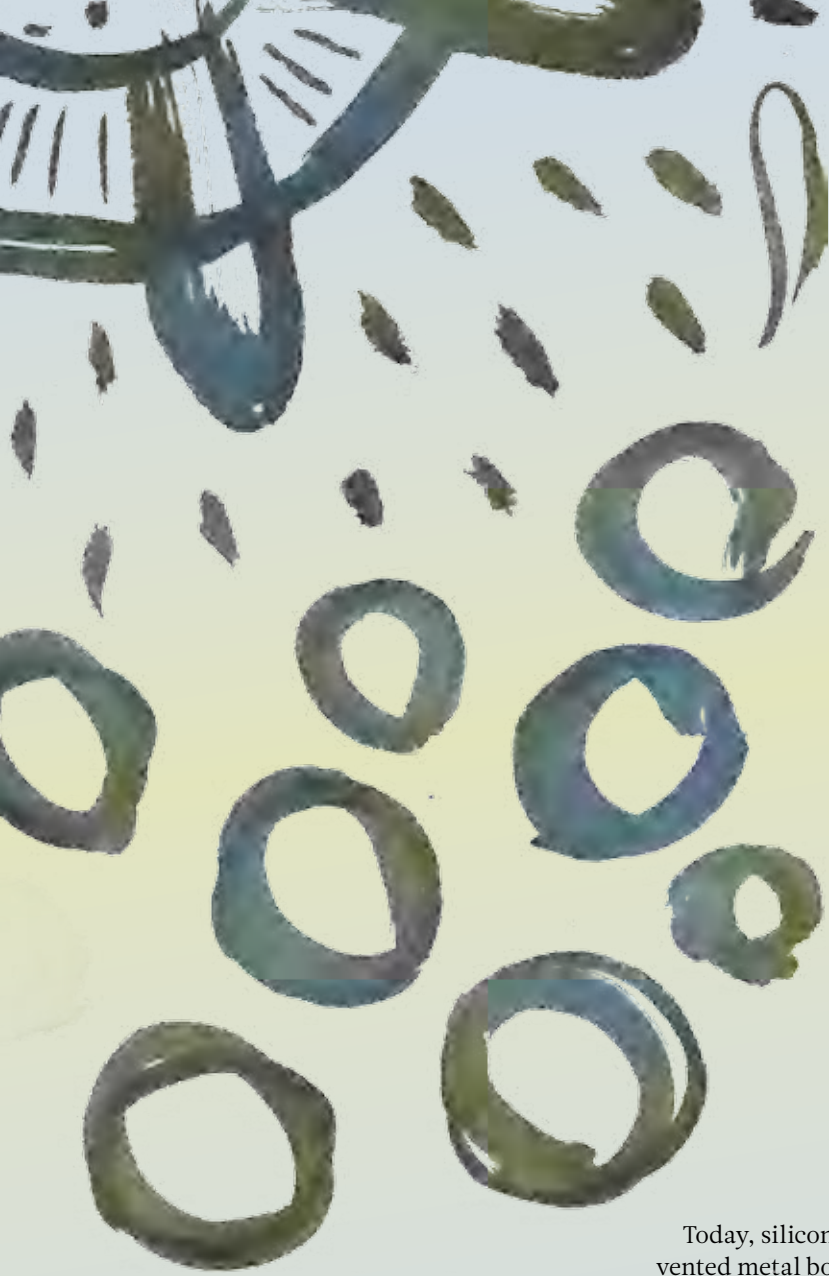
Across the country, people are exposed to airborne chemicals from an array of sources — gasoline and diesel engines, natural-gas wells, heating furnaces, pesticide applications and factories. In the hills of Appalachia, the concrete canyons of Manhattan and the tree-lined streets of Corvallis and Eugene — and as far away as West Africa and Peru — people are monitoring the air they breathe with the help of scientists at Oregon State University.

Researchers in Oregon State's Environmental Health Sciences Center have developed a sampling

approach that tracks chemicals with extreme sensitivity. In a lab led by Kim Anderson, professor of Environmental and Molecular Toxicology, scientists specialize in what are called “passive samplers.” Over the last two decades, Anderson's group has deployed more than 19,000 such monitors that collect chemicals in air and water for measurement in her lab.

In 2004, this technology — which works silently without fans or other motorized components — helped to allay fears of a public health threat. Data collected by Anderson's team in the Willamette River near Newburg demonstrated that contaminants such as pesticides were not responsible for fish deformities that had raised alarms. The cause turned out to be an infectious parasite.

In 2010, immediately after the Deepwater Horizon oil disaster in



the Gulf of Mexico, Anderson's lab deployed air samplers in four coastal states. Results revealed the presence of petroleum compounds, including some not typically monitored by the U.S. Environmental Protection Agency. Further testing at Oregon State's zebrafish lab showed that these chemicals can affect embryonic development.

Today, silicone wristbands and vented metal boxes are among the Anderson lab's sampling platforms. They capture more than 1,400 of the many thousands of chemicals that may be present in our homes, neighborhoods and workplaces.

Scientists even have a name for the accumulation of chemicals, both natural and synthetic, and other factors that affect health: the "exposome." Coined in 2005 by

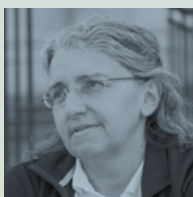
Dr. Christopher Wild, director of the International Agency for Research on Cancer, the exposome shapes us from Day One. In the womb, drugs and pollutants can affect development. As we age, interactions with environmental chemicals, UV radiation and microbes continue to unfold, sometimes leading to diseases, such as cancer and diabetes, that can take decades to emerge.

"There are a lot of exposures we don't have a grip on," says Anderson. "We don't have a lot of data. A contaminant may or may not be bioavailable. It has to cross some sort of biological threshold in order to have an effect on an organism."

Following the Chemical Trail

Linking environmental exposure to human health is tricky business. It starts with knowing the myriad chemicals we encounter every day in personal care products, household furnishings, medications, food, water and air. By monitoring for many chemicals at one time, Anderson and her team are beginning to define part of the exposome for individuals and for communities.

But that's only the first step along the trail from exposure to health. Once they extract the chemicals from a sampling device, researchers identify each compound in a mass spectrometer. This machine separates molecules first by ionizing them in an electric field and then by passing them through a magnetic field where they spread out like runners in a long-distance race.




Kim Anderson



Laurel Kincl



Joe Beckman



Next, the scientists need to know if the chemicals are bioactive ... that is, can they affect cells and disrupt the body's networks. So researchers may send sample extracts to Oregon State's highly automated zebrafish lab, in which the effect of chemicals — or their lack of effect — on developing embryos can be determined within days. Or they might walk samples next door to the Linus Pauling Institute where scientists run them through the Ames test, a common method for seeing if chemicals cause mutations in DNA.

In either case, small amounts of chemicals can reveal large clues about the potential for a biological impact. That surprises Joe Beckman,

the director of OSU's Environmental Health Sciences Center. "The miniaturization that's possible with these tests is really important because the wristbands really don't pick up that much material," he says. "There's not that much surface area. To me it's astonishing that they pick up as much as they do."

Anderson explains that the samplers mimic the most basic part of living organisms: the cell. "Passive sampling is a surrogate for a cell," she says. "It's very lipophilic (attractive to organic compounds such as proteins and lipids), like your cells are. And it has pores within the

polymers. There are different types of polymers, carbon or silicone, that mimic a cell. The key to any of the polymers we use is the chemistry."

In a study to test methods for using wristbands, Anderson's team — including Steven O'Connell, a former graduate student; and Laurel Kincl, assistant professor in the College of Public Health and Human Sciences — asked eight roofers who work with hot asphalt materials to wear them on the job. While some wristbands were worn for a single eight-hour shift and others for a 40-hour work-



Climate Change and Health

Impacts are likely from heat waves, drought and more

As the world warms, insects and pathogens are on the move. Heat waves are getting hotter and more frequent. Algal blooms are increasing in frequency, intensity and duration, posing risks to drinking water and shellfish consumption. Wildfires are putting more particulates into the air, leading to increases in asthma and hospital admissions for respiratory distress.


"I actually view climate change as the highest priority in environmental health," says Perry Hystad, an epidemiologist in the College of Public Health and Human Sciences. In 2014, Hystad's global study of air pollution and health received an Early Independence Award from the National Institutes of Health. Among other things, he plans to focus on the influence of climate on heat stress, air quality and allergens.

In the Pacific Northwest, human health is likely to take a hit from drought, wildfires, heat waves and infectious diseases, according to the Oregon Health Authority. In 2010, the agency led a planning effort, funded by the Centers for Disease Control

and Prevention (CDC), to identify climate change risks to public health and how they can be addressed. The Oregon Climate Change Research Institute (OCCRI) at Oregon State contributed expertise and data and worked with the Benton County Department of Public Health to assess vulnerabilities to hazards.

Heat-related illness is an example. According to the CDC, 423 workers died in the United States from heat exposure between 1992 and 2006. In Oregon, OSU epidemiologist Jeff Bethel and Renee Harger, former master's student in public health, surveyed 100 migrant farmworkers about their exposure to heat during the previous week. About two-thirds reported symptoms (heavy sweating, headache, extreme fatigue) consistent with heat-related illness, although they didn't exclude other ailments.

Compared to the South or Southwest, the Pacific Northwest is not normally associated with heat-related illness, Bethel says. That may be changing.



week, petroleum-based compounds were recovered from all of the devices. Among the chemicals were 12 PAHs on the U.S. Environmental Protection Agency's list of priority pollutants. The researchers published their results in *Environmental Science and Technology*, a professional journal.

Citizen Science

Anderson sees such monitoring efforts as a way to engage non-scientists in research. "Everybody loves to know more about their environment," she says. As a girl,

she was inspired by her grandfather who had a fourth-grade education but read every *National Geographic*, educating himself. "He was so excited when I got my geology degree. He wanted to know more about his environment. He isn't unique. There are lots of people like that," she adds.

Almost 500 people have signed up with Anderson's lab to receive updates on opportunities to participate in monitoring projects. Additional requests have come from small businesses (gas stations) and government agencies (the Department of Defense).

In New York City, researchers at Columbia University are using wristbands from Anderson's lab to monitor chemical exposure among pregnant women in low-income areas of the city. "The silicone wristbands offer a huge advance over what we've been able to do," says Julie Herbstman, one of the investigators on the project.

Since 1998, researchers have monitored chemical exposure by asking women to wear small backpacks equipped with air filters

Microcosms for Nano

Small particles could have big impacts

Many of the products we buy — sunscreen, stain- and odor-resistant clothing, fuel additives, sports equipment — contain nanoparticles that have been designed for a purpose. These materials (about 100,000 times smaller than the width of a human hair) can block sunlight, prevent microbial growth, lubricate surfaces and confer tensile strength.

However, in some cases, they can also disrupt biological processes. That possibility keeps Stacey Harper (Environmental and Molecular Toxicology; Chemical, Biological and Environmental Engineering) coming to her lab every day. The assistant professor and her research team have pioneered new methods to find out how nanoparticles affect life at the cellular level and what those impacts might mean for ecosystems and human health.

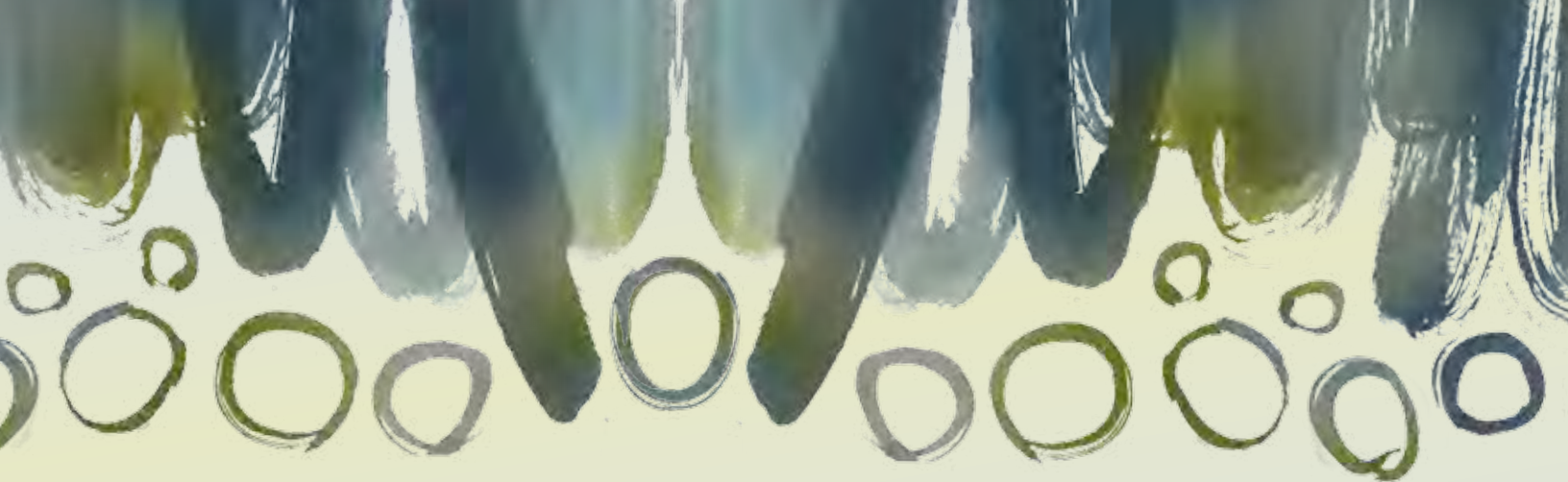
With funding from the National Science Foundation, they have created microcosms, simplified aquaria composed of algae, bacteria, zooplankton and fish. By adding nanoparticles, they can detect changes that would not be apparent with one organism alone. Silver, zinc oxide and titanium dioxide

nanoparticles are under scrutiny "because they are the most prevalent ones in aquatic ecosystems," says Harper.

Also relevant to aquatic systems are nano-based pesticides. In a project funded by the U.S. Department of Agriculture, Harper and her team are determining how the nanoparticles added to these chemicals alter their movement through soil and water. It's possible, she adds, that their bioavailability could change as well.

Biological effects may stem from shape as well as chemistry. In a project funded by the National Institutes of Health, Harper's team is working with Oregon State chemists and wood scientists to determine how "prickly" forms of gold-based particles and nanocellulose affect living systems

Harper has tested hundreds of nanoparticles and found less than 20 that appear to be toxic at realistic concentrations. As for sunscreen, a study by George Tuttle, a master's student, compared chemical-based products to those that use nanoparticles as a barrier to sunlight. "We found that they (nanoparticles) were way less toxic" than the chemical formulations, Harper says.



attached to battery-powered pumps. Because of the continuous hum and weight (5 pounds), researchers limited exposure time to 48 hours. In contrast, the wristbands are unobtrusive, and people can wear them 24/7 for longer periods of time.

In Ohio, Anderson's team is working with the University of Cincinnati College of Medicine and Carroll (County) Concerned Citizens to monitor air quality around natural-gas wells. Vented sampling boxes have been stationed around the wells, and homeowners are wearing wristbands to track personal exposure.

In West Eugene, OSU is working with a community group, Beyond Toxics. Passive samplers and spirometers (devices that measure the force of a person's breath) could provide an effective way to measure exposure and breathing difficulties such as asthma. Poor air quality has been well-documented in low-income neighborhoods and schools near highways, railroad switching yards and factories.

Funding for these and other projects comes from a variety of sources: the National Institute of

Environmental Health Sciences, the U.S. Environmental Protection Agency and even the Food and Agricultural Organization of the United Nations. The goal in all cases is to "strengthen the influence of science on decision-making," says Anderson. "We have lots of questions but not much data. I like to bring numbers and facts to the table." **terra**

Radioactive Ecology

Researchers look for impacts beyond humans

With memories of the Fukushima nuclear disaster still fresh, radioactive pollution can generate strong feelings among members of the public. So when questions arise about health impacts on humans and other organisms, Kathryn Higley can find herself in the media spotlight.

The head of Oregon State University's Department of Nuclear Engineering and Radiation Health Physics specializes in radioecology, the science of radioactivity in the environment. She and her students are studying the transport and effect of radioactive pollutants on vegetation and animals. "Whether it's natural, human-made, intentional or accidental, the goal is to understand where they go and what the impact is," she says.

Human health impacts are pretty well-known, but there's been a shift in philosophy about the environment. "In the past we assumed that if you protect humans, you protect the environment," but, she notes, that is changing.

"Humans are one of the most radiation-sensitive organisms,

but they are not necessarily the most sensitive. We know that pine trees, for example, are about the same in terms of radiation sensitivity. Why that is, we're not sure. We would expect other mammals to be similarly sensitive."

While the effects of high radiation exposures are well understood, low doses, particularly for wildlife, are problematic. "There is evidence that animals in the wild are more sensitive to radiation effects than animals examined under laboratory settings. We are developing the tools that will help accurately relate radiation exposure to effect," Higley says.

Oregon State maintains one of the few radioecology research programs in the country. Higley and her students are exploring topics such as the absorption of radioactivity by plants and the radiation sensitivity of trout, snails and other animals.

