terra

A world of research & creativity at Oregon State University • Spring 2009

Energy Lifeline

Nuclear innovations advance climate goals

NUCLEAR SOLUTION

When author Gwyneth Cravens (*Power to Save the World*, published by Vintage, 2008) brought her message of conversion to Oregon State University in February, she found an engaged, congenial audience. The former editor at *Harper's* and *The New Yorker* had been opposed to nuclear power until she learned more about the industry and compared its record to that of coal and other fossil fuels. She advocates for renewables such as solar and wind, but with an urgent need to meet increasing global energy demands and to reduce carbon emissions, she sees nuclear energy as a critical part of the solution.

Wading into this debate is not for the timid. It brings up memories of Three Mile Island, Chernobyl and, in the Northwest, battles over Oregon's Trojan plant and the overly ambitious Washington Public Power Supply System (nicknamed Whoops) project. Blog posts and media stories focus on myriad topics from uranium mining to power station economics and nuclear weapons. And then there are the technical details about grid reliability, co-generation, baseload power and other issues. Bringing up nuclear energy, even OSU's radically new approach, to those of us who have stayed out of the fray usually leads to questions about waste and safety. Oregon is one of eight states that prohibit new nuclear power plants until a permanent waste repository is constructed.

Much as opponents might like, nuclear technology is not going away. According to the International Atomic Energy Agency, 436 nuclear power stations produce 16 percent of the world's electricity. There are 44 nuclear stations under construction, including six in China (using a "passively safe" design tested at OSU). The U.S. Department of Energy suggests that global electricity demand could double by 2050. The Obama administration calls nuclear power a necessary component of policies to reduce climate change.

As our cover story notes, OSU is a leader in the responsible development of this energy source. The Department of Nuclear Engineering and Radiation Health Physics addresses concerns about safety, waste and proliferation. Chinese engineers train here to prepare for their country's nuclear power expansion. A spinoff company, NuScale Power, is leading commercial development of OSU research with a small-scale, modular design that, if approved by the Nuclear Regulatory Commission, could offer investors and communities a flexible alternative to megaprojects.

People tend to have strong opinions about nuclear, pro or con. Gwyneth Cravens has shown that opinions can change when facts temper fears.

— Nick Houtman
Editor

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President
Edward Ray

Vice President for University Advancement
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Vice President for Research
John Cassady

Editor and Director of Research Communications
Nicolas Houtman

Research Writer
Lee Sherman

Contributing Writers
Celene Carillo, Jana Zvibleman

Design
Santiago Uceda

Photography
Jill Bartlett, Jim Carroll, Jim Folts, Bill Gerth, Karl Maasdam

Illustration
Alex Nabaum, Juliette Borda, Ismael Concha

OSU is Oregon's largest public research university with more than $231 million in research funding in FY2008. 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 natural resources, earth dynamics and sustainability, life sciences, entrepreneurship and the arts and sciences.

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Contact Nicolas Houtman at:
nick.houtman@oregonstate.edu
402 Kerr Administration Building
Oregon State University
Corvallis, OR 97331
541.737.0783

On the cover
Illustration by Alex Nabaum

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Departments

8 **INNOVATION**
Promoting Entrepreneurship and Invention
Market Globally, Eat Locally

9 **VITALITY**
Advancing the Life Sciences
Sensors for Safety

17 **STEWARDSHIP**
Managing Nature's Resources
Restoring the Flow

22 **NEW TERRAIN**
Science on the Horizon
Looking for Evidence of America's First People
Kearney Hall, Showcase for Civil Engineers
New Buzz about OSU Honeybee Specialist
Next Generation Building Materials

24 **FOOTPRINTS**
Tracking Research Impact
Where Grass Seed Is King

Also in this issue

25 Envisioning the Forest

On the Web at ***oregonstate.edu/terra***

Hear Tracy Daugherty read from his new book, *Hiding Man*
Watch OSU students perform in Tom Stoppard's drama *Arcadia*

Features

2 Power Surge

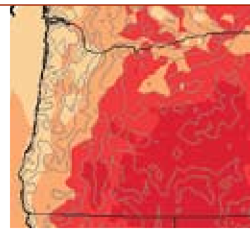
Meeting global targets for energy demand and carbon emissions will require safer, small-scale nuclear technologies. José Reyes and his colleagues are creating them.

10 Stage Kiss

As if mastering the role of a teenage prodigy wasn't enough, Arianne Jacques had to learn to portray romance on stage during OSU Theatre's production of *Arcadia*.

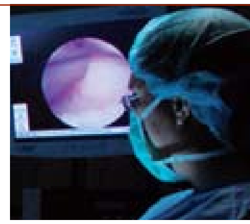
14 Climate by the Numbers

Wildfires, rainfall, sea levels and ocean currents are likely to change as the planet warms. Modelers get a glimpse of alternative futures.



18 Cut to the Bone

When canine enthusiasm turned to a yelp and a limp, the aging chow mix became a candidate for Wendy Baltzer's new surgical technique.



Power Surge

New nuclear technologies meet needs for electricity and safety

BY LEE SHERMAN | PHOTOS BY KARL MAASDAM

Last winter, the cavernous vault housing OSU's nuclear test facility was base camp for a team of elite scientists from Shanghai and Beijing. For six months, the Chinese engineers studied every bolt, tube and plastic elbow in the scale-model reactor. They ran accident simulations and analyzed the data. They posited every scenario under the sun, from a punctured pipe to "loss of coolant" to a complete loss of offsite power known as a "station blackout." Each time, the reactor shut down safely without a hitch.

Nuclear scientists YuQuang Li (left) from China's State Nuclear Power Technology Company and Professor HanYang Gu of Shanghai Jiaotong University calibrate instruments for a test of OSU's scale-model reactor.

In the spring, these top-gun scientists took their OSU training home to China. They're overseeing construction of the world's first Westinghouse AP1000 plant, which broke ground in Zhejiang Province in March. Three more of the Westinghouse plants will go up in short order. Cost to the Chinese government: $8 billion, including $500,000 for safety analysis test training at OSU as part of the Westinghouse tech-transfer program. By 2030, China hopes to have more than 100 reactors up and running.

"China has a very aggressive nuclear power plant plan," says OSU Professor Qiao Wu, who trained the Chinese team under contract to Westinghouse.

The Chinese team was in Corvallis to benefit from OSU's national leadership in developing advanced light-water nuclear energy technologies, making them safer, more efficient, more economical, more portable and more flexible. Groups who tour the Radiation Center — a '60s-vintage building on the west edge of campus — must sign in and clip on a visitor's badge before entering. The olive-drab corridors with their low ceilings and chocolate-brown linoleum seem unlikely passages into a world-class research facility. But up and down those modest hallways, ordinary wood-veneer doors open into some of the world's most advanced nuclear-science laboratories.

> "It is unlikely that we can meet our aggressive climate goals if we eliminate nuclear power as an option." *– President Obama, New Energy for America*

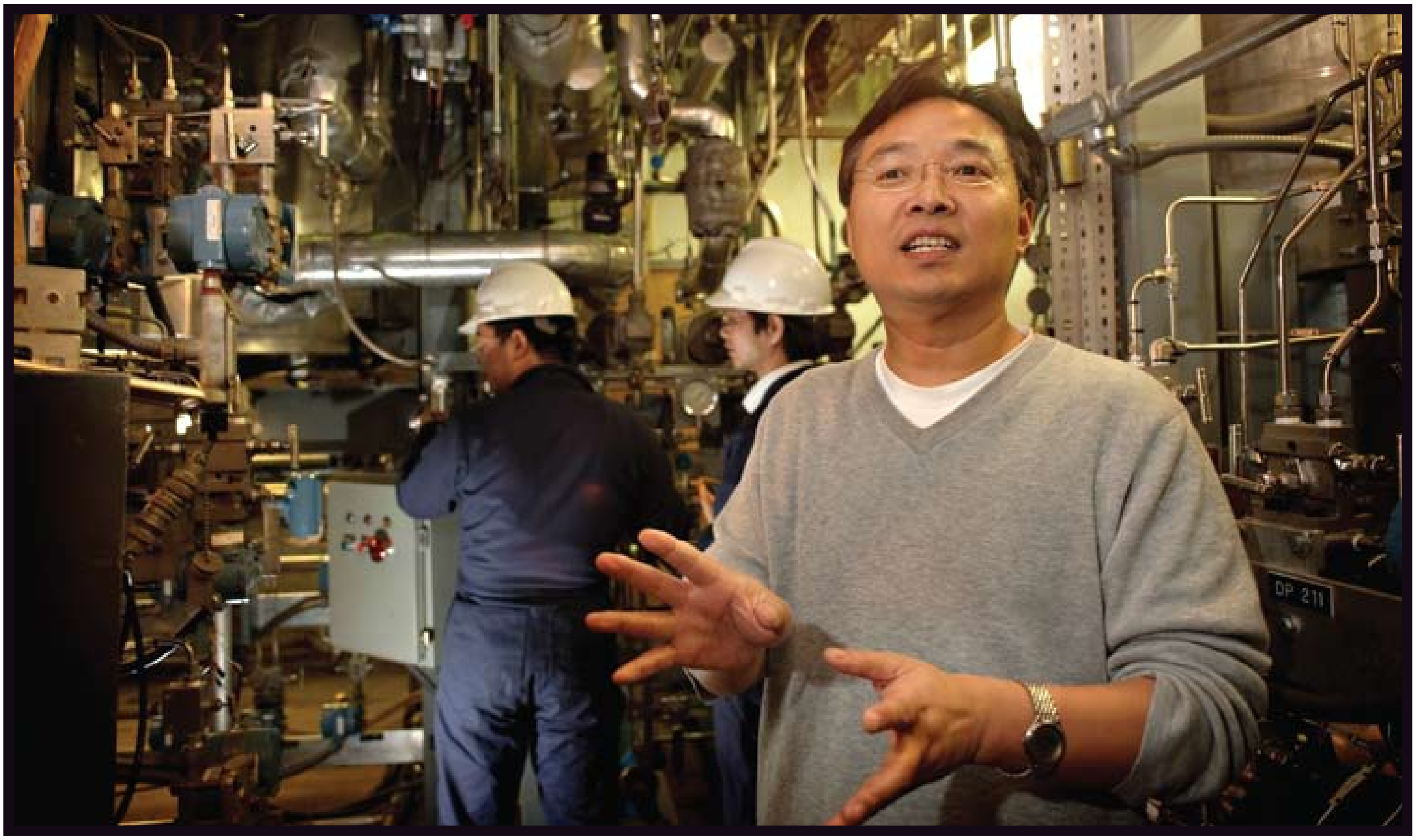
There, faculty and students are researching the next generation of nuclear power: high-temperature gas-cooled reactors, modular reactors that minimize operator error, new ways to reprocess and recycle spent fuel, uber-sophisticated computer simulations, remote radiation detection and other forward-looking technologies.

As environmental, economic and humanitarian threats loom across the globe, researchers point to nuclear's huge potential for cheap, clean electricity. Princeton University's Carbon Mitigation Initiative estimates that doubling global production of electricity by nuclear fission (now 16 percent or 370 gigawatts) could prevent 1 billion tons of annual carbon emissions by 2055.

Last fall, President Obama expressed support for continuing to explore nuclear technologies. "It is unlikely that we can meet our aggressive climate goals if we eliminate nuclear power as an option," the Obama New Energy for America plan states.

Aggressive for Passive

It's more than a little ironic that China is adopting this new-era technology ahead of the United States.



Last winter, OSU nuclear engineer Qiao Wu trained Chinese engineers in the operation of the Westinghouse AP1000 plant. Behind him are DongJian Zhao (left) of the Shanghai Nuclear Energy Research and Development Institute and Professor Hanyang Gu of Shanghai Jiaotong University.

After all, the AP1000 — a 1,000-megawatt light-water reactor that uses "passive" shutdown technologies to minimize operator error — was extensively tested in Corvallis at the university's Radiation Center, earning licensure from the U.S. Nuclear Regulatory Commission (NRC) in 2005. But as this and other innovative nuclear technologies were advancing in labs at OSU and other American universities such as MIT and the University of California, Berkeley, plant construction in the U.S. was stalled. Concern about proliferation (radioactive materials getting into the hands of terrorists or rogue nations) led to a ban on fuel reprocessing in 1976. The leak at Three Mile Island and the meltdown at Chernobyl hardened fears. Meanwhile, other nations moved ahead. Today, France gets 80 percent of its power from nuclear. Japan is at 30 percent. The U.S. is at 20 percent, a proportion that China, now at 2 percent, aspires to attain within 20 years.

In China, where cities are bursting at the seams and infrastructure is racing to catch up, the urgent need for power simply outstrips worries about nuclear accidents, explains Wu, a native of China. And then there's the environment. China's heavy reliance on coal is choking crowded urban areas.

> Nuclear energy is being revisited as an important clean, green alternative, along with wind and solar.

"The pollution is devastating," says Wu.

Indeed, pollution — more precisely, carbon dioxide and other fossil-fuel emissions — is at the heart of the nuclear-energy renaissance gathering momentum here and abroad. Greenhouse gases pose a threat to Planet Earth that dwarfs the danger of nuclear power, many scientists and environmentalists have concluded. In that context, nuclear energy is being revisited as an important clean, green alternative, along with wind and solar, because it can produce great quantities of energy and emit relatively little carbon dioxide.

"Global warming is the new touchstone for the nuclear debate," says OSU nuclear engineering Professor Todd Palmer. "A lot of former anti-nukes are now rallying around it. They've realized the value of the technology."

As the Earth warms, rising seas, failing crops, dwindling water supplies and slumping economies will hit the poorest peoples soonest and hardest, experts agree. Nuclear power could boost living standards in developing nations — thereby easing their adaptation to changing conditions — without adding to the problem by spewing harmful gases into the atmosphere, advocates argue.

"It is abundantly clear that countries with affordable electricity have citizens who live longer," says Palmer. "In study after study, quality of life is directly tied to cheap, abundant power. I tell my students that anything we can do to make nuclear technology more readily available to everybody is a humanitarian effort."

Nuclear Niche

OSU is in the vanguard of the rebirth. Its Department of Nuclear Engineering and Radiation Health Physics, whose enrollment has doubled since 2004, came in eighth (behind Michigan, MIT, Wisconsin, Texas A&M, Penn State, Berkeley and North Carolina State) in last year's *U.S. News and World Report's* college rankings. However, its research niche — safety — has earned it an international reputation that transcends the national ranking (which department Chair José Reyes points out is weighted heavily on statistical criteria such as numbers of students and faculty). In 2004, Reyes led a 14-nation United Nations research program in Vienna to lay out a worldwide vision for nuclear reactors that are "passively safe." His year with this nuclear brain trust inspired and energized him.

"It really gave me a global perspective," says Reyes. "There's a tremendous need for power in developing nations."

By using standardized designs that are pre-licensed and replicable (versus designing a unique plant for each site), emerging technologies can dramatically cut construction costs. While old-era plants went up at a snail's pace (seven to 10 years), new designs can be built in half the time. Utility companies can begin recouping their investments years earlier. Eyeing the quicker turnaround, U.S. companies have ordered at least half a dozen AP1000s for projects over the next decade.

Like older plants such as Oregon's Trojan (connected to the grid in 1975, decommissioned in 1993, demolished in 2006), the AP1000 is a pressurized light-water reactor. That is, it uses ordinary H_2O to cool the core, where pellets of uranium dioxide are stacked. The difference is that those old plants employed manmade mechanisms

VIRTUAL REACTION

Simulations let researchers "see" at subatomic scales

The new generation of nuclear technology benefits from a transformative technological advance: supercomputing. The conversion from pencils and slide rules to keyboards and computer clusters gives engineers potent tools to tighten safety margins and trim costs, tools that were unimaginable in decades gone by.

Next to safety, cost is the biggest hurdle for the nuclear industry. By helping to eliminate waste and minimize errors, computing can make nuclear energy more competitive with coal, hydropower and natural gas. And the best way to do that is through simulation.

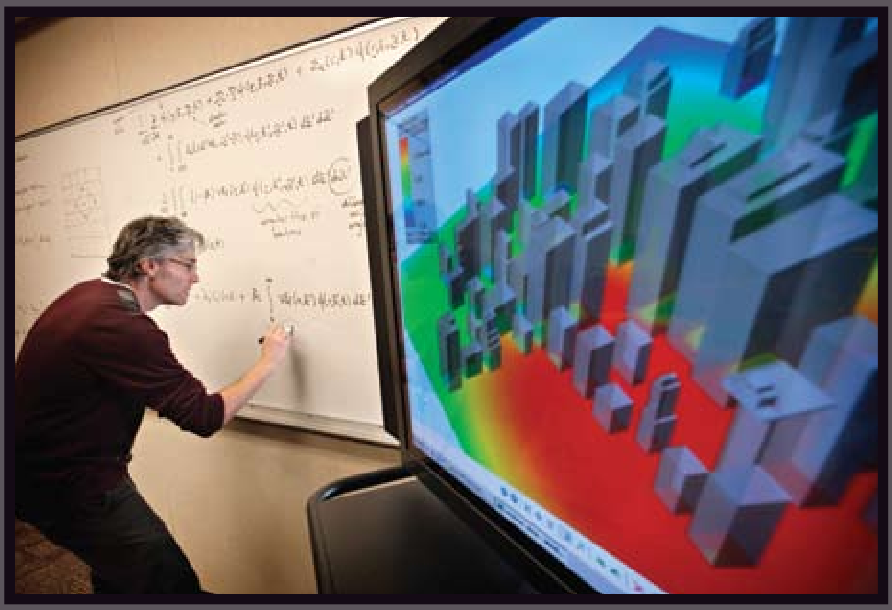
"Simulation lets us predict much more accurately how a system will behave," explains OSU researcher Todd Palmer, who specializes in fundamental physics. "In the nuclear industry, it has been very, very valuable in terms of 'squeezing the margin' out of a system" — that is, eliminating extraneous costs by making more precise projections in advance.

Simulation, he says, is the "third branch," behind theory and experimentation, of 21st-century science. "It's a sophisticated tool for interpolating amongst the data sets that you gather from experiments," he says. "You can coax details out of these problems you could never measure in an experiment."

Working at the nexus of physics, mathematics and computer science, Palmer creates digital enactments of nuclear reactions occurring on a subatomic scale. Although the reaction can't be seen visually, it can be pictured theoretically. Using thorny computations and computer code, Palmer can simulate the invisible chain reaction set off by uranium 235 isotopes inside nuclear fuel.

"It's intensely mathematical," says Palmer. "These problems are so hard, we call them 'trans-computable.' They can overwhelm any computer."

Computer-aided design is also nurturing the nuclear renaissance. "In the old days — 20, 30 years ago — all the drawings were done by hand," Assistant Professor Brian Woods notes. "You'd have electrical drawings, mechanical drawings, civil engineering drawings. Now, with computer-aided design and manufacturing (CAD/CAM), you can design the entire plant in three dimensions before you even pour any concrete."



Simulating nuclear reactions, says OSU nuclear physicist Todd Palmer, reveals details that are difficult to measure through experiment.

THE WASTE QUESTION

Recycle through reprocessing

When José Reyes shows folks around the Radiation Center, he likes to hold up a small, black cylinder about the size of a pencil eraser. "This," he says, "is a replica of a uranium fuel pellet. A pellet like this holds as much energy potential as three barrels of oil, one ton of coal, and 17,000 cubic feet of natural gas."

As compelling as those comparisons are, they don't address the long-term disposal of spent fuel. At OSU, these back-end issues, too, are getting attention. Alena Paulenova, a radiochemist from the former Czechoslovakia, is investigating ways to reprocess spent fuel. Reprocessing promises not only to squeeze more energy out of the fuel, but also to shrink the volume and slash the radioactivity of the remaining waste. About 97 percent of the spent fuel can be recycled, leaving only 3 percent as toxic waste.

One of three women on the eight-professor faculty (a female-to-male ratio that Todd Palmer lauds as "off the charts" in a male-dominated field), Paulenova is studying the chemical properties of actinides (radioactive elements such as uranium, plutonium, neptunium and americium) for the Advanced Fuel Cycle Initiative (AFCI). Current U.S. Department of Energy (DOE) plans for the ultimate disposal of solidified wastes in a deep, stable geological repository call for lower toxicity and, ultimately, novel reprocessing protocols. This is where Paulenova's research, funded by the DOE's Nuclear Energy University Program, fits in.

Unlike countries that recycle nuclear fuel (such as France and the United Kingdom), the U.S. employs the "open fuel cycle," which generates thousands of tons of long-lived radioactive waste. The processes being developed by Paulenova and other AFCI researchers — chemical separation of long-lived from shorter-lived elements — will lead toward a "closed fuel cycle" offering a dual benefit: reducing radioactivity as well as proliferation risks.

"Reprocessing spent fuel to recover uranium and plutonium avoids wastage of a valuable resource," says Paulenova. "They both can be recycled as fresh fuel, saving up to 30 percent of the natural uranium that would otherwise be needed. Recyclable materials currently locked up in storage could conceivably run the U.S. reactor fleet of about 100 gigawatts for almost 30 years without any new uranium input."

The waste that ends up in nuclear disposal sites will have a much more abbreviated half-life (the time it takes to lose half of its radioactivity), thus decaying to a relatively harmless state in several hundred years — compared with 100,000 years for waste stored without reprocessing.

"After chemical reprocessing, the waste will decay to an acceptable level of radiation in as little as 300 years," says Paulenova. "An 'acceptable radiation dose,' as defined by the NRC, means a level similar to natural uranium ore."

Another area of investigation seeks to bind plutonium to inert elements, rendering it un-useable for nuclear weapons production. The risk of proliferation would plummet, notes Paulenova.

Dramatic reductions in nuclear waste are possible, says Alena Paulenova, through spent-fuel reprocessing.

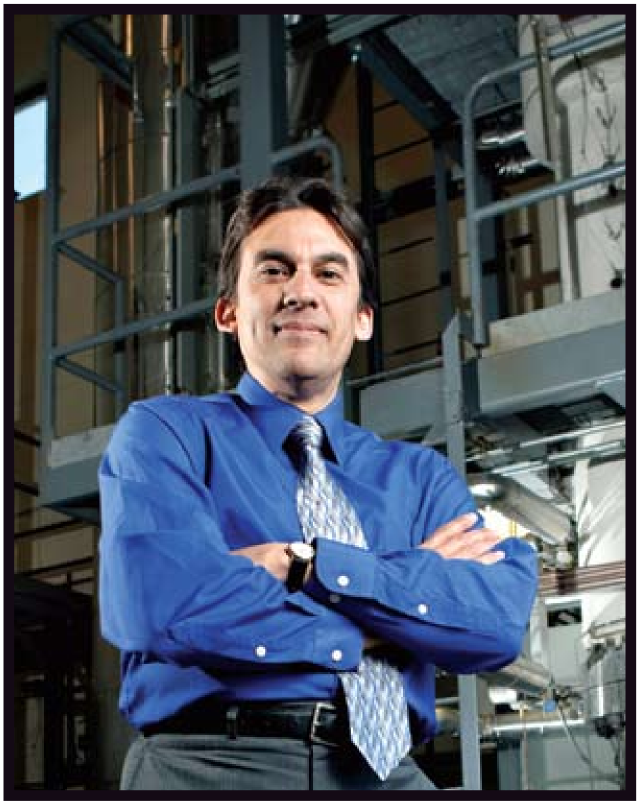
(valves and pumps), while the new design relies on natural forces (gravity, convection, evaporation and condensation) to shut down and cool the reactor during an accident. For 72 hours, no human action is needed. The flawed-operator nightmare (a doughnut-sated Homer Simpson snoozing at the controls of the fictional Springfield Nuclear Power Plant) is thus vanquished.

"The human element is often the weak link in reactor safety," notes Palmer.

Another study could lead to better monitoring through remote sensing with an "antineutrino detector." Alex Misner of Beaverton, Oregon, one of Palmer's graduate students, is collaborating with researchers at Lawrence Livermore and Sandia National Laboratories to distinguish normal operations from the abnormal use of a reactor for weapons material production. Down the road, the finding could lead to closer monitoring of nuclear activity in friendly — or unfriendly — nations.

Small Is Beautiful

The future of nuclear also comes down to a question of scale, and on that issue, pending certification, OSU technology is already moving into the international marketplace via NuScale Power. This OSU spinoff company, headquartered in downtown Corvallis, is developing compact, portable reactors that can be manufactured in the Henry Ford tradition, on an assembly line, then placed right where they're needed, singly or in clusters. About the size of a single-wide mobile home, the 300-ton units can be hauled by truck, barge or train. As local demand grows, communities can add new units. For developing nations, when the fuel is spent, the module is replaced, tightly monitored by the International Atomic Energy Agency. With current technology, the fuel will last for two years. This "distributed energy" model — ideal for remote locales (the Alaska bush, for instance) and small communities (especially in developing countries) — obviates the need for stringing power lines to a central grid.



José Reyes is taking OSU's small-scale, passively safe technologies global through the Corvallis-based spinoff company, NuScale Power.

Reyes, chief technology officer for NuScale, and CEO Paul Lorenzini, former president of PacificCorp (owner of Pacific Power) with an OSU Ph.D. in nuclear engineering, are scouting U.S. manufacturers and seeking customers across the globe. "It's exciting," says Reyes. "You lay out a map of the country and they say, 'This is where we need power.'"

The 12-module design, developed and tested in Reyes' lab, is now in the pre-application phase of the complex certification gauntlet. NuScale principals meet quarterly with the NRC, the agency that confers what Reyes calls the international "gold standard" of official approval. Data show a steep spike in safety for compact, passive reactors compared with conventional reactors. "Our risk study showed that the probability of an accident is more than extremely low; it's remarkably low," says Reyes.

Shrinking a passive design into moveable modules, encasing them in dual steel chambers and submerging them in a pool 65 feet beneath the earth pushes the chance of an accident almost off the charts, according to Reyes. "It's really a very, very robust design," he says. "I would describe it as a reactor inside a thermos bottle underwater, underground. On top of that you have a big, concrete lid. All of those serve as barriers to releasing radiation."

Comfort Zone

With nuclear technology surging forward, some of the old fears are fading. "For a long time, the biggest challenge we've had is public acceptance of the technology," says Palmer. "But younger generations are so much more comfortable with technology and so much more reliant on electricity for everything they use, from cell phones to PDAs to Xboxes. They're also so much more environmentally conscious. Those two things are coming together to really help people understand the value of nuclear technology."

Adds OSU nuclear engineer Brian Woods: "Tom Brokaw always talks about the World War II generation as the 'greatest generation.' Well, I believe the current generation of students will be the greatest generation because they'll be the ones to solve the world's energy crisis — and maybe even save the planet." terra

HIGH HEAT

From nuclear to hydrogen

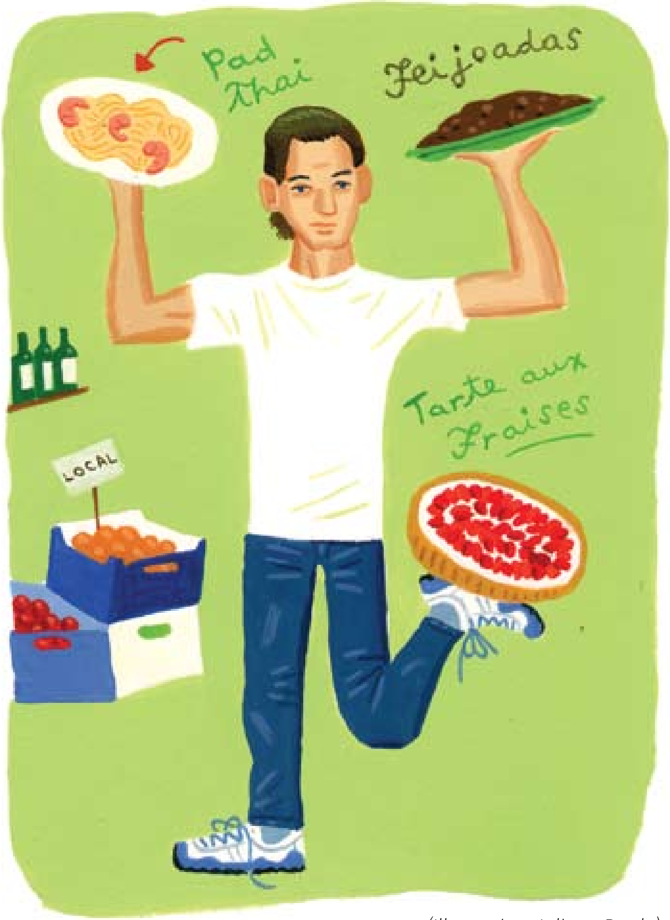
Farther out on the drawing board is another promising design: the high-temperature, gas-cooled reactor. The fuel, sand-like granules of uranium coated with silicon carbide, is cooled by helium instead of water. Not only is helium the universe's second most abundant element, it's also extremely stable and lighter than air (ideal for party balloons). If helium escapes into the atmosphere, it vanishes benignly into the heavens.

These reactors run at 1,000 degrees Celsius, three times hotter than light-water reactors, a level that significantly boosts efficiency. Even more intriguing to scientists is the possibility of producing hydrogen via a process called "thermochemical water-splitting." At very high temperatures, chemical catalysts can be used to "crack" H_2O molecules, thus freeing the hydrogen, a clean-burning alternative to petroleum. If, as many experts predict, future vehicles are fueled by hydrogen, gas-cooled reactors could power our cars at the same time they light up our homes, says OSU researcher Brian Woods.

Woods is focusing on the safety of two types of gas-cooled systems: "pebble bed" (the fuel is encased in tennis ball-sized "pebbles" of graphite tough enough to withstand mega-temperatures) and "prismatic block" (the fuel is contained in a cubic or hexagonal graphite lattice). With $6 million from the NRC, he and Todd Palmer are collaborating with the University of Michigan and Texas A&M to build a one-quarter-scale gas reactor test facility — unique in the nation — to test how the systems perform in even the worst-case scenario.

"It's our job," Woods says, "to make sure that no matter which design is used, it meets a rigorous standard, that you can say with absolute confidence that it will be safe in any and all accident conditions."

A new generation of high-temperature reactors cooled by helium is the subject of Brian Woods' research.



(Illustration: Juliette Borda)

Market Globally, Eat Locally

Think pad Thai, gyros, specialty pizza and bobotie

Dann Cutter has maintained a reactor on a nuclear submarine and, for the past 12 years, kept the computer networks running at Oregon State University's Hatfield Marine Science Center. He serves on the Waldport, Oregon, city council and two state advisory boards (rural health care and transportation). Why, then, would he return to college for more education?

The answer is personal, best explained by a photograph of his 4-year-old daughter, Kacey. "When Kassandra was born in 2004, I decided it was time to do something serious about my life goals," he says.

Today, the student in the College of Business and University Honors College is completing a bachelor's degree in business finance with minors in resource economics and mathematical sciences. Next fall, he will enter OSU's MBA program with the support of a Graduate Laurels Scholarship. In 2008, with sponsorship and financial support from the Austin Entrepreneurship Program, Cutter was one of 13 Americans accepted into an international fellowship at Stanford University. The Roundtable on Entrepreneurship Education (REE) teamed him up with students from China, Thailand and Australia and charged the group with developing a proposal for a sustainable food business.

Communicating through e-mail, Cutter and his peers shared their cultures and food specialties. They discussed hurdles for starting new businesses in their respective countries.

"Assumptions varied for each of us," says Cutter. "We take food safety regulations for granted in the U.S., but in Thailand, they're still developing their approach to food additives. Clean water is something else we take for granted, but you can't assume it will be available in other parts of the world."

Last October, 60 REE program participants representing nearly every continent met in a one-week workshop at Stanford. Cutter and his team created a business proposal combining a flair for international flavors (pad Thai, gyros, specialty pizza, bobotie and feijoada) with the requirement of locally produced foods and recipes. The group's presentation has generated follow-up interest from a venture capital firm.

During the workshop, Cutter introduced students to Oregon's diverse food industry and explained its reliance on international markets. He reached out to Oregon processors for samples of crab and shrimp, pears, hazelnuts, wine and microbrews and took cases of these foods to share with the other participants.

"It's easy to see markets that exist in your own local area," says Cutter. "This experience showed me that all entrepreneurship happens in a global market. You need to look at a much larger picture. Business creation is a worldwide endeavor."

Cutter maintains contact with the members of his group. "You come to understand that there are students around the world just like you who worry about paying their tuition and getting a job," he says.

Cutter's personal interest is the energy industry. His Honors College thesis focuses on the prospects for wave energy, but he has gained a broad understanding of how entrepreneurial behavior applies to many disciplines. "Entrepreneurship isn't just for business students," he says. "It's for students in agriculture, science, engineering and all others. It's as fundamental as math, reading and writing."

— NICK HOUTMAN

Sensors for Safety

Microbiologists aim for rapid, accurate monitoring of food and water

In her lab, microbiologist Janine Trempy (center), assisted by students Janine Hutchison (left) and Stephanie Dukovcic, investigates how pigmented cells of Siamese fighting fish can alert food inspectors and consumers to dangerous bacterial toxicity. (Photo: Karl Maasdam)

The news grabbed national headlines in early 2009: eight dead, hundreds sickened by food poisoning in 34 states. After investigators traced the outbreak to *Salmonella*-tainted peanut butter from a Georgia plant, stores pulled thousands of products from their shelves. Worried consumers tossed suspect items into the trash.

Clearly, contaminated foods must be destroyed. But every year, perfectly safe products can end up in the waste bin for lack of onsite testing technologies that are easy, reliable and directly assess microbial toxicity. A 2006 *E. coli* outbreak (strain 0157:H7) cost California spinach farmers $74 million. In 2008, tons of tomatoes were dumped during a *Salmonella* outbreak before the real culprit, a Mexican jalapeno pepper, was identified. Cost to growers: an estimated $450 million.

Until now, there's been no quick, accurate way to directly test food products for bacterial toxicity. But a breakthrough in the laboratory of OSU microbiologist Janine Trempy promises to help limit food-borne illnesses and spare lives while potentially saving companies millions in unnecessary recalls.

This very big discovery turned up in cells of a very small fish.

Trempy discovered that the pigment cells of the Siamese fighting fish, *Betta splendens*, act as a natural alarm — a "biosensor" — signaling the presence of toxin-producing bacteria that contaminate food or drinking water. Scientists had observed that the brilliantly hued fish gets lighter in color when stressed or exposed to toxic chemicals such as mercury. Trempy and her team of students observed the same color-change reaction when they exposed the fish's red pigment cells, called erythrophores, to toxin-producing bacteria such as *Salmonella*, *Bacillus cereus* and *Clostridium botulinum* (which causes botulism and has potential for use as a biological weapon).

"We discovered that the red pigment cells respond immediately to certain food-associated, toxin-producing bacteria responsible for making humans sick," explains Trempy, associate dean of the OSU College of Science. "This response to bacterial toxicity can be easily seen under a low-power microscope and quickly quantified, numerically, to describe the intensity of the situation."

The discovery's potential was immediately clear. Food inspectors, grocers, manufacturers, farmers and even consumers, could test food for safety right at the farm, the factory, the retail outlet or the home kitchen. Recalls could be done more strategically, pulling only foods that are proven dangerous rather than sweeping away everything with a "better-safe-than-sorry" approach.

Current detection technologies are simply too limited to be widely effective, Trempy explains in a recent paper in *Microbial Biotechnology*. Typically based on DNA or protein analysis, these technologies are unable to distinguish between live and dead bacteria, she says. Nor can they directly assess the degree of toxicity of the offending bacteria. They cannot recognize new or emerging strains. And there are challenges of speed and logistics.

"These challenges often include time-intensive sampling and testing practices, long culture times to increase the number of bacteria to detectable levels and costly shipment methods to move samples to a central laboratory for additional analysis to verify toxicity once a specific bacterium is detected," she says.

With the biosensor technology newly patented, Trempy is moving toward commercialization with a team of researchers at Cornell University. They are working to devise a portable, easy-to-use testing kit using advanced optics and software for image capture and interpretation — what she calls "futuristic hardware." She envisions a time in the not-too-distant future when food processors, distributors, handlers and consumers can find out instantly whether food is safe to eat.

— LEE SHERMAN

"A production is a series of moments, and each moment needs to be worked and given attention to get the timing and the mood right."
— Elizabeth Helman, Director

stage kiss

BY JANA ZVIBLEMAN | PHOTOS BY JIM FOLTS

Romance, history and science converge in OSU theater production

Arianne Jacques pondered the graphs projected on the screen and listened intently to Professor Ken Krane's explanations — Newton's First Law of Physics, Chaos Theory. She filled her notebook with scribbles about thermodynamics, algorithms, fractals and cosines.

But at "iterative process," the 21-year-old junior exclaimed, "I don't get it!" and tossed down her pen. She giggled as she looked around at Daniel Mueller and other friends in the lecture hall near Withycombe Theatre's backstage. Their return glances displayed concentration, confidence or consternation.

It wasn't that Jacques and the others needed to master facts for an exam. Their only test would be whether they understood enough to act as if they thoroughly comprehended the math and physics concepts.

Fortunately, acting is what Jacques does "get." She and her friends had landed roles in the University Theatre's winter production of *Arcadia* by Tom Stoppard. This was their first week of preparation. A veteran of the stage, Jacques is adept at drawing upon personal experiences; in her audition for teenage Thomasina, she used facial expressions, body language and voice to be playful, witty and flirtatious.

But, facing a complex role, Jacques said with a smile, "Thomasina is a genius, and I am not! I'm good at memorization, but I need to grasp how I'm going to say things before I get the words down. If I don't know what I'm meaning, there's no point; it'll sound flat."

That's why director Elizabeth Helman had arranged for this special lecture with emeritus physics professor Krane. And why, as Jacques grabbed her pencil again and persevered, later studying her notes and Googling physics Web sites, she gained confidence in the science.

Working intensely for weeks leading up to opening night, Jacques became Thomasina the precocious protégée, convincingly rattling off insightful lines to her tutor, Mueller's character Septimus, such as, "If there is an equation for a curve like a bell, there must be an equation for one like a bluebell, and if a bluebell, why not a rose? Do we believe nature is written in numbers?"

Science and Art

Set in an English country house during two time periods, the early 19th and late 20th centuries, *Arcadia* offers nuanced and challenging roles for students, says Helman. Characters explore the nature of truth, contrasting science with art and poetry, and investigate a mystery about the English poet Lord Byron.

"Stoppard reveals the science in the art and the art in the math," adds Helman, a visiting instructor in OSU's Theatre Arts Program. The play addresses history, landscape design, English literature, botany, gender bias, even sexual mores. With characters separated by centuries, yet juxtaposed at one table, the plot is intricate. It's a romance and a tragedy, a farce sprinkled with hilarious lines.

"*Arcadia* is about the search for knowledge, the human condition. Big ideas about everything, brilliantly. It's perfect for the university," Helman says.

It was also perfect for an interdisciplinary cast. Mueller studies anthropology, and among the other leads, Matt Holland is an English major. Kimberly Holling is in both theater and apparel design and helped sew the costumes.

Career Practice

Mueller appreciated the play's relevance to his academic program. "I study gender inequality, and this play deals with that, in the 1800s and in modern times. And cultural issues like class," he says. "Being inside a character is a different way of examining anthropology and philosophy (his minor). I gain perspective from experiencing my role and the reactions of other characters to mine — also from how other actors react to the script."

As a business major, junior Heather Hewlett has worked in some capacity on every theater production since coming to OSU. For *Arcadia*, she was assistant stage manager. "Theater helps with professionalism, like honoring your commitments. I've called actors when they were late to rehearsals and made sure everyone walked on stage at the right time and had their props. I've made sure lines were right. House managing, I've interacted out front too, greeting audience, taking tickets, handing out programs. Customer service helps me overcome my shyness."

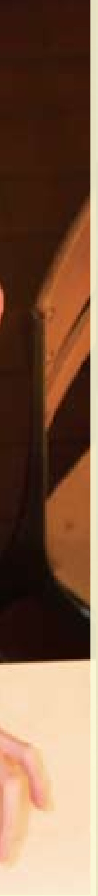
Doubling as *Arcadia*'s choreographer and dance instructor nurtured Hewlett's career plan to open a dance studio. Teaching students to waltz on stage, she found, could be complicated: The actor Mueller had never waltzed, yet his character must dance smoothly enough to teach and lead Thomasina.

Holling, in contrast, enjoys advanced ballroom dancing, yet her character must waltz poorly and reluctantly. She told Hewlett, "It's OK. I can act like a bad dancer!"

Romance on Stage

Once Jacques learned how to act like a math whiz, she had to master the portrayal of romantic passion. Through working together on previous productions, she and Mueller had a comfortable friendship. Yet as their *Arcadia* characters matured beyond flirting, Act 2 brought them to not only the waltz, but also to their first stage kiss. After much joking (and teeth brushing), they made their initial, tentative attempts.

"You're kissing like he's your



"Stoppard reveals the science in the art and the art in the math."
Elizabeth Helman

brother!" Helman called out. "It's cold and uncooked, like sushi! We need hot and spicy. Think Thai food!" Day after day, with the rest of the cast and crew wise-cracking and cheering, Helman coached the couple on arm placement, eye contact, breath, angle and timing.

Helman notes that kissing scenes must be treated like any other choreography in the show, "or else it gets weird for actors. A production is a series of moments and each moment needs to be worked and given attention to get the timing and the mood right," she says.

As dedicated students of the theater, Jacques and Mueller worked so diligently that by the final curtain, the star-crossed lovers and the whole production company had swept the audience off their feet to passionate applause. terra

Students gain confidence as they work with theater professionals to design costumes, to create choreography and to hone other elements of stagecraft.

The OSU Theatre schedule, including two productions in May, is online at ***oregonstate.edu/dept/theatre***

"IT TAKES CHUTZPAH"

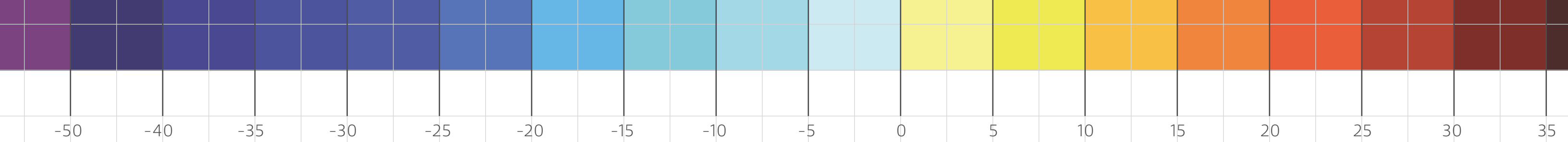
Theater provides training for life

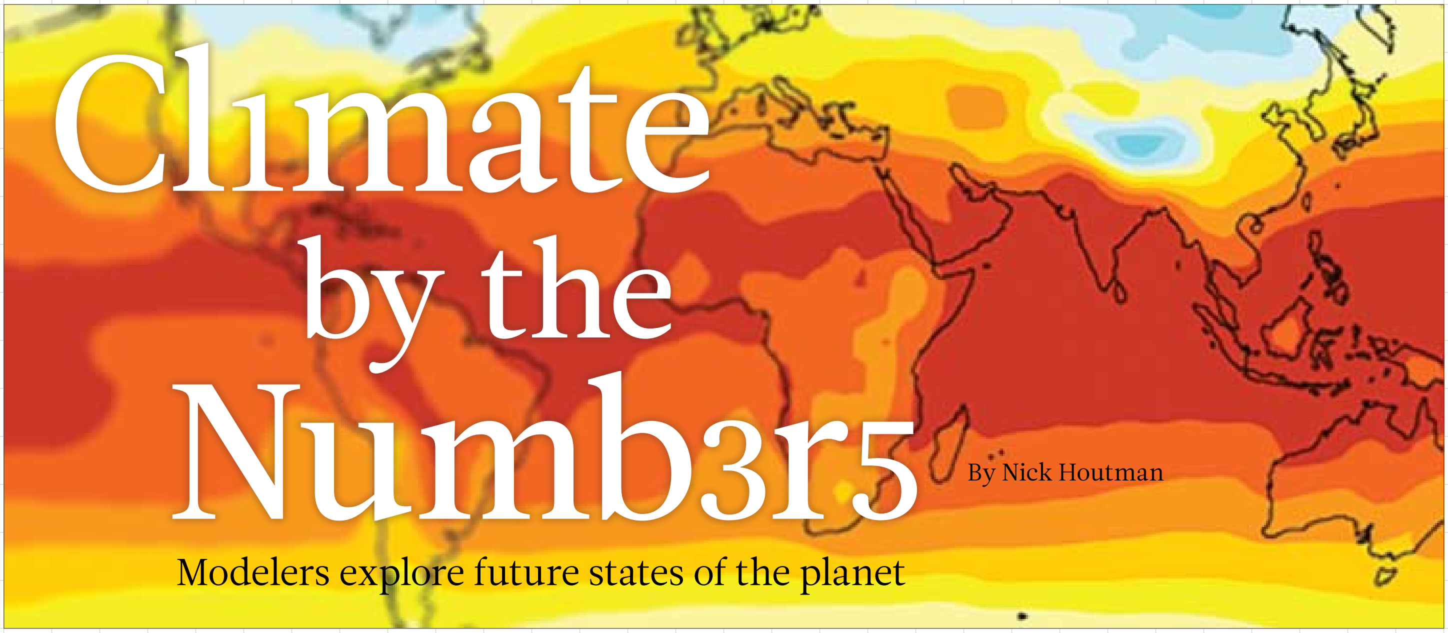
The theater experience enhances education, says Marion Rossi, who has taught OSU theater arts for 15 years. "For example, the whole process increases sensitivity to others. It enhances your ability to think and feel like someone else, connecting on a visceral level. Even if the character is completely different from, even abhorrent to, the actor, you have to think, 'What drives that person?' Whether you go into business, engineering, anything, this will help you in solving problems and entering into agreements with others. What could be more valuable?

"Of course, we also find students gaining in poise," Rossi adds. "It takes chutzpah to get up before 300 people and say, 'Look at me!' That confidence translates into their lives."

The benefits are not only for performers. "In our productions, students are running lights, building sets, dressing people. All gain abilities to work on a team. Yet individuals can push themselves to grow and excel," he says.

Whether in the crew, cast or audience, OSU Theatre exposes students to a wide range of traditions: Greek, Shakespeare and American modern. "We choose challenging subject matter, both public and private concerns, material not necessarily popular or easy to observe. We want students to understand the potential of theater to impact lives," says Rossi.





Climate by the Numb3r5

By Nick Houtman

Modelers explore future states of the planet

You can't just walk into the data center in the College of Oceanic and Atmospheric Sciences (COAS). The sign on the door says you need a pass card. There should be another sign too: Caution, planetary experiments in progress. Inside, computer clusters churn 24/7, spinning out information about ocean currents, winds, air temperatures, ice sheets and flows of energy. Lights blink and fans drone as they cool the machines that run calculations on command from scientists who may be just down the hall or on another continent. In this case, proximity doesn't matter.

Andreas Schmittner's office is a 30-second walk from the data center, but the COAS assistant professor doesn't have to go there to check on his experiments. From his desk, he logs on to his Linux computer cluster at the center and reviews the status of 20 or more projects that he may have running simultaneously.

Schmittner is an oceanographer who devotes himself to climate models, those mathematical descriptions of the real world that allow scientists to envision possible sea levels, ice sheets and temperature and precipitation patterns on a warmer planet. Grounded in physics and tested against real data from the past, climate models range from the simple to the complex. Think of them as alternative futures.

"Models should be regarded as tools to understand the climate system better and to address research questions," says Schmittner. "Depending on the research question you have, you use different tools. Just like in your workshop, if you need to screw something down, you don't need a wrench. You use a screwdriver."

> Models have become the high-tech workhorses of climate science.

In short, models have become the high-tech workhorses of climate science. Scientists rely on them to consider how coastal communities, food and water supplies, forests and weather would fare on a changing Earth.

More than 20 years ago, OSU researchers created models to study global atmospheric circulation and the Pacific Ocean system known as the El Niño Southern Oscillation. Today's models are more sophisticated and the goals more ambitious: to make them more realistic (aligned with actual climate data), to incorporate all significant processes and to identify the uncertainties that inevitably affect modeling outcomes.

With better models come results that illuminate how the world may change in coming decades. In a report published in the journal *Global Biogeochemical Cycles* that generated headlines in 2008, Schmittner showed that even if greenhouse gas emissions increase gradually until 2100 and are then virtually eliminated by 2300, the planet would continue to warm for the next 200 years or more.

In 2005, he and colleagues in Europe and North America reported that doubling the amount of carbon dioxide in the atmosphere (now about 35 percent higher than before the Industrial Revolution) could affect the North Atlantic with steep plankton declines and a 25 percent slowdown in currents that carry heat toward Europe. Actual observations based on water temperature and salinity suggest that currents may actually be slowing, but scientists are still debating what the data mean. "We have to get more observational data and improve our models," Schmittner told the BBC.

An Uncertain Future

Future scenarios amount to potential conditions in a changing world, not to firm predictions. “We can’t say exactly how much warmer the climate is going to be in 50 years,” says Karen Shell, an assistant professor in COAS. “Part of that is uncertainty in the science and how we translate the science into the models. You can’t take every single cloud and put it into a model. We don’t have the computational resources to do that.”

Shell came to OSU in 2008 from the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. She studies variations among the two dozen or so global circulation models used by the international climate science community. In the course of her work, she downloads so much data that she has generated calls from OSU network technicians. “They were concerned that my computer had been infected by a virus,” she says.

Data from modeling runs and from the field (including satellites, ocean buoys and monitoring stations on the polar ice sheets) are a modeler’s bread and butter. They contain clues about what drives the climate system over long periods of time. Shell and her colleagues analyze how models treat factors such as solar energy flows at the top of the atmosphere (how energy is absorbed and reflected) and the distribution of atmospheric water vapor from the equator to the poles.

“If you can figure out what’s causing the spread (among model results) and link that to satellite data, you can get clues about cause and effect,” says Shell. “That’s how you make progress. It’s slow progress, but it has to be done.

“I love what I do,” she adds, noting that model results provide important information for responding to the likely consequences of climate change.

Bringing It Home

Over the past two decades, models have improved in both scope (how many physical and biological processes they incorporate) and resolution (the grid or spatial density of a region). They enable researchers to look at what might be in store for Klamath Basin water supplies or for forest fire risks in the western United States. Hydrologist Steve Hostetler has worked on such regional issues for about 20 years for the U.S. Geological Survey. The courtesy professor in the OSU Department of Geosciences continues to work on current and past climate conditions with colleagues at the USGS, OSU and the University of Oregon.

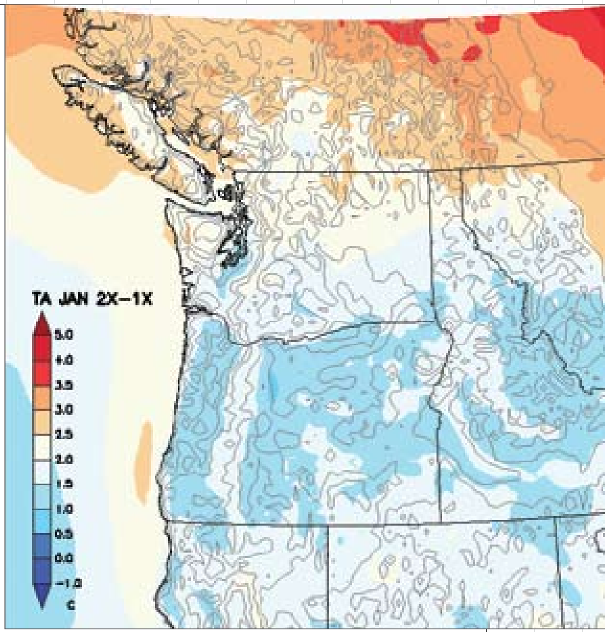
“It’s very collaborative with lots of different ways of looking at things, lots of different types of expertise. I seldom do things on my own,” he says.

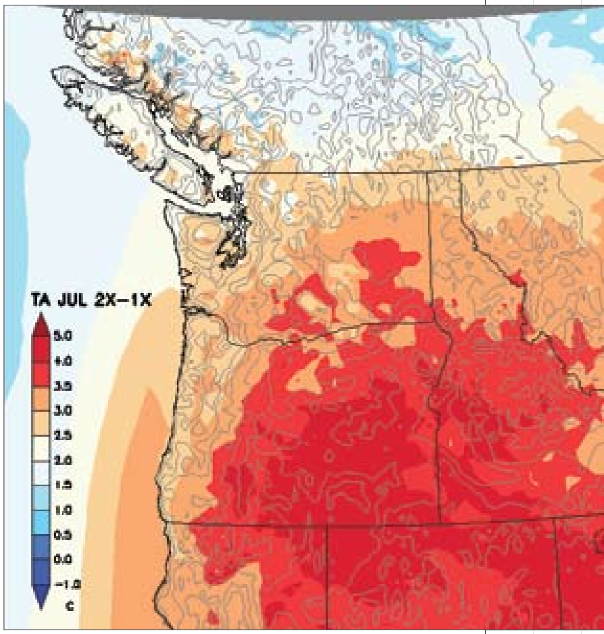
In the late 1980s, Hostetler was doing fieldwork for the USGS when he became interested in paleoclimate, focusing on trends over the last 50,000 years. Since then, he has used the results of global and regional atmospheric models to estimate how climate influences water balances and fire frequency in the West.

For the Klamath Basin, modeling can improve the accuracy of multiyear evaporation estimates, Hostetler has reported. Evaporation is critical for determining how much water is available from year to year. Under a changing climate, accurate predictions will be necessary for resolving the region’s legendary water disputes.

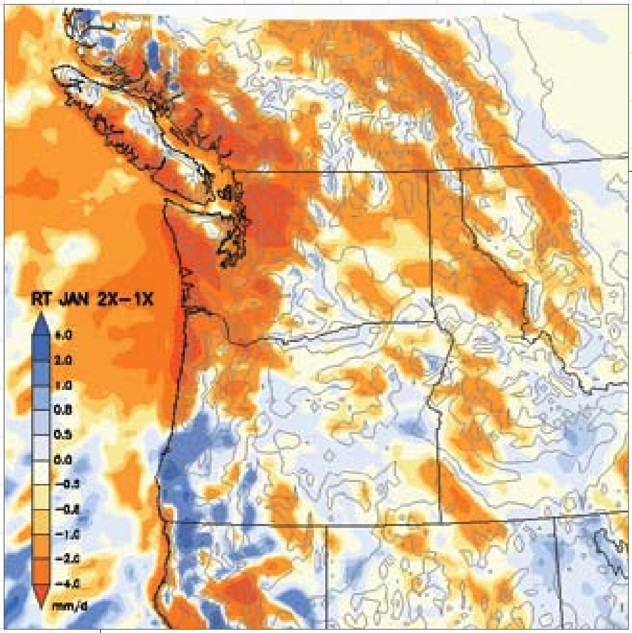
In 2006, Hostetler and two USGS scientists co-authored the *Atlas of Climatic Controls of Wildfire in the Western United States*. For the period 1980-2000, their maps show how fires were closely linked with monthly water and energy balances in eight ecoregions, including the coastal and interior Pacific Northwest. Their report could lead to better predictions of wildfire risk.

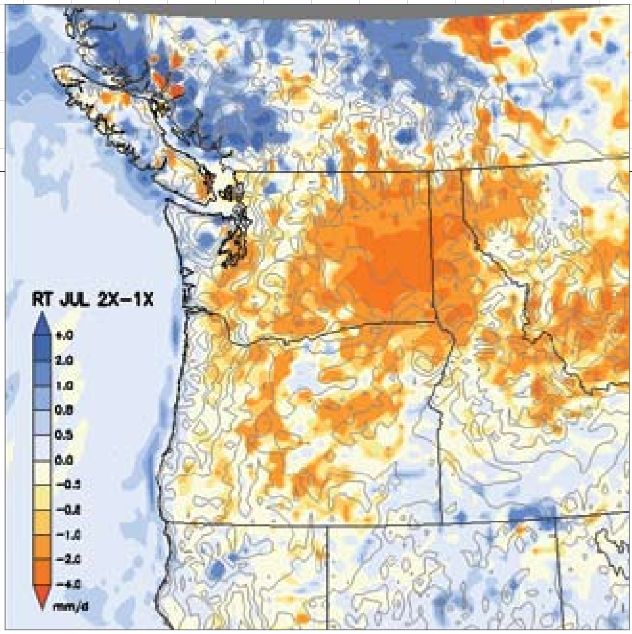
“A lot of modeling is really mundane, boring stuff. But when you complete something and can look at the results and interpret what’s going on, that’s the payoff. These maps are the payoff,” Hostetler says.





Modeled temperature increases in an atmosphere with twice as much carbon dioxide vary with topography and season (January, top; July, bottom) in these maps based on a 15-kilometer grid. (Maps: Steve Hostetler)





If carbon dioxide doubles in the atmosphere, winter precipitation could decline in Northwestern Oregon and Western Washington, according to model results. July precipitation declines are apparent in Eastern Washington and parts of Central and Eastern Oregon. (Maps: Steve Hostetler)

Mining the Data

Behind the doors at the COAS data center are the information systems that make such results possible. “We have the networking, computational and storage infrastructure to move large amounts of data,” says manager Chuck Sears, who salts conversation with talk of “terabytes” (one terabyte equals a million million data points) and “arrays” (large tables of data).

Models aren’t the center’s only source of data. Continuous streams of information from satellites, ocean buoys and other monitoring systems flow into the center’s databanks, enabling scientists to test and to refine their models. And since maps and other visual displays enhance communication among scientific teams and with the public, the center offers state-of-the-art visualization systems as well.

“We’ve created a production studio,” says Sears, “and we’ve enabled 2,000 different devices to be connected outside the center, as if they were in the center. These devices range from desktop computers to handheld devices such as iPhones.”

Increasingly, collaborative climate science is being done in remote offices and at meetings and other locations, not on the premises of computing centers. “Ultimately you have to get all of those data out for real work,” says Mark Abbott, dean of COAS and member of the National Science Board. “It’s going to be personalized and local. You’ll be able to get to it everywhere. The key is the balance between what’s in the center and what’s out on your desktop, your PDA (personal desktop assistant) or what you have in your home.”

Access to a variety of such devices allows scientists at COAS to act like symphony conductors, Abbott adds, orchestrating the different tools they need. “If you’re a real woodwinds expert, you just use that, but if you really want to use some other instruments, you can do that too.

“Supercomputer centers do great things,” he adds, “but the excitement is out on the edges,” where scientific teams are sharpening our views of a changing planet. terra

For more about the College of Oceanic and Atmospheric Sciences, which will celebrate its 50th anniversary July 17-19, 2009, see ***www.coas.oregonstate.edu***

PHILIP MOTE TO LEAD OREGON’S NEW CLIMATE RESEARCH INSTITUTE

Philip W. Mote, a national leader in analyzing the impacts of climate change, will direct the new Oregon Climate Change Research Institute (OCCRI). Established by the state Legislature in 2007, the institute will be located at Oregon State University and help the state plan for and respond to changing environmental conditions related to climate.

In addition to facilitating research and providing information to Oregon decision-makers, OCCRI will support the state’s Oregon Global Warming Commission. Mark Abbott, dean of the College of Oceanic and Atmospheric Sciences at OSU, is the commission’s vice-chair.

The former Washington state climatologist, Mote focuses on climate change impacts, including variations in Pacific Northwest and national snowpacks, sea levels, water resources, precipitation and temperatures. He is a lead author of the fourth assessment report by the Intergovernmental Panel on Climate Change.

“I am really excited to lead this new institute, building partnerships both among researchers across the Oregon University System and between researchers and people who need to understand what climate means for them,” Mote says.

Restoring the Flow

Insects hold the key to improved fish habitat in the Deschutes River Basin

If you had happened upon Lake Creek, a tributary of Central Oregon's Metolius River, in the fall of 2007, you might have seen Matt Shinderman and his Ecological Field Methods students standing nearly knee-deep in the water with dip nets in hand, hovering over tic-tac-toe style grids. And you might have been puzzled when they emptied their nets into buckets and began to pick and sort through the contents.

The biologist at Oregon State University's Cascades Campus and his students were surveying aquatic insects, or macro-invertebrates, to determine how the ecosystem was responding to the equivalent of major surgery.

"Stream macro-invertebrates are a key indicator of biological stability in systems like Lake Creek," says Shinderman, who works closely with Matt Orr, OSU-Cascades and University of Oregon instructor of biology and ecological restoration. Collecting samples before and after the restoration efforts let Shinderman, Orr and the students know how well the insects bounced back after workers with backhoes and dump trucks restored the stream to its original shape.

Lake Creek was once an important spawning ground for chinook and sockeye salmon, but the construction of the Pelton Round Butte dam complex nearly 50 years ago effectively cut off all salmonid migration to it and other tributaries. In order to reintroduce native salmon and steelhead into the upper Deschutes Basin, Portland General Electric (PGE) and the Confederated Tribes of the Warm Springs Reservation, who operate the complex, determined that restoring historically important tributaries was key to their success. Lake Creek was a priority.

"The historic value was high at Lake Creek, and its status was pretty poor for habitat value," says Shinderman, who is also a professional fly-fishing guide. Led by the Upper Deschutes Watershed Council, Deschutes National Forest and the privately owned Lake Creek Lodge, the restoration project aimed to improve fish and wildlife habitat by removing concrete, rock retaining walls and a large pond that had been built in the 1930s.

Back in the lab, Shinderman and his crew counted and identified their insects. Their conclusion: Populations dropped dramatically right after restoration work, but within six months, they rebounded and even showed a slight increase. Although it's too early to say how the stream manipulation will affect insects in the long term, the data clearly show that negative impacts are short-lived.

"We're really going to need, as with most ecological data sets, probably 10 years' worth of data to make any reliable comparisons in terms of before and after the project," says Shinderman. "There are so many variables that impact macro-invertebrate populations."

The Lake Creek project has already provided a useful model of landowner and agency collaboration. "We've definitely gained traction as a result of Lake Creek," says Shinderman. "The results here have generally been positive, and they provide a great opportunity to approach private landowners in the future."

Next up in the Deschutes Basin: Camp Polk Meadow. The U.S. Forest Service, the Deschutes Basin Land Trust, the watershed council and a private landowner plan to restore this section off Whychus Creek, which runs through an old ranch. "This is a highly disturbed system and a significant restoration," says Shinderman. "Lake Creek helped pave the way for this project."

— CELENE CARILLO

Aquatic macro-invertebrates like these mayflies are important indicators of stream health and water quality. (Photo: Bill Gerth)

Students enrolled in a restoration field course collect stream macro-invertebrates with Matt Shinderman, top, and Instructor Karen Allen, lower right. (Photo courtesy of Matt Shinderman)

Cut to the Bone

Wendy Baltzer's surgical technique does the trick for an old dog

As writer and dog owner Lee Sherman takes notes outside the Chang Surgical Suite, OSU veterinary surgeon Wendy Baltzer (center) removes Chewy's torn tissue using state-of-the-art arthroscopic instruments.

The surgical suite in OSU's small animal clinic bristles with crisp efficiency. A masked med tech wearing scrubs of sea-foam green unpacks sterile instruments from stainless-steel carts, treading lightly on puffy blue booties. Above the operating table, a state-of-the-art Stryker scope hangs like a giant jointed bug with shiny hooded eyes. The scene suggests an episode of "ER" — until the patient is wheeled in.

By Lee Sherman | Photos by Jill Bartlett | Illustrations by Ismael Concha

Patient No. 504-775 is a medium-sized, black-and-white canine, flat on his back, a pincushion of IV needles and plastic tubes. His head hangs limply, ears in a reverse flop. Three legs splay wildly, the fourth shaved bare and suspended vertically. Chewy! My graying old Chow mix, his injured leg naked and pink, looks unbearably vulnerable. My heart constricts with love.

I'm sitting just outside the Chang Surgical Suite, nearly pressing my nose to the viewing window while the team expertly preps my dog for arthroscopic surgery. The lump in my throat doesn't stop me from smiling at the incongruity of it all: The mongrel I rescued from the pound 13 years ago for $35 is undergoing a $3,000 treatment at the Lois Bates Acheson Veterinary Teaching Hospital, whose $300,000 scope would be the envy of many human hospitals. The sight of my overweight mutt sprouting IV tubes, his vital signs blipping across a video screen as a nurse swabs disinfectant on his leg, is both poignant and droll.

While Chewy's pedigree is not pure, his zest for life is. Unbridled exuberance is often his undoing. He has been bested by a porcupine (100 quills in the snout), humiliated by a pair of Rottweilers (a nasty bite on the flank), and scolded by me (too many times to count) for gleefully chasing my cat whenever he thinks he can get away with it. In December, he tore his knee running after a deer on our wooded hillside, yelping and sinking to the ground in pain. In doing so, he joined the 1 million other American dogs that go under the scalpel each year with a rupture of the cranial cruciate ligament, a tough, fibrous tissue that holds the leg bones in place. The annual cost to pet owners: $1.3 billion, according to a 2005 article in the *Journal of the American Veterinary Medical Association*.

That's where Wendy Baltzer comes in. As one of a handful of Oregon doctors specializing in canine knee repairs, the assistant professor in OSU's College of Veterinary Medicine performs eight to 10 cruciate ligament surgeries a month. Sixty-pound Chewy, who was referred to OSU by his regular vet in Corvallis, is a mid-sized patient for Baltzer, who has operated on miniatures weighing barely 2 pounds all the way up to mastiffs and Great Pyrenees tipping the scale at 230. "No other species has such a wide size disparity as the dog," she says. "But on the inside, they're all the same."

Seeing Within

Even to a casual observer, Baltzer's command of the scene is clear. The 40-year-old surgeon, noticeably pregnant under her scrubs, strides into the operating theater with a calm certitude gained from 15 years of teaching, research and clinical practice, the past three at OSU. Growing up on a California ranch where animals were as integral to her world as oxygen, she also happened to live next-door to a veterinarian. Add to that her love of science, and a career caring for domestic species was almost preordained.

On this December morning as Chewy lies unconscious, she confers with her team (a resident, an intern, two fourth-year students, an anesthesiologist, a nurse anesthetist and a surgery technician) and then examines the instruments gleaming on a cloth of periwinkle blue: the to-be-expected needles, syringes and scalpels alongside more industrial-type tools — screws, hammers, chisels, drills. I try to push away the thought that they look uncomfortably like medieval torture devices.

Baltzer is about to perform a two-part procedure while the students observe and sometimes assist: arthroscopic removal of Chewy's torn tissue followed by a "tibia plateau-leveling osteotomy" to alter the angle at which his two large leg bones — the tibia and femur — meet at the knee. (See illustrations below)

This technique, invented by late Eugene veterinarian Barclay Slocum, makes the ropelike cruciate unnecessary. Trying to fix the ligament with tissue from a cadaver, as doctors typically do in humans, means months of downtime.

"It takes a year for them to recover," Baltzer explains. "With humans, you can control their activity a lot more closely. But for my patients, I need something that's a lot more stable much more quickly. With this technique, there's much less chance of failure."

As Chewy lies supine and inert, a breathing tube protruding between his teeth, Baltzer cuts two tiny incisions (she calls them "portals") in his knee. Through one portal she inserts the scope — a fiberoptic camera about the size of a breath mint — which is linked to a television monitor. Through the other she guides a tiny instrument called a shaver. Then, watching the magnified image of Chewy's torn tissue on the overhead screen — a glowing kaleidoscope in shades of scarlet, pink and magenta — she manipulates the tools with her small, gloved hands, adeptly cutting away the ragged remnants of the painful rupture that had forced Chewy to totter around on three legs. The shaver sucks up the frayed tissue as it cuts.

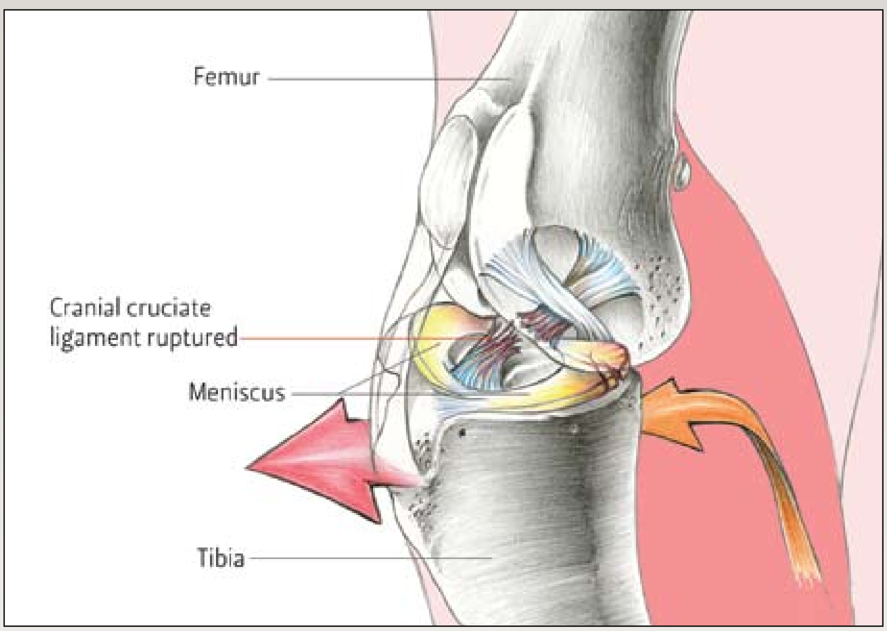
> "Because we're a teaching institution, we try to do everything state-of-the-art."
> Wendy Baltzer

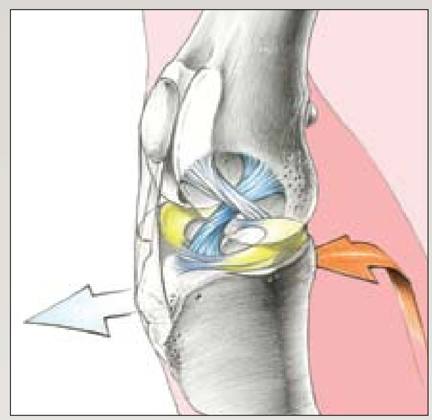
"Learning to triangulate — to figure out where you are inside the joint while watching the monitor — is kind of like playing video games," says Baltzer, who teaches courses in principles of surgery, small-animal surgery and small-animal medicine. "It takes two or three years to master."

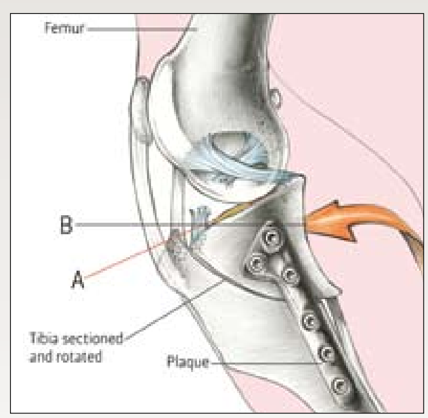
Cadavers and Spleens

Baltzer honed the delicate art of arthroscopic surgery as a resident at Texas A&M University. "To be a surgeon, you have to be kinesthetic," she says. "When I was a third-year vet student practicing surgery on a

Baltzer performed a "tibia plateau-leveling osteotomy" on Chewy. The technique changes the biomechanics of the animal's leg by altering the angle at which the two large leg bones meet at the knee. Normally, the lower bone (the tibia) is inclined at the joint and held in place by the cruciate ligament, which prevents the upper bone (the femur) from sliding off. After arthroscopically removing the torn ligament and meniscus, the surgeon notched the tibia and shifted it forward. A metal plate secures the bone.







VETERINARIAN AND ARTIST

Illustrator Ismael Concha is a graduate student and teaching assistant in the OSU College of Veterinary Medicine. As an undergraduate in his native Chile, he switched majors from art to vet med. "I was fascinated with the anatomy course," he says. "The shape, color and structure captivated me." He is experimenting in computer animation and aspires to a career in medical and science communication.

cadaver dog, I was the first person in the class to get the spleen out. I loved it! My professor came to me and said, 'You should do surgery.'"

In those days, minimally invasive surgery was an emerging field. Not until last year did it become coursework required by the American College of Veterinary Surgeons.

The scope Baltzer is using on Chewy, which international medical equipment manufacturer Stryker provided to the teaching hospital for about half-price, makes OSU uniquely positioned in the state. "As far as I know," Baltzer says, "we're the only referral practice in Oregon that does arthroscopy on all knees. Because we're a teaching institution, we try to do everything state-of-the-art. It's more time-consuming than traditional surgery, and it's less profitable because of the equipment cost. But research has shown that arthroscopy has a much quicker healing period. The patient is walking on the leg a lot sooner, and they're much more comfortable postoperatively."

After the damaged ligament and meniscus (a pillow-like disc that cushions the joint) are gone, Baltzer opens the leg for Step Two of the procedure. I had been lulled by the relatively bloodless arthroscopy, so I'm jolted by how fast the wads of gauze being packed around Chewy's exposed bone are soaked in blood. I wince at the electric drill's high-pitched *whirrrrr* as the doctor slices into the bone. Trying to quiet my nerves, I take note of Chewy's chest rising and falling, rising and falling. I scrutinize the anesthesiologist, whose eyes are fixed on the rainbow of electronic signals flowing rhythmically across a computer screen to monitor blood pressure, heart rate and oxygen levels. Everything's OK. I will myself to take a deep breath.

The last step before closing the incision is to affix a stainless steel plate over the cut bone. Drilling holes in bone isn't all that different, Baltzer asserts, from drilling into wood for the carpentry projects she does at home with her husband, Craig Ruaux, an assistant professor in internal medicine at OSU. Using a depth gauge, she judges which size of surgical-grade screws are needed to secure Chewy's new leg plate.

PROVING GROUND FOR VETERINARY PRACTICE

In 2008, Chewy was one of almost 6,000 dogs and cats referred by veterinarians across the Pacific Northwest to OSU's small-animal clinic and hospital, a leading institution not only in minimally invasive surgery but also in therapeutic laser research and treatments for cancer, cardiovascular disease and other illnesses.

After his surgery, Chewy participated in a double-blind study (meaning that nobody knows which patients are getting the therapy and which are getting a placebo) conducted by his surgeon Wendy Baltzer. She is administering low-level laser treatments to 12 subjects to test whether the technique speeds healing after surgery. Another recent study led her to invent a new method of Achilles tendon repair using a muscle flap as described in the March 2009 issue of *Journal of Veterinary Surgery*. And with a seed grant from the American Kennel Club Canine Health Foundation, she is currently looking into hormonal links to the growing incidence among dogs of cruciate ligament ruptures like the one that hobbled Chewy.

Baltzer's career demonstrates the three-pronged mission of a land grant university. That's because teaching, research and outreach are tightly bound into every aspect of her practice. It's this tripartite opportunity — to mentor aspiring veterinarians, to investigate novel treatments and to heal cherished pets — that keeps Baltzer in academia when she could earn significantly more in private practice. She sums up her commitment this way: "You can't help but love coming to work."

An anesthetized chow mix gets world-class care for a torn ligament.

Tail End

When the last bit of hardware is in place, the surgeon catches my eye through the viewing window. "Wait there," she mouths. A minute later, she rounds the corner and walks down the hall toward me, shaking loose her hair from the blue bonnet.

"It went great," she assures me. "Now there's nothing left but the suturing. Chewy will be fine — he just won't be able to run around like a maniac."

As she heads out to do rounds with students assigned to clinical rotation, I look back at the OR where the resident is closing the skin over the plate glinting in Chewy's leg. The suite's crisp sterility has been marred by wastebaskets overflowing with stained towels and bloody gauze. I think about how far Chewy's leg has carried him, the hundreds of miles of beach sand, forest trail, park lawn and city sidewalk we've trekked together, his nose scenting the way.

With his meniscus gone he'll get arthritis eventually, Baltzer says. And his days of table scraps are over: Per doctor's orders, he'll come home to a strict diet. Losing his excess weight will help prevent a rupture on his other knee.

This plain dog — who a friend once noted is "always smiling" — has been given another chance to romp and snuffle and snuggle and grin. As for me, I've been granted more time with the four-legged pal of unknown lineage who can melt my heart with a simple wag of his tail. terra

Building Materials for Sustainability

In the burgeoning green building sector, Oregon is poised to become a national leader. A new R&D partnership forged with cross-university linkages positions the state as a major powerhouse in sustainable materials, technologies and designs.

Oregon BEST (Built Environment and Sustainable Technologies Center) has pulled together $1.6 million in multi-source funding to infuse and expand research efforts under way at Oregon State and Portland State universities. OSU will create a green building materials lab, where engineers and forestry scientists will work on projects such as super-strong hybrid poplar, environmentally friendly concrete and recycled-plastic insulation. PSU's new green building research lab will draw researchers from across the state to use infrared cameras and thermal-characterization equipment to test building features such as green roofs, window glazing, interior moisture levels and surface temperatures.

The new partnership will put Oregon on track for a federally funded research center down the road, experts predict.

"By collaborating between campuses," says Scott Ashford, head of the OSU School of Civil and Construction Engineering, "Oregon becomes a force to be reckoned with in the green building sector."

Learn more about sustainable-building research at *oregonbest.org*

On the Trail of America's First People

Along the Oregon coast, in Idaho's Salmon River canyon and in Baja California, Loren Davis has searched for signs of North America's earliest inhabitants. His work along the southern Oregon coast has pushed back documented occupation of this area by 1,500 years.

Now, the OSU archaeologist will take a deeper look into the inland and coastal routes used by ancient people to reach the Americas. Davis has been named the executive director of the Keystone Archaeological Research Fund, established through a $1 million gift from Joséph and Ruth Cramer of Denver, Colorado.

The fund will provide research opportunities for students and new equipment for field studies. Davis uses Earth science techniques to identify sites where ancient people could have lived, made stone points or stored food. Recently, his efforts have extended underwater. Last May, he participated in a search for submerged prehistoric sites off the coast of Baja California Sur. He hopes to use similar methods to find early sites off the Oregon coast.

Buzz about New OSU Honeybee Specialist

Ramesh Sagili arrived in Corvallis in February to start a honeybee research program targeting mites, pesticides, stress and nutrition. The new OSU bee specialist is part of an initiative to help ensure that there are enough healthy honeybees to pollinate Oregon's crops.

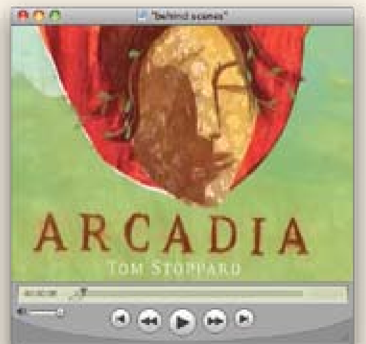
Sagili says Varroa mites, nutritional deficiencies or other factors might be the cause of colony collapse disorder, which occurs when adult honeybees abandon a hive. Sagili's position was created at the request of Oregon agricultural groups worried about the health and supply of honeybees, which are crucial pollinators for many of the state's crops, including blueberries, pears, cherries, apples and vegetable seeds.

"Colony collapse disorder is so complex that it will be a long time before we arrive at a conclusion as to what is causing it," Sagili adds. "But meanwhile, beekeepers need to take steps to maintain healthy and strong colonies."

See Terra on the Web at Oregonstate.edu/terra

Anatomy of a Play

Hear from the actors and see behind-the-scenes preparations for the OSU Theatre production of *Arcadia*, an award-winning play by British playwright Tom Stoppard. Empathy, communication and teamwork are some of the skills students learn as they gain confidence on the stage.



In His Own Words

Tracy Daugherty loves a good story and knows how to tell one. In March, the OSU English professor gave a reading from his latest book, *Hiding Man: A Biography of Donald Barthelme* (St. Martin's Press, 2009), at Oregon State University. Listen to excerpts about the writing assignment, working with editors at *The New Yorker* and Barthelme's visit to Corvallis.

Reactor Core

See the core of OSU's research reactor, which is bathed in a characteristic blue glow resulting from the interaction of high-energy electrons and water (also known as Cerenkov radiation). While the center of each fuel rod typically reaches 350 degrees Celsius (662 degrees Fahrenheit), the average temperature of the surrounding water is only about 35 degrees C (95 degrees F), more like bath water. OSU researchers use the core for imaging studies, materials analysis, radiation health physics applications and other topics. The reactor serves many OSU departments and universities around the world.

Kearney Hall, Showcase for Civil Engineers

An antiquated building on OSU's northeast corner has undergone a thoroughly modern makeover. Celebrants who attend Kearney Hall's grand opening on May 15 will observe its 19th-century heritage faithfully refurbished on the exterior. But on the inside, Kearney has been utterly transformed.

With its recycled materials, nontoxic finishes, salvaged woods, efficient lighting, low-flow fixtures and native landscaping, it is a stellar example of 21st-century sustainability. Certification for meeting U.S. Green Building Council LEED (Leadership in Energy and Environmental Design) principles is pending.

Being a healthy place for Earth and earthlings, however, is far from Kearney's only asset. The building, home to the School of Civil and Construction Engineering, is also a showcase for state-of-the-art engineering principles. As students climb the fir-plank stairs and walk the polished-concrete halls to their classes in the sleek new classrooms, lecture hall and multi-use teaching laboratory, they see materials and structures that are typically hidden. Exposed ducts and valves, pipes and wires, beams and bolts not only lend an edgy aesthetic, they also demonstrate construction in action. Students can even peer through glass portals to see structural secrets within the walls. In essence, the building is itself a teacher for tomorrow's engineers.

Formerly Apperson Hall, the building was renamed in honor of alumni Lee and Connie Kearney (Civil Engineering, 1963, and Education, 1965, respectively), whose generous $4 million gift anchored the $12 million project. Programs housed in Kearney Hall include the Kiewit Center for Infrastructure and Transportation and the Robert C. Wilson Graduate Program in Business and Engineering.

Tours for the public will be given on May 15 from 1 to 4 p.m., followed by the grand opening celebration at 4:30 p.m. in front of Kearney Hall at the corner of N.W. 14th Street and Monroe Avenue.

Where Grass Seed Is King

Oregon's Willamette Valley is the undisputed "grass-seed capital of the world." In close partnership with growers and scientists at the U.S. Department of Agriculture, OSU researchers and agronomists have been at the forefront of an industry worth $500 million today.

1909 Seed Lab starts up on campus for research and testing.

1920 Grass seed introduced to the Willamette Valley and, by 1924, is a $1 million industry.

$1 MIL

1929 Fluorescence test introduced to distinguish perennial from annual ryegrass species.

1937 Oregon State Agricultural College's seed certification service begins inspection for germination rates and purity requirements.

1950 Grass seed is a $30 million industry in Oregon.

$30 MIL

1970s Research conducted on alternatives to open-field burning, used since the 1940s to control diseases. Studies of air movement helped farmers control smoke. Mechanical residue treatments incorporated into cropping systems.

1992 – 1997 Research on non-burning alternatives, crop systems and straw uses helps farmers respond to a law reducing open-field burning.

1998 OSU testing of toxic compounds in straw-borne endophytes (fungi living inside plants) saves Oregon's annual straw export market of about 300,000 tons, mostly to Japan.

2000-2005 Global grass-seed demand pushes rapid harvesting, cleaning, labeling and shipping. Redesigned seed inspection stations in the Seed Lab cut certification turnaround from 20 days to seven.

2008 725 million pounds of forage and turf-grass seed produced in Oregon, and 800,000 tons of grass straw exported off-shore for livestock feed.

Envisioning the Forest

Computer models combine economy and ecology

John Sessions coaxes maximum efficiency out of the intensely complex puzzle of forestry with a careful eye to minimal ecological impact. (Photo: Jim Carroll)

John Sessions likes to refer to forestry as "a bio-energy puzzle." Like a lot of 21st-century puzzles, its solutions are digital and mathematical.

"Forest landscape planning, as it is known today, was not possible before the advent of high-speed computers, geographic information systems, modern algorithms and graphic interfaces," says the holder of the endowed Richard Strachan Chair of Forest Operations Management at OSU.

Translation: Long-term sustainability for Oregon's forest industry now relies on data, knowledge, software and advanced computing power. Harvesting wood in sensitive ecosystems makes up one set of puzzle pieces. The other has to do with earning a living in a volatile economy and a competitive world. Trying to achieve these goals — protecting the environment while producing timber products — can cause tension.

Professor Sessions' mission, indeed his passion, is figuring out how to meld the myriad elements of nature, regulation, jurisdiction and commerce to maximize efficiency without sacrificing ecology. To do this, he uses a method called "combinatorial optimization." Boiled down, that simply means "getting the best out of the most." In support of Oregon Department of Forestry (ODF) efforts, he has designed a software program called Harvest and Habitat, which crunches voluminous sets of data on possible cutting schedules, forest structure (age, species and density of trees) and wood transport for 632,000 acres of Northwest forests. The resulting simulations are used by ODF to guide management decisions in seven districts, including Tillamook, Astoria and Forest Grove. Foresters use the models to compare one harvest strategy against another — *before* bringing in the loggers and the loaders.

But simulation software is just the tip of the Douglas fir for Sessions, a Distinguished Professor of Forestry. He brings a lifetime of forest-science experience (including managing 4,000 workers on a Brazilian pulp plantation and consulting for 15 countries worldwide) to his astonishing workload at OSU. Admitting, with some embarrassment, to working 12 hours every single day except Christmas and Thanksgiving, the youthful 65-year-old can't fathom a more satisfying way to spend his earthly time allotment. Academia satisfies his two deepest drives: "I like solving problems, and I like teaching students."

The problems he solves include the mundane, even minute, details of day-to-day forestry: the logistics of getting logs out of the woods and to the mills in the quickest, cheapest and eco-friendliest way. Often, he says, it comes down to scheduling — of harvests, of crews, of trucks. As part of a proposed Oregon Innovation Council initiative, Sessions will study the comings and goings of log trucks to help minimize wasteful trips.

Quite simply, inefficiency sticks in his craw.

"Why," he wonders with a note of irritation, "would you ever see two empty log trucks, or two loaded log trucks, going down the road in opposite directions? You say, 'Is there a way they could spend less time traveling unloaded as they move from job to job?' We're looking at using advanced algorithms, along with GPS and satellite phones, to help us assign the trucks more efficiently."

In Corvallis: **OSU Foundation**
850 SW 35th Street
Corvallis, OR 97333
Voice 541-737-4218
Toll Free 800-354-7281
Fax 541-737-0498

In Portland: **OSU Foundation**
707 SW Washington, Suite 500,
Portland, OR 97205
Voice 503-241-9333
Toll Free 866-218-8930
Fax 503-553-3454

Online: **CampaignforOSU.org**

Terra
416 Kerr Administration Building
Oregon State University
Corvallis, OR 97331

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Brent Matteson, a Ph.D. student in Nuclear Chemistry, works in Assistant Professor Alena Paulenova's lab (Laboratory of Transuranic Elements). A fellow of the Civil Radioactive Waste Management Program of the U.S. Department of Energy, he studies the chemical behavior of neptunium (Np). See "Power Surge," Page 2. (Photo: Karl Maasdam)

Listen to OSU researchers, follow their stories and see more photos, at **oregonstate.edu/terra**