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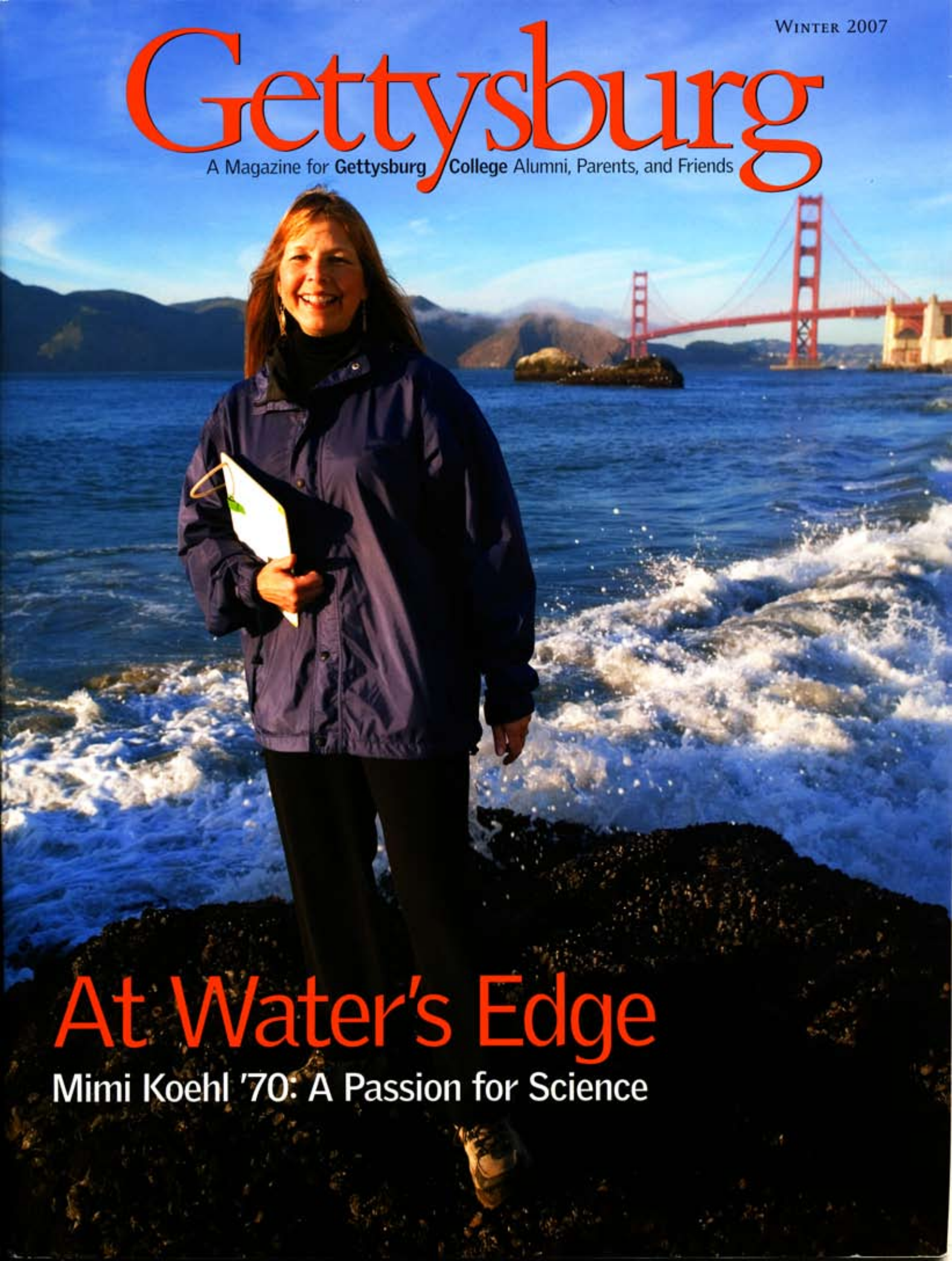

At Water's Edge

Mimi Koehl '70: A Passion for Science

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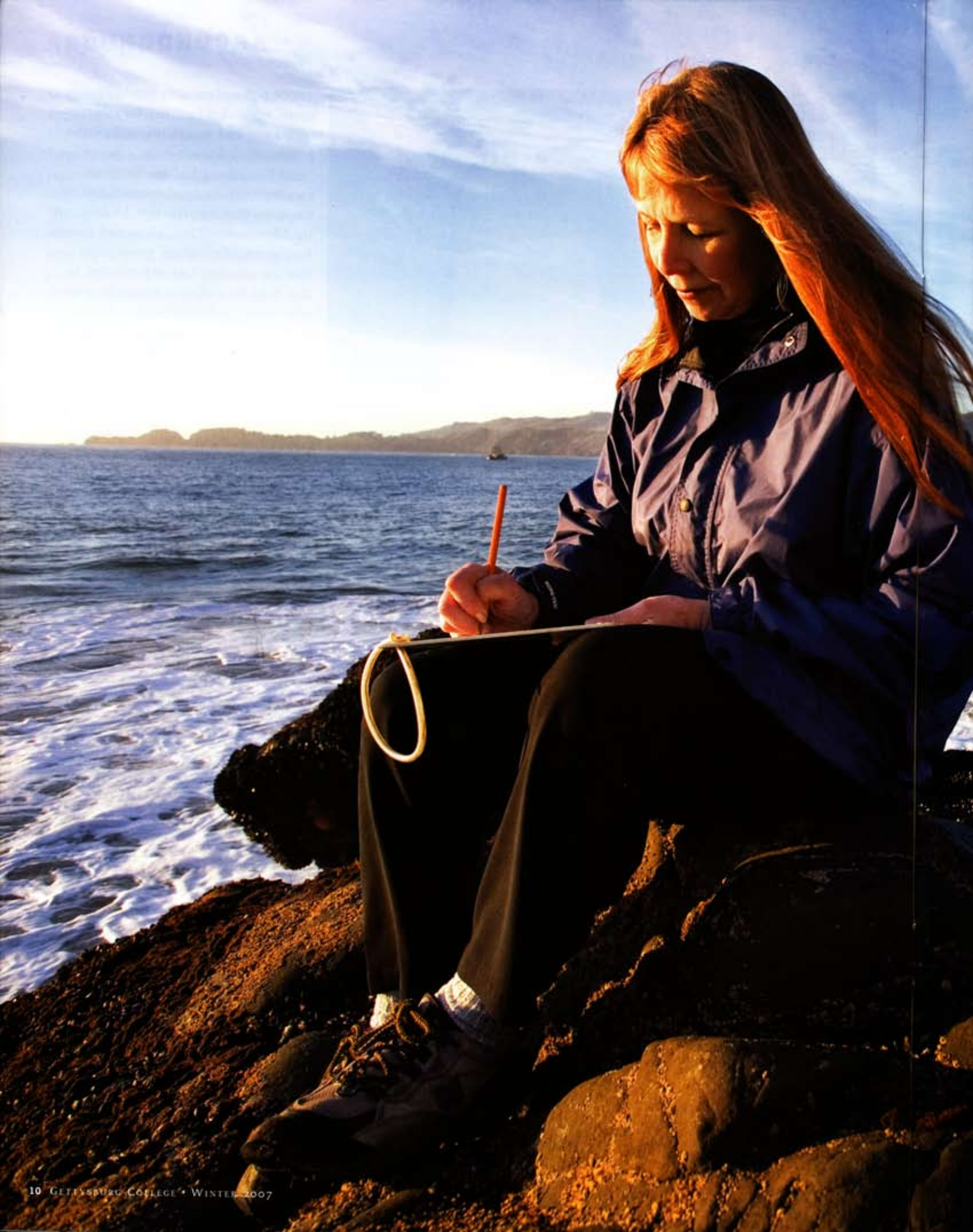

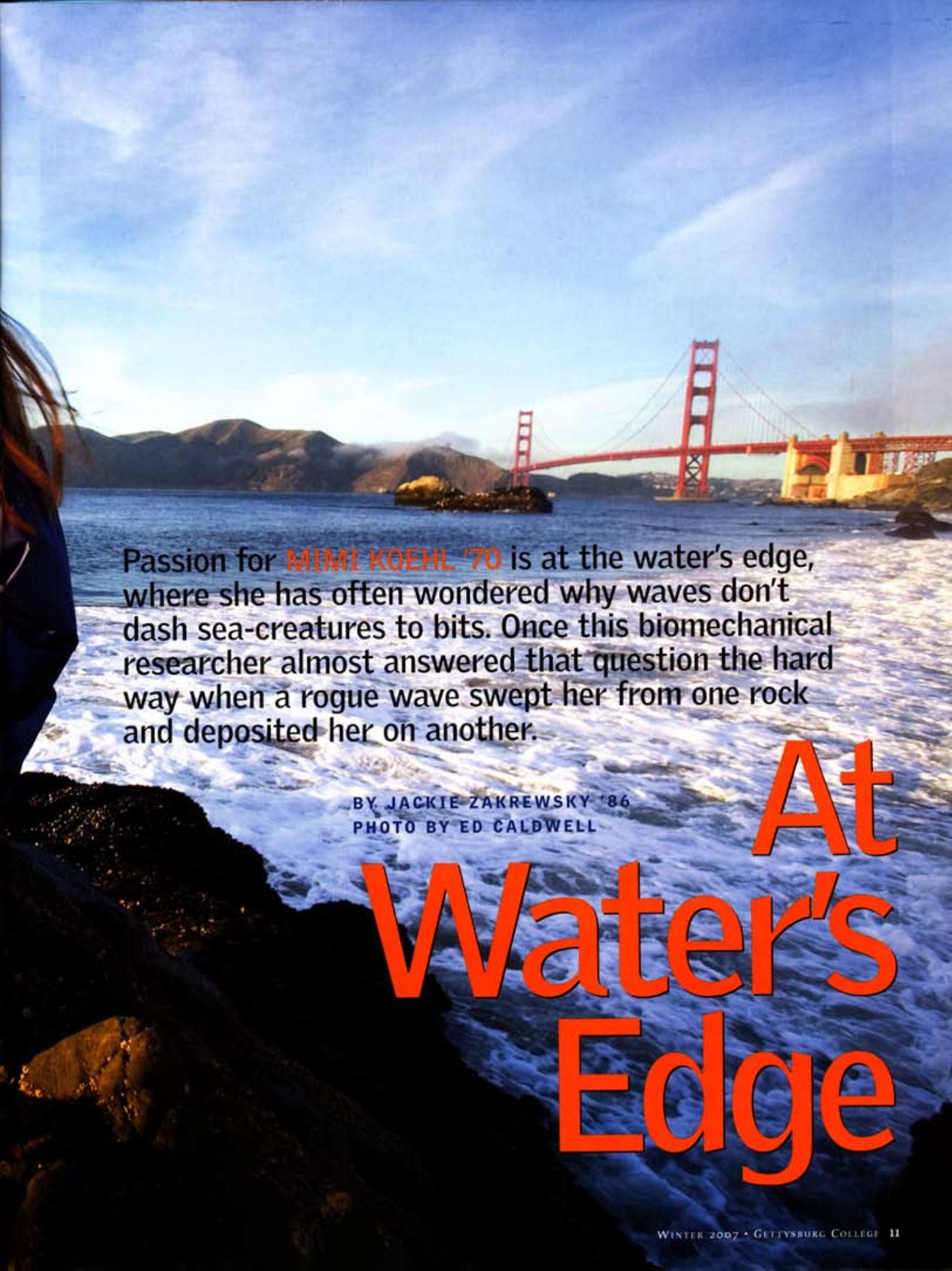

Passion for MIMI KOEHL '70 is at the water's edge, where she has often wondered why waves don't dash sea-creatures to bits. Once this biomechanical researcher almost answered that question the hard way when a rogue wave swept her from one rock and deposited her on another.

BY JACKIE ZAKREWSKY '86
PHOTO BY ED CALDWELL

At Water's Edge

THERE'S NO SUCH THING AS A TYPICAL DAY AT THE BEACH FOR MIMI KOEHL '70. SURE, SHE MAY DIG HER TOES INTO THE SAND LIKE THE REST OF US, OR STOP TO WATCH SOME SURFERS. BUT MORE THAN LIKELY SHE'LL DON HER FOUL-WEATHER GEAR AND SPEND A MORNING BOLTING ELECTRONIC EQUIPMENT TO SLIPPERY ROCKS.

Even in warmer climes (no foul weather gear required), life for Koehl at the water's edge — and beyond — isn't simply "fun in the sun." It's about wondering why living things in the sea aren't dashed to bits by the waves. It may even mean being nearly dashed to bits herself when a rogue wave sweeps her off one rock and deposits her on another.

Such close shaves aren't the reason Koehl considers science "exciting." Nor is the considerable recognition she has received for her innovative work in biomechanics. Honors range from a MacArthur Foundation fellowship (commonly known as a "genius grant") in 1990 to election to the National Academy of Sciences in 2001. For Koehl, the thrill of science is found in the intellectual sleuthing she does using tools of engineering and physics to explore biological questions. How do animals like lobsters use antennae to catch odors from the water around them? How do the larvae of bottom-dwelling marine animals — "microscopic babies" carried away in the ocean — find suitable homes in chaotic waters? How did the feathers on some recently discovered dinosaurs affect their aerodynamic performance?

"My branch of science is visual," Koehl said, speaking like the artist she once aspired to be. "For example, watching how eddies swirl in turbulent waters is mesmerizing. There's aesthetic pleasure in the things I study. They're beautiful if you simply look at them — but even more beautiful when you understand how they work."

Mr. Potato Head gets serious

Koehl is the Virginia G. and Robert E. Gill Professor of Natural History in the Department of Integrative Biology at the University of California at Berkeley. The position is prestigious, but it does not mean she only works in a rarefied realm of pure research. She teaches undergraduate courses along with graduate ones, runs a lab, and supervises a staff. There's also fieldwork that has taken her far and wide — from the wave-swept shores of Tatoosh Island in the Pacific Northwest to the far balmier coral reefs of Palau and Australia. And there are papers to write and grants to chase, even for a big-name professor.

Koehl's work also takes place in a climate not always hospitable to science. Of great concern to her, she said, is "how science is perceived by the lay public and sometimes misrepresented by people with political agendas. I'm heartbroken that science is too often perceived as dull, incomprehensible, or irrelevant."

To combat such views, Koehl teaches a graduate course in communicating science to the public via a variety of media. She also gave up precious research time while on sabbatical leave at the University of Colorado in 2005 to participate in a project of the

National Academy of Sciences aimed at getting kids (especially girls) interested in becoming scientists. They produced a series of books and a website for middle school students to illustrate the adventureness of scientists' lives. Koehl is one of 10 scientists profiled for the series. *Nature's Machines: The Story of Biomechanist Mimi Koehl* was published by Joseph Henry Press in 2005. A companion website (www.iWASwondering.org) uses cartoons and experiments that kids can do on their own to show what inspired the work of the featured scientists in the lab and in the field. In one scene, Koehl is being hoisted in a bucket-like contraption to the top of a high cliff at Tatoosh while asking, "Whoa! Has anybody ever fallen out of this thing?"

The experience at Tatoosh was indeed inspirational for Koehl. As a graduate student at Duke in 1972, she was intrigued by how creatures living on wave-swept shores, like sea anemones and kelp, could withstand crashing waves. To find out, she devised a series of experiments that she carried out at Tatoosh — experiments that required rigging lots of equipment to wave-beaten rocks to measure water speed and force.

Koehl didn't realize it at the time, but "rigging" would become key to her work. In the emerging field of biomechanics, much of the equipment she needs must be self-created. Sometimes she also rigs up models of organisms out of various materials, ranging from feathers and foam to clay and wire.

Later, those were the raw ingredients that Koehl and undergraduate researchers used to create models of feathered dinosaurs based on fossils recently unearthed in China. Theories about the functions of these feathers range from aerodynamics to insulation — all of which can be tested with physical models of the dinosaurs, even though the animals are extinct. Experiments can help researchers study everything from aerodynamic stability when a gust of wind hits the dinosaur, to the ability to glide, parachute, or maneuver while falling through the air. Models can be configured into different postures and the feathers can be removed or added. "We play like Mr. Potato Head with the models," Koehl said. But with one big difference: Their play explores "serious questions about which structural features of the dinosaurs affect their aerodynamic performance."

Exploring flight

Feathered dinosaurs aren't Koehl's only foray into questions about the origins of flight. In the mid-1980s she garnered considerable attention, even in the popular press, for work that she and evolutionary biologist Joel Kingsolver did using models of prehistoric insects to understand how stubby flaps evolved into long wings.

Various theories abounded. The flaps acted as parachutes. They were for gliding. They were for steering. They had nothing to do with flight, but rather were solar panels that collected heat. Koehl and Kingsolver created models of the extinct insects, using fossils as well as information about the behavior and heat-exchange properties of living insects to guide their design. They "flew" their models in a wind tunnel to test the different theories and were able to rule out the ones that were physically impossible.

With not a bone in their bodies, giant sea anemones look more like flowers than animals.

Keyed up over dyslexia

Imagine you've been dubbed a genius — thanks to the MacArthur Foundation. You run your own lab at one of the top public research universities in the country. You're a member of the National Academy of Sciences.

But you can't work the newly installed numerical keypad lock to get into your laboratory.

For Mimi Koehl '70, the inability to open her office door became more than just a frustrating experience when two friends separately suggested that she may be dyslexic. That possibility prompted Koehl to get tested at a learning center, where she discovered, in her 40s, that she is indeed dyslexic.

While attending a class for adults with learning disabilities, Koehl realized that she already had many coping strategies in place, such as "color coding everything, or using a ruler to help me read words in the right order on a page." She joked, "Somehow I made it through," but admitted that in school "it took me forever to do assignments that involved reading."

Dyslexia gave Koehl the key to unlock her office — literally. Previously, when she asked for a key, she was told, "No. Only the police can have one." Under the Americans with Disabilities Act, she was eligible to have her very own key — an accommodation granted her as someone with a learning disability.

And, no, Koehl is not the only designated genius to be diagnosed with dyslexia. It's a condition that she shares with Albert Einstein and fellow MacArthur winner Jack Horner of *Jurassic Park* fame.

The journal *Science* called the work "an elegant series of studies." Their experiments showed that stubby wing-like structures are effective solar panels for warming insects of all sizes, but can only affect the aerodynamic performance of large insects. As the magazine *Natural Science* explained, this finding suggested the possibility that, if natural selection led to an increase in body size over many generations in a population of primitive insects with stubby protowings — that is, if large individuals tended to survive and reproduce more than small ones — then the "insects

might reach the realm of aerial effects simply by [becoming] larger, without any accompanying change of body shape or relative wing lengths." That a novel function — gliding — could arise simply via an evolutionary change in body size was a surprise that Koehl and Kingsolver hadn't expected.

As *Science* pointed out, "The idea that a dramatic change in the function of a structure might come about without a change in geometry — in other words, a drastic redesign — is unfamiliar to most biologists."

Working between fields

"My work is not just straight physics, not just straight engineering, not just straight biology," Koehl said. "My work borrows approaches and techniques from all those fields and I use them to ask biological questions." A big advantage is that "you can learn new things that someone sitting in one field won't."

An engineer, for example, won't study the origins of animal flight, and a paleontologist digging up bones won't know how to measure how the shape of wings could affect the ability to maneuver. By having "a foot in each discipline," Koehl is free to explore a wide range of questions. "It's fun to learn new things," she said. "Working between disciplines you're always challenged to learn new things and meet interesting people."

There are challenges, however. How do you learn all the background that you need in several fields? How do you train students who want to do interdisciplinary research? Where do you publish your results — in journals for biologists or journals for engineers? How do you convince other scientists or funding agencies that your approach to research is not just wacky?

Many of these problems were solved for Koehl when she won a "genius grant" from the MacArthur Foundation. "I salted it away," she said. "I use it anytime I have a brand-new idea I want to try." It helps avoid the Catch-22 of landing a research grant. "You can't get funding until you demonstrate that an idea will work," but such testing itself requires money, she said. Thanks to her MacArthur award, "I have funding to buy the equipment, to go on the field trip, to buy the supplies necessary to try out new ideas." It's a far cry from her early years at Berkeley when she scrimped and saved to buy her own research supplies.

Charting a career path

Koehl grew up in Silver Spring, Md., just outside Washington, D.C., where her father was a physics professor and dean at George Washington University. Her mother was a professional artist who painted portraits and landscapes.

Koehl was an art major when she started her studies at Gettysburg, but switched to biology after taking a class to meet her science distribution requirement. (See "The Power of a Liberal Arts Education" this page.) "I had been fascinated by natural forms in my artwork, but once I took biology and discovered that scientists had the tools to figure out how those natural forms worked, I was hooked," Koehl said. After graduation, she headed to Woods Hole Oceanographic Institution in Massachusetts to work as a research assistant, biding her time until she went to graduate school at Duke University. Biomechanics pioneer Steve

The power of a liberal arts education

Mimi Koehl's college experience may provide one of the best arguments for the value of a liberal arts education. The one-time art major found her true passion while fulfilling a distribution requirement in science.

The requirement was a biology class taught by Prof. Robert Barnes — a course that set Koehl on a career path in the emerging field of biomechanics, where her innovative work has won her many accolades, including a MacArthur Foundation "genius grant," and an endowed professorship at the University of California at Berkeley.

"What I discovered in his class was that natural forms fascinated me. I was using natural forms in artwork to create images," Koehl said, but science offered a further allure: "As a scientist, you could study the consequences of those forms." She decided to switch her major to biology.

Besides launching Koehl's career path in science, the College benefited her in other ways. "It was the place where I found my self-confidence," she said. "I went to a very big, very competitive, very impersonal suburban high school" in Silver Spring, Md., where she was a shy "nerd" who graduated near the top of her class of 1,000. At Gettysburg College, she said, both students and faculty "got to know who I was on my own terms. It was small enough and congenial enough that I could get my footing, which I had never done before."

Indeed. Before Koehl left the College as a Phi Beta Kappa graduate in the spring of 1970, her classmates that fall had voted her homecoming queen.

Koehl returned to the College last May to receive an honorary degree at Commencement 2006. Previously, the College awarded her with a Young Alumni Achievement Award (1985) and a Distinguished Alumni Award (1998).

A colony of anemone-like zoanthids, which Mimi Koehl has studied in Brazil and Panama.

A great green anemone, with urchins, starfish, and other creatures inhabiting a tidal pool.

Wainwright became a key mentor and her Ph.D. adviser at Duke.

Another big influence was Bob Paine, a well-known ecologist at the University of Washington, who introduced her to the rich marine environment of Tatoosh. In 1976 he also invited her to join him and his students on a research trip to study the rocky coasts of South America, giving her a chance to explore how various species of seaweeds with very different structures could all survive in crashing waves. This detour happened when she was completing her Ph.D. work at Duke; after returning from Chile she had to immerse herself in writing her dissertation, which she cranked out in record time (two months).

After earning a Ph.D. in zoology from Duke in 1976, Koehl completed two postdoctoral fellowships. First came a stint at Friday Harbor Laboratories at the University of Washington for research on how marine animals that eat plankton — microscopic organisms carried in the water — catch their prey by acting like filters. At the University of York in England, she studied how spicules — needlelike particles embedded in the soft bodies of animals like sponges, sea whips, and starfish — affected mechanical behavior. She then headed to Brown University as an assistant professor in the Division of Biology and Medicine for a year before joining the faculty at Berkeley, where her department put her up for tenure review after three years instead of the usual six. (The research that Koehl and her students and postdocs have pursued during her years at Berkeley are described on their website: http://ib.berkeley.edu/labs/koehl.)

When Koehl first arrived on the Berkeley campus, there were few women professors in science departments — something that has changed today. For the past 25 years, Koehl has found enormous support in meeting with a group of other women scientists every other Thursday. Problems discussed in the group have evolved along with the women's careers — from questions of how to teach or start a lab to "Should I retire?" Member Ellen Daniell's book, *Every Other Thursday: Stories and Strategies from Successful Women Scientists*, published by Yale University Press this year, details the workings of the group, including how a member makes a contract with the group to pursue solutions and then report back on her progress. In joining the group, Koehl said she found that "the forum wasn't a whiny group, but a safe place to meet with people facing similar issues and discussing practical solutions to problems in our careers."

As the group's youngest member, Koehl has no plans to retire anytime soon. The projects she works on can takes years to yield results — and she's willing to wait. "Too often, I think that kids get the message that science is too hard and too boring," she said. "Just a bunch of facts to be memorized. Science is hard work, but it can be fun and exciting to try to solve mysteries about how the world around us works." It's all a matter of wading in.

Wave-Swept Shore

Among Koehl's efforts to reach the general public about the wonders of science is her 2006 book, *Wave-Swept Shore: The Rigors of Life on a Rocky Coast*, which explores the rich variety of marine life that thrives along wave-battered coasts. A collaboration with photographer Anne Wertheim Rosenfeld, the sumptuously illustrated book offers 87 "exquisite pictures" that "provide an eye-catching and instructive accompaniment to Koehl's descriptive prose," according to *Natural History*. Those passages are "hard-core physics," Koehl said, "but there's not a single equation in the book." The message she'd like readers to take away: "Science isn't dull and you can understand it based on your experience in the world and make your pleasure in the natural world even greater."