William Cochlan and Phytoplankton: a Quiet Scholar of Unlikely Heroes
About the Cover:
Story on page 32.
The NOAA ship Ronald H. Brown (R-104) a Global Class research vessel departs San Francisco on May 23, 2016 during a month-long ocean cruise that extended from Baja, Mexico to Haida Gwaii, Canada. Among the 38 scientists aboard were three former SF State graduate students from Dr. Cochlan’s Phytoplankton Ecophysiology Laboratory: Julian Herndon (now at Univ. Washington), Brian Bill (now at NOAA Northwest Fisheries Science Center) and Chris Ikeda (RTC). They conducted collaborative research to assess the effects of multiple ecosystem stressors — ocean acidification, temperature, and nutrients on coastal phytoplankton and the production of biotoxins. Both Herndon and Ikeda conducted their SF State dissertation research with Cochlan on the fish-killing raphidophyte Heterosigma akashiwo (left inset), whereas Bill studied the domoic acid producing diatom Pseudo-nitzschia australis (right inset), as well as other toxic species of this genus found in the northeast subarctic Pacific Ocean. Together their findings demonstrate not only the plasticity of these successful species to acquire nutrients and out-compete other phytoplankton, but quantified their growth and toxic responses to environmental factors that are varying as a function of climate change. Results of their findings have been published in a number of highly respected journals, and include:
Ship Photo credit: Beverley Medynski

About the Back Cover:
Story on page 14.
Formation of DNA/protein complex in DNA repair pathway. The left panel shows schematic representation of active site/adduct interactions. The right panel shows DNA/protein complex at atomic resolution. Such high resolution complexes are used in computer modeling by Dr. Guliaev’s laboratory at SF State to predict repair efficiency.
Population studies in the RTC Molecular Facility: by Heather Dutra

In the past decade ecologists have increasingly employed molecular data as they study how organisms relate to their environments and how they adapt and change over time. This is especially true for the faculty and researchers in Building 36, home to the Shared Molecular Facility at Romberg Tiburon Center (RTC), San Francisco State’s field campus on San Francisco Bay. Investigators in this warehouse-like building filled with modern working laboratories have specialized instruments for genetic analysis, and the data they gather addresses pressing ecological questions. The entire center is dedicated to environmental studies and has a unique claim to fame: RTC is the only university research and teaching lab located on the brackish, marshy estuary where the freshwater from the Delta meets the oceanic waters of the Pacific. For decades, ships have streamed into the Bay from all over the world, transporting and introducing new species on a regular basis. At RTC academic researchers are perfectly situated to study the interaction of native aquatic life with the foreign interlopers that significantly impact the Bay’s ecology. Focusing on issues from contaminants to habitat destruction, on ecosystems local and distant, and applying the powerful molecular tools available onsite, RTC students are conducting an impressive amount of research on the global threats to marine life.

Dr Sarah Cohen, a professor of Biology, and her students, support the shared molecular lab facility so it is available for use by SF State and Smithsonian researchers and others. Advanced genetic resources such as DNA sequencers and analyzers and a variety of PCR machines are available thanks to an NSF facilities grant, the College of Science and Engineering, and some generous donors.
**RTC’s onsite molecular facility**, a core laboratory with the equipment to extract, amplify, and analyze genetic material, is an integral part of the research process. Says Kate Barretto, a recent graduate researcher in the lab of Dr. Ed Carpenter, the core molecular facility is a great resource for “other laboratories at the RTC that do not primarily focus on molecular biology, but would like to use it as a supplement or new facet to their research.” In other words, investigators can use the molecular lab as an essential bridge between the study of ecological patterns and processes and molecular mechanisms and methods of analysis.

Laura Melroy, a recent graduate researcher in Dr. Sarah Cohen’s RTC lab, carried out field and laboratory studies showing the benefits of an onsite molecular lab. Genetics played a big role in her research on differences among species of sea stars in the genus *Leptasterias*. Marine biologists consider the little six-rayed organisms to be part of a “cryptic species complex,” meaning that to a human observer, the species within the genus look virtually identical. Sitting at her computer, with the humming of laboratory equipment around her, Melroy watched multi-colored lines dance across the screen. The zigzag lines represent pieces of genetic code that reveal the identities of co-occurring species within this remarkably diverse genus.

*Leptasterias* are great model organisms for studying the influence of local habitat on population health. Because offspring travel only a limited distance after birth, “*Leptasterias* can be indicators of local environmental conditions,” said Melroy, “like changes in climate and variation in outflow from the Bay.” She added, “They can also help to assess the health of populations of other species” by serving as indicator species. Armed with this information, she and coworkers have made important comparisons between populations of sea stars along California’s central coast. Currently, an epidemic is affecting sea stars in some of California’s intertidal regions. This puzzling malady, called Sea Star Wasting Disease, has quickly killed off large numbers of sea stars by literally disintegrating them. Currently, we have limited understanding on what is causing this dramatic dieoff among many species of sea stars. By using genetic variation to estimate movement patterns among populations, Melroy and coworkers can better understand dispersal in sea stars, including factors that relate to the spread of this deadly disease.
In another room, RTC graduate researcher Calvin Lee leans over a large table while focusing on pipetting liquid containing isolated and amplified DNA from a small vial into a blue agar gel. He is isolating genes from English Sole, particularly genes that function in the fish’s adaptive immune response. This group of specialized genes is responsible for alerting the body to foreign invaders. Lee is studying the group to address questions about tumors that plague California native flat fish. Prior to coming to RTC, Lee worked with the California Department of Fish and Wildlife where he helped to conduct trawl studies on fish and invertebrates in the Bay. He noticed that some flat fish had massive tumors sometimes covering the eyes and other parts of the body. His curiosity piqued, Lee spent his first RTC semester comparing tumors of California flat fish with those of flat fish (including English Sole) in European and Japanese waters. Did a similar phenomenon cause tumors in the Bay Area species? Did factors such as pollutants or a virus cause all of these tumors, regardless of region?

Using genetic data, Lee was able to compare DNA from flat fish tumors here and abroad and soon discovered that a global tumor-causing pathogen is at work. Now that he has used molecular tools to identify the pathogen in San Francisco Bay fish, Lee is surveying immune system genes to find out how fish may respond to the tumors. He suspects that contaminants may play a role in how tumors develop in these fish as also discovered by researchers in other locations and species. Lee’s research will help enlighten environmental managers and the public about the related issues of disease and pollutants in aquatic environments.

Polymerase chain reaction (PCR) machines are essential to the field of genetics and molecular ecology. The machines can rapidly raise, lower and hold at specific temperatures to allow for PCRs to take place and amplify the gene of interest. These machines were donated and purchased through funding from SF State.
Avdeep Grewal (Class of 2012) does field work as a sales representative for the international biotechnology company Qiagen in their Valencia, California division. Nina Daquigan (Class of 2014) is a microbiologist at the U.S. Food and Drug Administration (FDA) in Laurel, Maryland. These two young women have different ethnic backgrounds and perform separate work procedures each day. Both, however, graduated recently with master’s degrees from the SF State Professional Science Masters Program (PSM). They both credit the program’s founding director, Dr. Lily Chen, with shaping the highly practical graduate sequence that helped them land jobs. And like the program’s 30 other graduates since 2010, they both praise Chen for the “total devotion” she shows her students as they prepare for new millennial biology careers.

“What is the next step once you have graduated?” The typical paths open to newly graduated life science students are graduate school, health-related education such as medical and dental school, and low-level field and laboratory jobs. At SF State University, Chen’s novel graduate program for bioscience majors provides a relevant education for today’s better-paying mid-level positions—especially in the strong regional and state job market.

The PSM program offers an innovative curriculum with graduate classes centering on either stem cell science or biotechnology the first year and an off-campus internship—usually in industry or government in (or during) the second year. Class work and internships both contribute to the program’s unique ambiance. The curriculum adds business courses to more traditional biotech course material. And the off-campus internship exposes students to a greater and more realistic range of experiences than does the typical graduate study for the Biotechnology or the Stem Cell Science concentration. This program admitted its first cohort of students in Fall 2010, since then seven cohort classes have matriculated into the program.

Students finishing their bachelor’s degree in life science face a question that Chen knew all too well from her own experience: Whereas the primary emphasis of traditional master’s degree programs has been to prepare students for success in Ph.D. programs, SF State’s PSM program creates a different pathway for rapid entries into management-track positions in life science careers.
We help them build their resume, coach them to improve their interview skills, and give them a good introduction to what a biotech career looks like.”
Chen’s dedicated mentoring fosters teamwork in the laboratory and results in a high rate of student employment after graduation—an astonishing 95 percent.

Chen meets regularly with the PSM students who work outside of her lab, and has high standards when screening prospective students for the 10 to 12 students the program will admit each fall semester. “We look for students who are ready to be challenged and have a strong desire to consider different career paths due to the constantly evolving and interdisciplinary nature of biotechnology and the life science workforce,” she said. “We also value research or work experience and a potential to communicate, collaborate, and work hard.” In turn, the PSM faculty works closely with these hand-picked scholars. “Students come in as a cohort so we serve the students as a group... we see them very frequently and give them a lot of guidance about communication and teamwork and how to present themselves,” said Sveen. Grewal recalls that because each year’s cohort “entered a new space together, they developed a tight bond between our fellow classmates,” and Chen works to reinforce this cohesiveness.

Dr. Linda Chen observes that her colleague “deeply cares about her students,” whether taking time to work out class schedules or the time to get to know students in order to nominate them for various awards. She is truly dedicated to the success of her students.” According to Nina Daquigan, Chen was “more than an academic advisor... more than just a coach. She also acted as a peer, a friend that listened to my struggle on what to do after graduation...”


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A typical chemistry lab is a sensory barrage: Pipettes, test tube racks, safety goggles, and open manuals litter black-top lab benches. Chemicals that smell vaguely of sulfur or cleaning fluid bubble in Erlenmeyer flasks. Centrifuges whir, Bunsen burners whistle, students clink glassware while hurrying from reagent shelves to fume hoods. The casual visitor to San Francisco State University will encounter such sights, smells, and sounds while strolling the corridors of Thornton Hall. The newcomer to Dr. Anton Guliaev’s sixth-floor computational chemistry lab, however, will find something surprisingly different: a chemistry workspace containing little more than electronic boxes on desktops, the tapping of fingers on keyboards, and the aroma of freshly made coffee.

This deceptive tranquility hides a high-energy and productive drive to uncover how cancer-causing chemicals can affect DNA repair proteins and eventually lead to cancer. While others search for the same cancer-causing clues in nearby wet chemistry labs at other institutions, Guliaev and six students use computational chemistry. With it, they zero in on which carcinogens bind to the active sites of which DNA repair proteins. Eventually, their work could lead to cheaper cancer drugs for the millions of Americans now struggling with cancer.

Guliaev is an outgoing Russian-born chemistry professor who arrived at SF State in 2007. After graduating from Moscow University and earning a Master’s in biophysics in 1993, in 1994 he went on to participate in an exchange program with Bowling Green State University in Ohio. His doctoral work initially focused on photochemistry—chemical reactions that involve light such as photosynthesis—and he finished in 2000. “I tell you the truth,” says Guliaev, speaking about the stateside photochemistry Ph.D. program in his distinctive Russian accent, “I didn’t like it that much.” But his advisor in Moscow told him, “Go. I guarantee you will find something you like. If you don’t like it, then come back. But don’t say no just because you don’t know exactly what they’re doing.” He now passes similar advice on to students contemplating graduate school. “Just get into a good program. The opportunity will come.”

After receiving his PhD, Guliaev worked at Lawrence Berkeley National Laboratory doing biochemical work, including structural analysis of genetic material with NMR (Nuclear Magnetic Resonance). Chemists use NMR to look at the structure of molecules. This expensive technique is the basis for the MRIs (Magnetic Resonance Imaging) so common in human medicine. Doctors use MRIs as noninvasive tools to take multidimensional pictures of soft tissues such as organs and muscles. One such application is finding and diagnosing tumors. Guliaev used NMR to identify and picture the three-dimensional structures of nucleic and amino acids so he could look more closely at protein-DNA interactions. Nucleic acids are the building blocks of DNA, while amino acids are the building blocks of proteins. DNA repair proteins attach to DNA to fix errors that creep up in the nucleic acid sequence from mutations that occur during DNA replication. These errors can result from insults such as ultraviolet light or chemical carcinogens. Knowledge of the interactions between DNA and dedicated repair proteins are essential to studying how DNA is repaired.

Guliaev later suggested he could try to model protein-DNA interactions on a computer instead of using NMR, and this became his first step into the modern world of computational chemistry—a then revolutionary way to study interactions between proteins and drugs by simulating them on a computer. Guliaev used computers to simulate the reaction between two molecules such as a DNA repair protein and cadmium—a carcinogen found in cigarettes and industrial production. These simulations allowed him to create an image of how molecules bind without physically mixing them in a test tube. With simulations, Guliaev could run many more trials much more quickly than could someone in a wet chemistry lab and also bypass limitations such as expensive NMR analyses. The field of computational chemistry was just beginning to become popular when Guliaev...
accepted a job offer from SF State as a computational biochemist. Once he had established his lab in Thornton Hall, he geared up his current research effort: (1) to learn how a few specific kinds of DNA repair proteins fold into 3D shapes; (2) what potentially harmful compounds each can bind in each protein’s active site; and (3) how this binding may render each DNA repair protein useless at fixing errors in mutated DNA.

Ultimately, Guliaev’s lab focuses on how particular DNA repair proteins relate to cancer. DNA repair proteins exist inside the membrane-bound nucleus of all single-celled organisms such as yeast and all multicellular organisms such as humans. DNA repair proteins fix stretches of DNA by repairing or replacing the nucleic acid code that has been damaged by carcinogens, such as those inhaled from cigarette smoke. “There is a very, very, very powerful mechanism developed by Mother Nature which actually has the ability to repair the DNA,” Guliaev says. DNA repair proteins are essential to life, he explains, “because if the DNA is not going to be repaired . . . we will have some serious diseases, some serious problems.” Our DNA is constantly subject to various attacks, he goes on, “not only just from smoking—inhaling the various pollutants—but also from natural causes like exposure to the sunlight for example.” These attackers also harm DNA repair proteins by binding to the protein’s active site so it is unable to repair damaged DNA.

Computational chemistry is essential to cancer research because it allows Guliaev to forgo expensive wet chemistry lab techniques as he simulates how carcinogens interact with DNA and the mechanisms that repair DNA. Chemistry labs at SF State and at other institutions, such as UCSF and Stanford, still utilize wet chemistry techniques to look at DNA repair proteins despite the costs. This is because wet chemistry methods may produce results more quickly and require less energy; in addition, they confirm the findings of computational chemistry methods. Computational chemistry, by contrast, requires running time for the computer calculations to simulate the interaction. For example, it can take about one month for a computer to perform all the calculations necessary to simulate how one protein folds. This lengthy period is needed because there are so many variables such as the number of amino acids and how each amino acid interacts with the one next to it. Wet chemistry trials on DNA repair protein research may be faster. However, they still contain much trial and error to determine which drugs will interact in desired ways with DNA repair proteins. Guliaev uses computational chemistry to bypass the many trials required in wet chemistry. Therefore, to study the same protein-drug reaction, Guliaev would need one trial and months of computing time compared to perhaps dozens of trials that consume many days of chemist time in the lab.

Inside Guliaev’s lab are two rooms. The first looks more like an office: windowless, with four desks lining the walls, each bearing its own computer and at least one monitor. A coffee maker sits on the desk to the left, alluding to the countless hours spent by undergraduate and graduate students as they type away on their keyboards. Guliaev’s sense of humor is also in evidence in his non-traditional chemistry lab: He regularly calls his computers by pet names such as “Megatron” and “Optimus.” A door on the room’s far wall leads to a second space. One immediately notices the hum of the many servers fighting against the air conditioner in the stuffy room. Two tall cages taking up most of the space in the room also demand attention. One discovers, as well, that SF State houses its very own Adam and Eve, along with Gibbs, Bloopy, Maxwell, Ginder, and Miyagi. These “pets” are VHS...
player-sized servers positioned behind the tall metal cages. The cages facilitate airflow and communication between computers. As Guliaev puts it, “The advantages of working in University settings as that I do not need to think about the energy bill.” Despite the high energy cost, it is still a fraction of the cost of biochemical experiments carried out in wet chemistry labs.

A group of seven graduate and undergraduate students work in the computational chemistry lab. Before a student can begin modeling a protein on the computer, he or she must learn how to use Linux, a text-based operating system, as well as take a series of program tutorials to learn how to evaluate the protein structures. Peter Ngoi, a fifth year biochemistry major, finished these tutorials in about a month and a half. Ngoi first became interested in computational chemistry after taking one of Guliaev’s classes. “I just thought it was really cool how you can do all these tests on computers and you don’t even have to do it in real life,” he tells me. “That’s kind of strange and cool... What really hooked me into computational chemistry,” says Ngoi, “was being able to evaluate these structures—3-dimensional structures of whole enzymes—and be able to run the molecular dynamics simulations.”

Now, Ngoi is simulating the effects of mutating an amino acid in GOT-1, an enzyme that plays a role in amino acid metabolism. He wants to understand how HDAC binds to each of the Gotti’s structure and facilitates communication between the servers. After graduating in fall 2015, Ngoi is considering jobs in the biochemistry lab. But what are sirtuins? The short answer, as explained by Guliaev, is “nobody really knows for sure.” The longer answer is that sirtuins somehow promote cell division within the cell cycle. This means that sirtuins such as HDAC promote the cancer cell division that causes a tumor to grow ever larger. Amagata found that Streptosetin inhibits HDAC by binding to the active site so HDAC is unable to promote cell division in a cancer cell. In his wet chemistry lab on campus Amagata can study Streptosetin, but is unable to discover which of its two molecular structures best binds to HDAC. Guliaev simulated the interaction between Streptosetin and HDAC on the computer and discovered that Streptosetin A binds more efficiently with HDAC than the other structure, Streptosetin B. Guliaev’s simulations allowed Amagata to visualize how HDAC binds to each of the Streptosetin structures and how quickly HDAC can bind to each structure. With this information, he can apply Streptosetin A to upcoming cancer therapy drug research.

“Truly, he is the next best help,” laughs Amagata when referring to his collaboration with Guliaev on his latest sirtuin inhibitor research. And the future of cancer treatment, in general, requires assistance such as Guliaev’s. Cancer affects over 600,000 people in the United States, and their chemotherapy treatments cause unfortunate side effects like hair loss and vomiting. Thanks to computational chemistry, two new innovative therapies are in the works. The first is Target Cancer Therapy, which identifies repair proteins that can inhibit cancer cells from dividing; Amagata and Guliaev’s discovery of Streptosetin A as a HDAC inhibitor and tumor growth suppressor is essential to furthering Target Cancer Therapy. The second is Epigenetic Therapy, wherein a molecule changes the shape of the DNA within the cancer cells to stop them from dividing as Ngoi says, “the wave of the future.”

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Each cell found in an organism needs a mitochondria to provide energy and a nucleus to store information. In the same manner, Dr. Kimberly Tanner, director of the Science Education Partnership and Assessment Laboratory (SEPAL) at San Francisco State University, is the program’s nucleus, mitochondria, and more. Through her, SEPAL has undertaken the enormous task of dissecting, testing, and improving biology education. SEPAL’s staff, students, and faculty conduct research into new tools, techniques, and teaching methods that bring real-world scientific practices into classrooms—from kindergarten to graduate school. “We have fieldtrips of kids coming through here,” says Trisha de Vera, SEPAL administrator and resource center manager, “and we have lab coats waiting for them at each chair so they can actually feel like scientists when they come on to the campus.” Methods like this encourage children to ask questions and take an active role in their learning process. SEPAL aims to promote discovery, expand diversity within the sciences, and reduce the difficulty for both students and educators. With passion and dynamism, Kimberly Tanner guides it all.
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Posters on display in the SEPAL classroom Page 20: Think Like a Biologist Poster. The goal of all SEPAL courses and programs is to support students in learning to think like biologists in their everyday lives.

Referring to society, she adds “We absolutely know from a lot of different lines of research that the kinds of people who do science–and their personal, cultural, linguistic backgrounds–influence the kinds of questions they ask about the natural world. We are faced with challenges of climate change, energy management, genetic modification, healthcare challenges of all sorts, and we really need lots of different perspectives working on those problems.”

At this point her eyebrows were raised and her hands moved as if she were winding a kite string. “Our lab is committed to trying to make the scientific workforce–both in terms of research and in terms of other professions like teaching and healthcare–reflect the rich diversity we have in our country.” She detailed the new 2017 Howard Hughes Medical Institute (HHMI) funded effort – Biology FEST, Faculty Empowering Students in Transformation – as an example. This new effort will engage upper division biology student leaders in a biology service-learning course that will partner them in teams with biology faculty instructors. Together, these student-faculty teams will build new curricular activities, like homework and case studies, that connect biology content to the home communities and personal lives of biology students, as well as highlight the contributions of scientists from many different cultural and personal backgrounds.

As a girl Tanner found the inspiration to pursue a degree in science after working with her high school biology teachers, Charlotte McBee and Peggy Welch. Tanner was the first in her family to attend college, she says, and she completed her undergraduate studies at Rice University in Houston, Texas. She earned her doctorate in neuroscience at the University of California, San Francisco, where she remained to work in UCSF’s science education program. In 2004 she was hired as a member of SF State’s biology faculty as a professor specializing in science education.

After outlining her own academic pathway, Tanner continued to explain SEPAL’s third focus: reducing the difficulty of learning and teaching science. Science tends to be complex, interconnected and fact-dense. “A lot of people find the sciences difficult or challenging,” Tanner said, swaying from side to side in her chair as if searching for something. “We also know that a large proportion of the population just doesn’t understand a lot of scientific ideas. Part of what we do in the [SEPAL] lab is to try and understand what’s difficult for people to learn in science, think about why it’s difficult to learn, and how to get that kind of information to really talented faculty so they can more directly address what’s difficult.”

Tanner’s lab has taken a new approach to addressing how and why science seems so difficult to so many. For people to understand individual fields of science such as climate change or genetic modification, she says, it’s crucial for them to be able to link ideas. “It is the connections between the ideas that are important.” The thought of connections prompts her to look down at her neck scarf: she relates that she is searching for the silk-screened neurons that were on the scarf she wore the day before. That simple, telling behavior exemplified the true scientist’s search for associations and connections in everything they do—even, sometimes, in what they wear! Tanner is known around campus for wearing biology-themed scarves such as another favorite scarf that is dotted with mitochondria.

She continued her introduction to SEPAL, describing another current study that relates to association and the difficulties in learning science. Her lab is conducting research to identify the differences between how non-biology majors and biology experts sort the cards based on fundamental biological ideas. Her study found a difference between how the two groups organize information. “What’s really interesting, if you ask a non-major [to sort the cards], they put all the plant problems together, they put the human problems together, and they put the microorganism problems together. So they represent biology based on organism type. If you ask faculty or expert scientists to do that same kind of sorting, they will say, ‘Oh, these are all about energy and matter, this is how we deal with energy and matter in living systems. Oh, these are all about information flow in genetics and how you copy cells. Oh, this is really all about evolution...”

Thus, the sorting used by experts allows them to group large sets of similar information into more manageable groups. Educators call this method “chunking,” and it allows for easier access and use of learned information. Tanner and colleagues are now applying discoveries like this sorting dichotomy in classrooms to help address the difficulties in learning science.

As Tanner finished discussing the last of SEPAL’s three missions, her eyes seemed lit from within and her hand gestures became even more animated. At times, she reached out as if pointing to a ship on the horizon. Her obvious excitement made me wonder and ask about, what motivates her passionate approach to science and teaching science. Science tends to be complex, interconnected and fact-dense. “A lot of people find the sciences difficult or challenging,” Tanner said, swaying from side to side in her chair as if searching for something.

Page 20:

Background photo of mitochondria. Mitochondria are key structures inside complex cells that manage chemical energy, enabling the cell to perform its functions.

Page 22:

bottom photo: SF State Biology graduate students are engaged in an innovative cell biology education research to improve their own classroom teaching.
Tanner's professional passion is clearly intertwined with SEPAL's successful history. In April 2014, SEPAL celebrated its 10-year anniversary. Tanner and her staff both created and developed the center’s numerous programs and research projects.

Trisha de Vera, SEPAL’s administrator and resource center manager, has been with the educational laboratory since its inception. I sat with de Vera, an enthusiastic administrator, to ask more about SEPAL’s sources of momentum and success. Without hesitation, de Vera answered, “Kimberly Tanner! It’s her drive, and I really mean that to the letter, D-R-I-V-E.” She spoke with eyes wide and index finger pointing as if she were selecting each letter from a suspended touch screen. “She has the drive to do everything and anything. It’s her drive and her passion for science education that has made this program very successful.”

Asked about her favorite among Tanner’s personal traits, de Vera again answered immediately. “She knows all of her students by name,” she said. “If there are students that need a little extra help, she is always willing to go the extra mile; her door is always open.”

Tanner’s availability has made her a respected resource among staff, students, and faculty that extends far beyond SF State. When asked which of Tanner’s accomplishments since starting SEPAL has had the greatest impact, de Vera responded decisively. Receiving a huge Howard Hughes Medical Institute grant to support one of SEPAL’s innovative programs, Biology Faculty Explorations in Scientific Teaching, Tanner received this invitation-only grant in 2012 for the maximum stipend of $1.5 million. Tanner’s award represented the maximum stipend of $1.5 million.

“Tanner is clearly an instrumental and dynamic force in science education and her impact and accomplishments through SEPAL are evident. During our interview, Tanner shared these final thoughts: “What’s fabulous about SEPAL is that we really represent a large number of people who are going out and changing the world. We have more people that understand that we need to change the way that we are teaching and we need to think very carefully about who we’re teaching and how to engage them and make it relevant to their home communities…[in a way] that makes sense.” Tanner concludes: “If you had asked me 13 years ago if we would have so many people out changing the world, I would not have ever predicted what a powerful set of alums we [would] send out into the world every year.”

“Graduation time is a ‘very special time of year, because we are flooding all these fabulous advocates for social justice out in to the world that you know are going to make it a much better place for the next generation.’”

Stephanie Malgrange explained how her experiences with Tanner have impacted her education and aspirations. “She is one of the most driven and focused people I have ever met. I think she is a pillar in this department in terms of the type of work that she’s doing and making broad changes with the biology department. Seeing her in action has helped me form the mental picture of the type of teacher that I want to be. She is someone to live up to in terms of what she does and how she does it. She is a rock star scientist!”

First year graduate student Ellen Young also shared SEPAL’s impact on her academic development. Studying in the program has “deeply impacted who I am,” she said. “Coming to SEPAL has helped me put into words how much I do value community and want to cultivate it in a biology classroom. It has also provided alternative ways of teaching biology that I see as more effective and are supported by evidence.” It excites her, Young continued, “to be a part of something that feels transformative.”

Casually sipping from a black mug filled with coffee, Young outlined some of Tanner’s qualities that she most admires. “Her skill set is really diverse. She is a really skilled biologist and scientific thinker, really bright and an astounding scientist!” As Young talked, her hands moved as if she was stitching a quilt. Occasionally her expression bore the upturned, awestruck look of a girl watching fireworks. She ended by saying that Tanner was “so connective.” She has this really amazing ability to bring people together. I think,” she ended by saying “that she brings out the best in a lot of people. She has taught me so much about being a professional, demanding that I rise to being a colleague rather than treating me as a student. I feel like I’m in the process of rising and I think that’s because of her expectations.”

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“Graduation time is a ‘very special time of year, because we are flooding all these fabulous advocates for social justice out in to the world that you know are going to make it a much better place for the next generation.’”

Page 24 Top photo: SEPAL Program Administrator, Trisha de Vera, partnered with Professor Kimberly Tanner to found and grow SEPAL since 2004.

Page 24 Bottom photo: Science instructors from both SFSU and San Francisco Bay area community colleges collaborate to explore active learning approaches, develop assessments to gauge learning, and practice strategies to promote inclusive teaching at the annual SEPAL Scientific Teaching Institute.


Page 25 Lower left photos: Top: Even in large-enrollment biology courses, SF State students experience evidence-based teaching strategies in every class session, such that every student has multiple opportunities to talk about the biology they are studying. Bottom: SF State Biology graduate students are engaged in learning new evidence-based teaching strategies as future science faculty.
Ed Carpenter: Maverick with a Microscopic Topic
by Chelsea Pruitt

“Ed Carpenter, Professor at San Francisco State’s Romberg Tiburon Center, travels to Antarctica to conduct pioneering studies on nitrogen fixation by bacteria. His research is funded by the National Science Foundation.”

It’s a Monday morning in Tiburon, California. Spring sunshine is bathing the entire Bay Area in blinding light and an atypical heat. Residents of the green, hilly community are out and about, eager to soak up sun after an unusually chilly winter. Dr. Ed Carpenter, working at San Francisco State’s Romberg Tiburon Center for Environmental Studies, may be surrounded by an unseasonably warm mid April, but his mind is focused on one of the coldest, most desolate places on the planet: Antarctica. His current research takes him to Earth’s southernmost continent to gain important insights from some of the world’s smallest organisms.
Carpenter is now a low-key, avuncular professor of microbial ecology, but his early school days in upstate New York were surprisingly lacking in disciplinary focus and application. “You know it’s funny,” he recalled recently from his office at RTC, “I didn’t have very much guidance in high school. Nobody even told me to take the SAT’s.” This unstructured approach to schooling might have dammed another student’s shine, but not Carpenter’s. He was one of just two students from his high school to receive a New York State’s Regents Diploma and he leveraged this recognition to gain admittance to the State University of New York, even without formal college boards.

“My first semester I took the same attitude that I took in high school, which was sort of coasting through things.” After a brief scare that he might flunk out of SUNY, however, Carpenter changed school, which was sort of coasting through things.” After a brief scare that he might flunk out of SUNY, however, Carpenter changed school, which was sort of coasting through things.” After a brief scare that he might flunk out of SUNY, however, Carpenter changed his approach to school and propelled himself toward and through a degree in Zoology. He followed up his B.S. with both Master’s and doctoral degrees in the same subject from North Carolina State University. That led him to a post-doctoral fellowship at Woods Hole Oceanographic Institution on Cape Cod, MA. He then continued his career with a teaching job at Stony Brook University on Long Island, NY. He worked there for 25 years until taking his current teaching position at San Francisco State University in 2000. Like many long-tenured professors, Carpenter has an impressive curriculum vitae. What sets him apart are his continual inquiries into phenomena in remote environments and his determination to find answers despite their difficult retrieval.

In 1969, Carpenter pursued an opportunity at Woods Hole Oceanographic Institute on Cape Cod, to collaborate on research with a postdoctoral mentor Dr. R.R.L. Guilland. He recalls his curiosity, “Everything I looked at, you know, I saw unique things and new things and I got all excited about it.” While working on his Master’s degree in North Carolina, his lab work primarily focused on fish and he contemplated becoming an ichthyologist or a fisheries biologist. But complications arose while experimenting on these “smelly” life forms. “It was so difficult to work with fish. I would carry out experiments with them and if I tried to replicate these experimental conditions, there was just a tremendous amount of variability. Other problems were that they were smelly, they were hard to work with, you had to have a lot of formalin or alcohol to preserve them in, and it was hard to get numbers to do statistical analyses on them.”

These frustrations led Carpenter to narrow his research focus from the bigger to the smaller—way smaller. An opportunity from a professor to study phytoplankton led Carpenter to appreciate the simplicity of studying microorganisms. He explains, “I can take a little bottle of seawater and get all the numbers in the world. I can get the species composition and abundance. I can carry out experiments and I don’t have to have all these big unwieldy bottles with fish in them.” Carpenter is referring to the fact that from a vial of seawater, one can determine the different species of microorganisms present, and determine the environmental conditions which affect species composition and abundance. For these reasons and for the remainder of his Doctoral studies, he continued to research and experiment on phytoplankton.

Biology students learn that nitrogen fixation occurs when hydrogen and electrons alter atmospheric nitrogen to form ammonia, a compound in which the nitrogen can react more easily with other elements and form new compounds. While this may sound didactic, the process is a vital part of the complex geochemical cycles upon which we depend. Microorganisms Only bacteria are capable of are constantly fixing nitrogen on land, and in water. And Carpenter is overwhelmingly interested in this process. If you ask him to divulge a few of his most interesting scientific finds, he gives stories in which the key players are nitrogen fixers—most of them such minute bacterial species that people are unaware of their existence. Shifting his interest toward these microbes paved a pathway for Carpenter toward research opportunities in exotic, far-distant locations. His research has primarily focused on the way bacteria and other microorganisms perform nitrogen fixation in ecosystems in Zanzibar, Madagascar, Costa Rica, and more currently, Antarctica. In all of the above locales, Carpenter saw that there was little or no research being done on nitrogen fixation, so he set out to change that. Carpenter’s research has a constant theme that many a budding scientist would like to emulate: Be the first to explore something!

Carpenter’s ball of determined curiosity got rolling when he was stationed off the Atlantic coast in 1972. One day, he was in a marine research boat that was skimming the water’s surface for large algal communities. He noticed small bits of plastic in every net-full he retrieved. At that time, the threat of widespread ocean pollution was just emerging and people were just starting to learn how our global human populations are fatally harming Earth’s ecosystems. “So I wrote up a paper,” he recalls, “and said, ‘The middle of the ocean is contaminated with all these plastics.’ I got that published in a good journal and that was the first paper on plastic pollution in the

The ice free regions of Antarctica (A, in red) and a satellite image of the McMurdo Dry Valleys. Images courtesy of Dr. Carpenter.
Texas and its presence is a scary symbol of human-induced damage to the planet. The drastic progression of ocean pollution in the decades since Carpenter’s 1972 research makes his contribution all the clearer. Scientists investigating the current extent of ocean pollution often reference his findings. While his findings were pointed, he insists that his initial discovery “was just accidental.” He goes on, “There were just so many new things that you could find when you went out there and I just said, ‘Oh, that’s interesting! I’m going to look into that and write it up.’” He follows that statement with a bashful chuckle.

Carpenter again recognized an opportunity for new exploration in 1979 while he was studying with class at the Finch La Selva Biological Station in the northeastern Costa Rican rainforest. While doing field research, he noticed big canopies of trees that turned out to be leguminous. “So I said,” he recalls, “Legumes...then they should have nitrogen fixers...” Carpenter was referring to the scientifically established fact that bacteria in the genus Rhizobium fix nitrogen solely in the roots of legumes. This led him to explore colonies of photosynthetic bacteria in leaves of rainforest trees and also carry out nitrogen fixation above ground. Carpenter saw that the field of rainforest nitrogen fixation research was a little foggy 30 years ago. Investigators knew very little about the subject and his intrigue and curiosity led him to pursue answers until he was satisfied. He notes, “Up to that point, nobody had really worked on nitrogen fixation in rainforests.” It was this pattern of innovative thinking eventually inspired Carpenter to travel to Antarctica to carry out research funded by the National Science Foundation. What sent him to a continent with zero permanent residents? He explains that once again, he “wanted to try to find something no one was working on.” He was undeterred by his own knowledge that “It’s totally dark [in winter], it’s extremely windy, and it’s about -60°C.” He began his frostbitten, NSF-funded research in a two-year rotating position in the National Science Foundation’s Division of Polar Biology and Medicine. Initially, he began studying bacteria that inhabit snow around lakes in arctic ‘deserts’ called the McMurdo Dry Valleys. He noticed, however, that these lakes were the focus of a lot of similar research. Carpenter was looking for something new, so he pursued knowledge on the microbial makeup of dry valley hyporheic zones. A hyporheic zone is the wet soil around a glacial meltwater stream. Antarctic hyporheic zones contain species composition similar to damp zones in the McMurdo Dry Valleys and other arctic deserts, but lack the overcrowded researcher population. Few animals and plants can tolerate Antarctica’s ultra extreme climate, and even fewer of those microbial organisms can inhabit the hyporheic zone. The limited biodiversity in those narrow meltwater zones consists of just tundra-grades (also known as moss piglets) and nematodes (a.k.a. roundworms). Carpenter explains that these tiny organisms are “freeze-dried” in austral winter only to thaw out in spring, like frozen dinners. Once thawed, these tiny organisms photosynthesize, and nearby cyanobacteria begin to fix nitrogen. This simple chain serves as an important source of organic carbon for dry valley ecosystems. This is where Carpenter’s current thoughts lie: the intricate inner workings of a subzero ecosystem in the desert regions on a continent 8,341 miles away.

Why would such a pioneer choose to teach at SF State’s Romberg Tiburon Center? Carpenter considered his experiences to be good material for what students need to learn. And who could disagree with a man whose knowledge base and research background are both so broad and so deep? He says, “I like teaching at SFSU because I have opinions on what is important for students to learn and I think I do a good job at teaching.” In the future, he plans to continue his Antarctic research and send graduate students, under his leadership, to the planet’s southernmost destination. He hopes to further expand scientific knowledge about nitrogen fixation in the Antarctic dry valleys. Whenever his intrigue and curiosity lead him next, Dr. Ed Carpenter will no doubt ask the hard questions that others have yet to pose. As the great French novelist Gustave Flaubert once wrote, “Be regular and ordinary in your life so that you may be violent and original in your work.” Violent may be a slight exaggeration, but there is no doubt that Carpenter’s work has been original and precedent setting. His ability to look at the surrounding world and recognize the gray areas of science continues to set him apart from the masses of scientists and individuals alike. When asked about the innovative nature of his research, however, he chuckles characteristically and simply says, “I try.”

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Photos by Alex Parker.
Most living things—plants, fungi, animals, and others—need oxygen to live and thrive. Plants produce oxygen as they capture light energy and build carbohydrates through photosynthesis. Most of our atmospheric oxygen, however, comes from another, less famous source—the phytoplankton. Collectively through their photosynthesis in the world’s oceans, single-celled, microscopic phytoplankton pump out 40 to 60 percent of the oxygen that humans and other aerobic organisms breathe. Phytoplankton also recycle the carbon dioxide they use as particulate organic carbon, and by sinking out of the upper ocean, they sequester some of the excess CO₂ to

“We can’t preserve an environment if we don’t understand it.”
Phytoplankton includes both phototrophic and zooplankton, although the latter are more animal-like and multi-cellular, both groups assume a wide array of elaborate and dazzling shapes. Some phototrophic plankton are slim and elongated, others spherical or jagged. In one class—the diatoms, every organism has a glass-like cell wall made of silica. And if viewed through a microscope, every teaspoon-sized cubic centimeter of seawater glistens and vibrates with thousands of these minute organisms. Marine food chains (or the more complex food webs) begin with phytoplankton and end—a after a bigger-eats-bigger bucket brigade—in large ocean predators like tunas and sharks. Beyond the oxygen that phytoplankton produce and the CO2 they sponge up, these organisms die and sink along with those glass exoskeletons to form diatomaceous earth—layers hundreds of meters thick and rich in silicates. Another phytoplankton group, the coccolithophores, have outer plates made primarily of calcium carbonate. These accumulate over thousands of years and re-emerge from the ocean floor in massive structural works such as the White Cliffs of Dover.

For poorly understood reasons, some kinds of phytoplankton will overpopulate to form massive blooms that form low-oxygen regions (anoxic zones) as they die and are decomposed by bacteria. Other phytoplankton species produce lethal biotoxins that negatively impact the ecosystem and even cause human fatalities. Both types of phytoplankton bloom events are termed harmful algal blooms (HABs).

William Cochlan has made a long career of trying to understand these primary producers and their unceasingly "‘The whole marine ecosystem depends on them,’ he told this reporter. ‘So if their health is in jeopardy, it will affect the greater marine ecosystem and the oxygen that we breathe.’ In his quiet, scholarly way, Cochlan is both a champion and preservationist for these unlikely planetary heroes. By studying phytoplankton and the group's somewhat mysterious status, he can better understand the viability and the health of our oceans and the higher levels of life that are supported by the marine pyramidal base. As Cochlan puts it, 'We can't preserve an environment if we don't understand it.'

Cochlan's career-long interest in phytoplankton continues with his research at Romberg Tiburon Center for Environmental Studies (RTC)—SF State’s off-campus research and teaching facility on SF Bay. His fascination started, however, during his undergraduate years at the University of British Columbia (UBC) in the late 1970s. The single-celled oceanic heroes first intrigued him while he was working under the mentorship of several individuals; he recalls as being 'bright, caring, and enthusiastic graduate students and faculty.' The graduate students, in particular, helped him understand the importance of phytoplankton as they assisted under-graduates like Cochlan with individual research projects and in 'hands-on' lab classes. For his honor's thesis as a senior, Cochlan studied how UV radiation impacts the availability of copper in the sea and the resultant growth of phytoplankton. This research engaged and excited him because it placed him “right on the cusp of new knowledge.” He recalls, in particular, learning from one graduate student mentor that, “If you don't understand the basis—the fundamentals—of what’s driving the marine ecosystem, there's no way you can solve problems” such as climate change and ocean acidification today.

Cochlan has devoted much of his career to researching one of phytoplankton's most exciting manifestations: bloom development and the way marine microorganisms use nitrogen. Cochlan describes phytoplankton blooms as being visible as large patches of brown or green discolored algae. A recent master's degree graduate from SF State, such blooms can grow very large with some "the size of a city." Many of the blooms Cochlan studies are right off the Pacific coast and in the spring and summer of 2015 a toxic diatom species formed a massive bloom from southern California all the way up to his home country of Canada and southern Alaska.

Cochlan explains that phytoplankton cells divide and reproduce exponentially, thus their biomass can increase very quickly—since phytoplankton such as diatoms usually divide at least once each day. At this conservative rate, a single cell could give rise to over 1,000 cells in just 10 days. Dinoflagellates, another common phytoplankton group second only in abundance to diatoms, can look armed with plate-like walls when viewed under a microscope. These phytoplankton cells usually exhaust nitrogen from the water first, he says, and then the bloom starts to die.

Cochlan started his work on phytoplankton during his senior thesis research project at UBC. The path he followed, however, was much different than the one he planned on taking. While growing up, he was always interested in becoming a naval aviator in the Royal Canadian Navy (RCN). Unfortunately, he says, after the last aircraft carrier in the RCN was decommissioned during his first years of high school, careers as jet pilots in the Navy "ceased to exist." Because of this, after high school graduation, Cochlan declined a commission as an officer cadet at Canada’s Naval Academy, then the Royal Roads Military College. While his dream of becoming a naval pilot seemed to be crashing, his career in oceanography arose from the wreckage.

He entered UBC as a general science major, and easily transitioned to an honors marine biology program—a decision, he says, came “natural” to him. Cochlan grew up in a small town about 100 miles north of Vancouver, Canada, on the eastern shores of the Salish Sea, the inland waters of British Columbia. He lived so close to the ocean, in fact, that he "could throw a rock from his front yard and hit the saltchuck" (BC slang for salt water).

Starting a continuing throughout his formal education and academic career, Cochlan has studied two economically important groups of phytoplankton: certain diatoms that small fish consume in upwelling surface or toxic golden-brown flagellates called Heterosigma akashiwo, which kill fish. Amongst the diatoms, Cochlan and his graduate students work mainly on species in the phytoplankton bloom.
Cochlan and his students use a variety of sophisticated tools and instrumentation to study phytoplankton, and measure their responses to the ever-changing chemical and biological oceanic environment.

The second phytoplankton species that Cochlan and graduate students have been studying recently—Heterosigma akashiwo, has a different impact on the marine ecosystem. When commercial fish species raised in caged systems in the Pacific Northwest and British Columbia encounter this golden-brown alga, it can kill the fish very rapidly. Although scientists know that Heterosigma akashiwo produces a toxin, Cochlan and his colleagues at The National Oceanic and Atmospheric Administration (NOAA) have yet to identify it. Mammals seem to be immune to the poison, but it can cause chronic illness as well as short- and long-term memory loss. In three recorded cases, the toxin has killed people who ate contaminated clams. The second phytoplankton species in a process called alleopathy. Despite such complicated puzzles—in fact, because of them—Cochlan finds the research "fresh and exciting."

Cochlan and his students use a variety of sophisticated tools and instrumentation to study phytoplankton, and measure their responses to the ever-changing chemical and biological oceanic environment. According to Dr. G. Jason Smith, an Associate Research Scientist at the Moss Landing Marine Laboratory in Monterey and a world authority on diatoms, Cochlan’s work is “seminal in defining nitrogen uptake.” Cochlan is also a pioneer in researching algal blooms at sea, and has worked from the Equatorial Pacific to the Southern Ocean off Antarctica. In the summer of 2014, Cochlan served as Chief Scientist for a collaborative scientific mission on the 279-foot research vessel the Melville, operated by Scripps Institution of Oceanography. On this mission, funded by the National Science Foundation, Cochlan, his students from SF State, and a team of research colleagues from several American and Canadian universities cruised for 26 days off the Pacific coast between Point Sur, CA, and Seattle, WA. They focused their study on how pH affects the nutritional quality of phytoplankton and the toxicity of harmful algal blooms. To accomplish this, he and his SF State co-workers had
to develop a technique for controlling pH in experiments conducted on board a ship while at sea—something that no other team had done before. They came up with a way to manipulate and regulate the pH to which they were exposing phytoplankton experimentally. Cochlan’s team is finishing the final analyses, but so far they have found that in more acidic water (i.e., with a lower pH range), the HABs are much more toxic. This has powerful implications for understanding global climate change since ocean acidification (OA) is one of its dramatic consequences.

Phytoplankton studies are essential because the microscopic organisms are not only the foundation of marine ecosystems, but their viability and productivity impacts the health of the World’s oceans and ultimately the health of the whole planet. Cochlan explains that climate change and ocean acidification could intensify the negative impacts of harmful algal blooms, but he and colleagues are just beginning to understand how acidification affects phytoplankton. Cochlan predicts that increased temperature could lead to increased rainfall in Washington State and other parts of the Pacific Northwest and this, in turn, could reduce the salinity (saltiness) of water in the Salish Sea. He and his coworkers recently published studies suggesting that decreases in salinity could promote bigger, more frequent, and more toxic blooms involving phytoplankton species such as *Heterosigma akashiwo*. This would be bad news for fish, fisheries, and human health. HABs are also very concerning because blooms can harm consumers even at low cellular densities. In other words, even with a low number of poisonous cells per liter of seawater, the HAB can be highly toxic.

Looking toward the future, Cochlan plans to continue studying how environmental factors such as salinity and ocean acidification impact phytoplankton growth and toxicity and how these environmental stressors may act synergistically to accelerate toxic risk to marine ecosystems and humans. And he hopes to gather information quickly enough so that marine scientists and conservation managers can both lessen harmful effects and ensure that phytoplankton continue to positively influence the environment. The alarming increase in harmful algal blooms in some regions is just “another reason we need to be concerned about climatic change and acidifying seas,” he concludes. Clearly, phytoplankton species—our unsung providers of global oxygen—can also be intermittent and mysterious poisoners of other sea life. Only through continuing study, adds Cochlan, can we understand their future impacts on “shellfish resources, local economies, human health and wildlife populations in a changing world.” Although these are complex and challenging issues, the world-class facilities and instrumentation amassed at Cochlan’s laboratory permit him and his student researchers to make dramatic discoveries and provide valuable insight into the health of World’s oceans. Through the creation of this transferable knowledge, the potential risk to human health can be assessed, and the toxic impacts on recreational, commercial and indigenous fisheries minimized in the US and around the World. ♦
A student is preparing to present a short talk to his fellow classmates on an assigned reading about the human immunodeficiency virus (HIV). Dr. Pleuni Pennings had previously assigned that article and now she looks on with an expression of intense curiosity as to what he will say. As the instructor of this course, this is natural. But it’s even more natural to Professor Pennings because perpetual curiosity defines her personality, her many professional preoccupations, and her passionate interest in drug resistant HIV.

“I would like to make sure that it [HIV] doesn’t become resistant to drugs at all”

Pennings is one of SF State’s newest biology professors and an evolutionary scholar who has been conducting HIV research since 2010. She hopes to understand the factors that govern how drug resistance evolves within the HIV virus so she can help find ways to stop the progression. “I would like to make sure that it [HIV] doesn’t become resistant to drugs at all,” she says. “We need to understand why it happens sometimes and not other times, so we can prevent it.”

Left:
A poster Dr. Pennings created that addresses her teaching plans for the semester.
I’m interested in finding out why the virus can become resistant to drugs in some patients, but not in others”}

Dr. Pleuni Pennings
Department of Biology

Dr. Pleuni Pennings attended Aberdeen University in Scotland, where she began as a math major in 1993. Her future would change, however, after she befriended a few biology students who were living in her dormitory. “They would talk about biology all the time,” recalls Pennings. “It was really fascinating to hear all the amazing stuff they were talking about: they really sparked my interest in biology.” A year later she transferred to the University of Amsterdam, and changed majors to biology. After graduating from the University of Amsterdam in 2000, Pennings attended Ludwig Maximilians-Universität in Munich. After six more years, she had earned a doctorate in Evolutionary Biology. Pennings worked as a postdoctoral scholar in several programs that focused their research on drug resistance in HIV. In 2010, she moved to Boston to study the population genetics of HIV resistance with Dr. John Wakeley at Harvard University. Arriving in Boston had been “tough,” she says. “I did not know many people.” Although she enjoyed the intellectual challenges, she’d “always wanted to live in California.” So seeking better weather and expanded job opportunities, Pennings and her husband moved to the Bay Area in 2012. For two more years, she continued her postdoctoral work on HIV resistance, this time at Stanford University with Dr. Dmitri Petrov.

In 2014, Pennings applied to several different universities in the Bay Area in hopes of teaching biology and sharing with students her abiding curiosity about drug resistance. Pennings thought SF State would be a great place to work and would offer the chance to collaborate with evolutionary biologist Scott Roy and virologist Joseph Romeo, among others. “The one school that I really wanted to teach at was SF State,” Pennings confides. “When I was notified that I got the job here, I could not have been any happier!”

While planning her courses and establishing her laboratory, Pennings has continued her research on the evolution of drug resistance in HIV. “I’m interested in finding out why the virus can become resistant to drugs in some patients, but not in others,” she explains. Although there have been many studies on HIV in the past, her study focuses on an angle beyond what medical doctors observe. “When medical doctors do observe failure of drugs, they know that the virus has evolved resistance to that particular drug,” she says. “But we are interested in why some patients get drug resistance and some patients don’t, they may think it’s because that these patients are not always taking their medication.” When a patient skips doses of the potent mixed “cocktail” of drugs he or she must take—for the rest of their life—it is more likely that the virus evolves resistance. However, this doesn’t mean that all resistance is due to missed doses.

In Pennings’ studies of resistant HIV, she looks to see if virus particles bearing gene mutations for drug resistance were already present in a human’s body before they took HIV medications. Perhaps the drugs are ineffective in those patients, she says, not because they skipped doses, but because they harbored a few virus particles containing resistance mutations to begin with. This, she believes, might render the medication ineffective for them. “Mutations happen all the time,” says Pennings. “So the difference between patients who [develop] resistance and those who don’t may be something that happened to the virus before they started their treatment.”

In 2009, prior to working on HIV, Pennings conducted evolutionary research on ants in Germany and in America. “I worked on two species of ants,” says Pennings, “one species we used to call “Longis” and the other we called “Pamis.” These are really small little ants that live inside acorns,” she explains. The two ant species, the “Longis” (Temnochilus longispinosus) and the “Pamis” (Protomognathus americanus) are enemies. When the “Longis” queen has pupae—the ant version of eggs with the queen’s offspring inside—the “Pamis” ants will attempt to steal the pupae back to their own acorns, tuck them inside, and after they hatch, use the newly emerged “Longi” ants as slaves. Pennings describes why researchers call them slaves: “They work for the wrong species of ants,” she says. The “Longi” slave ants inadvertently work for the betterment of the “Pamis” ants.

In 1993, a patient is taking two drugs, these drugs may not reach all parts of the body equally well [drug B reaches the brain, but not drug A].

Below: If a patient is taking two drugs, these drugs may not reach all parts of the body equally well [drug B reaches the brain, but not drug A].

Above: If a patient is taking two drugs, these drugs may not reach all parts of the body equally well [drug B reaches the brain, but not drug A].

Top right: Dr Pennings and colleagues studied how differential drug penetration can lead to the evolution of multi drug resistance, even when treatment is with multiple drugs [see Moreno et al, 2015, PNAS].

Dr. Pleuni Pennings attended Aberdeen University in Scotland, where she began as a math major in 1993.
"It’s like cows that give milk, but instead of their own youngsters drinking the milk it’s us, the wrong species. The cows are producing the milk, but they are helping us, instead of their own kids."

Pennings and a group of young researchers led by their professor Susanne Fotzik, travelled from Germany to do fieldwork in the United States in the summers of 2009 and 2010. The group searched for ants in upstate New York and Virginia, to observe how and why the ants would react to each other. Pennings and her fellow researchers sifted through mounds of acorns to find those with ants inside. "If you open up the acorn you can see that there’s lots of small ants, and since they are really small there’s maybe 50 or 100 ants inside an acorn." Searching for the ants was no easy process; some days Pennings and her team would open and examine nuts for hours without finding ants. When they were successful, however, they would collect the ants in plastic containers and take them back to Germany for further study. In the lab, Pennings and her team were able to probe the relationship between the two ant species. When they placed a ‘Pam’ ant near a ‘Longi’ ant, they could see (with the help of a microscope) that the ‘Longi’ ant was primed to attack and aggress. "We think they do that because when the ‘Longi’ smell the ‘Pam,’ they know that their children are at risk, so they know it’s better to be ready to fight. And they do fight if the ‘Pams’ come and try to eat their acorn." Such detailed study of behavior in two entwined species can help biologists better understand the principles of co-evolution.

Pennings hopes she can share her research experiences with her students at SF State. In her first semester, Fall 2014, Pennings taught Biology 864. This graduate course focused on recent developments in virology and used HIV and influenza viruses as case studies. Observes Maricela Prado, a graduate student in the biology department, “I like the way she explains things.” Dr. Pennings is “more like a student. She is very interactive and she explains everything very well. She is very approachable,” adds Prado. “You can text her, email her—she is always available.”

Rather than implementing a plan of precisely what she’ll cover in class before the semester starts, Pennings decides on the class discussions week-by-week, based on world events. For instance, when the Ebola outbreak happened (in 2014-2015), Pennings covered the growing threat as it was happening. "When the Ebola epidemic occurred, I had students talk about it in class. We were interested in, ‘How is the virus that is causing the epidemic different? Has it evolved? Is it different than previous Ebola epidemics?’ Pennings also provides weekly reading assignments to the students and directs each student to focus on a specific aspect of the subject, just the way a team of evolutionary biologists would. Students then report back and discuss the pieces together. “I think it’s a lot of fun to teach this class,” says Pennings.

Pennings also presents a wealth of information from her current and past research in her blog, betterscientist.wordpress.com. “She posted some information about the Ebola epidemic that I found to be very informative,” says Dr. Robert Ramirez, a professor of microbiology and SF State’s Associate Dean of the College of Science and Engineering. “I found the virology information that she posts on her webpage to be so interesting,” Ramirez says, “that I told my Biology 410 students they should read and view the information that is there to help them understand the world of viruses and the BIO 420 course material.”

In Spring 2015, Pennings co-taught Biology 355: Genetics, alongside fellow biology professor Scott Roy. This enabled her to share some of her experiences in evolution research with SF State students. And it provided new ways to fuel her restless, ever-growing curiosity.

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Brain drawing
Poster drawn by students in Dr Pennings’ lab. Dr Pennings believes that drawing is a great way to learn and teach.
Picture your parent or grandparent suffering from muscular dystrophy (MD). Years of therapy have only slowed the progression of the disease, and this disease has gradually eroded your loved one’s ability to walk. You fear that you might have inherited genes for the debilitating disease and could also pass them on to your own children or grandchildren. Despite your fears, there is reason for hope: Research on muscle formation will someday lead to early treatments for genetically caused developmental diseases such as MD. Effective treatments are many years away, but they could be partly based on the nearly limitless potential applications of developmental biology. This is a specialty that San Francisco State biologist Carmen Domingo is exploring in her lab with student researchers. Domingo is a forerunner in developmental biology and devotes more than full time to training others in this revolutionary field.
Dr. Carmen Domingo
Department of Biology
and Interim Dean of CoSE

For 20 years, Dr. Domingo has instructed both future science teachers, who can inspire a wide range of youngsters, and new biologists, who may someday grow replacement muscles and other organs from stem cells. Her simultaneous involvement with several student training programs, including the NIH SF BUILD program, aims to increase the diversity of people pursuing a career in the biomedical sciences. These students—like Domingo herself—face must overcome challenges to pursue a scientific career.

Born to immigrant parents, Domingo grew up in the 1970s as a young Latina student who initially aspired to become a physician. Raised in a working class neighborhood in Hawthorne, CA, Domingo learned from her parents to value education and to pursue her passions. In high school, she studied hard and was motivated to succeed, despite the lack of a mentor at her high school and the absence of expectations from her teachers. Her hard work paid off in very high good school grades, which gained her admission to UC Irvine.

Undergraduate studies at UC Irvine was an eye-opening experience for Domingo, as she began to meet other students who came from economically privileged families. She noticed the apparent lack of diversity in the student body and the faculty, and had difficulty relating to her professors. Domingo said that there was “literally only one professor I knew who was of a different ethnic group.” But she stayed determined, driven by her desire to succeed in college and pursue a medical career.

As she tackled her pre-med studies, she discovered a new fascination with developmental biology. Her interest in the subject grew during an opportunity to work with Dr. Marianne Bronner, a researcher at UC Irvine who studies how the peripheral nervous system is built during vertebrate embryogenesis. In Bronner’s lab, Domingo found this dual emphasis at San Francisco State and started teaching.

In 1991, while a second-year graduate student, Domingo had another formative opportunity—this time to teach an Introductory Biology lab course to undergraduate UC Berkeley students. Nervous and uncertain, but determined to help unlock the wonders of life science for these students, Domingo unknowingly began to develop a student-centered approach to her class. Her main strategies, assigning group work and fostering cooperation between students, were both successful and highly popular. Domingo’s first class garnered high course evaluations and a graduate teaching award. “In my opinion,” Domingo explains, “good teaching is engaging students to think about how to solve problems, not pure memorization.” She continued to develop and try out educational techniques that could help students find their own creative and innovative problem-solving solutions for college and their later careers.

Domingo finished her doctoral and post-doctoral work at UC Berkeley, and then began searching for an employer that valued the combination of research and teaching as much as she did. Domingo found this dual emphasis at San Francisco State and started teaching here in 1997 as an assistant biology professor. When asked why she chose SF State, Domingo emphasizes the importance of a diverse and multicultural academic body. This breadth, she says, helps unlock the creativity and innovation required in life science research—her own and her students. She considers SF State, one of the nation’s most diverse groups of both students and faculty, as an inspiring place for fresh research ideas. She firmly believes that students from various cultures working together are most likely to think of novel ways to solve problems in scientific research. She believes she could continue her own research here and at the same time, train and develop aspiring teachers and researchers. She has proven precisely this during her two decades at SF State.

Domingo’s research interests remain in developmental biology. For years, her laboratory group has studied how muscles form during embryogenesis in the frog *Xenopus laevis*. Her current focus is on the role played by non-coding RNA molecules in muscle formation. When asked why she chose the comical *Xenopus*—with its big splayed feet and blotchy camouflaged skin—as her research model, Domingo explained that “This model system allows us to follow the development from the fertilized egg to the tadpole in a dish, since these stages develop outside the protective environment of the mother.” *Xenopus* is a perfect animal model due to the high yield of eggs per female, the eggs’ easy observability after fertilization, and their aforementioned external development. Behaviorally, the frogs also share similar developmental patterns with humans and have a segmented body and muscle development closer to our own than many other common experimental organisms. Combining these advantages, *Xenopus* can serve as a good laboratory model for studying developmental and muscular diseases.

Domingo’s laboratory on the 7th floor of Hensill Hall has a homey, laid back feel to it, with each of the six rooms bearing tall stacks of books and dense clusters of laboratory equipment. Every corner of the lab has a dedicated purpose for developmental biology research, from a computer room for analyzing data to a prep room for mixing and plating growth media. When asked how her research relates to stem cells, Domingo replies that “Pluripotent stem cells, which can differentiate into almost any kind of specialized cell, play a huge role in both developmental biology and stem cell research.” She explains that the potential applications of pluripotent stem cells include growing replacement organs for patients with organ failure and helping patients recover from muscle dystrophy.

Domingo’s lab is home to many SF State students. One of her undergraduate students, Jason Garcia, is conducting research with *Xenopus* to elucidate the role of micro RNA-206 in muscle formation in developing frogs. This research might have some therapeutic applications as research from other labs has shown that this specific RNA is associated with certain muscle diseases in humans. Domingo’s lab group has found that reducing the level of micro RNA-206 during development can cause muscles to fuse their ability to elongate and form aligned muscle fibers in the tadpole. She is currently working with her students to identify the downstream targets regulated by this micro RNA to better understand how muscles achieve parallel alignment in regular segments along the body axis.

Besides devoting many hours per week to her undergraduate students and graduate lab students, Domingo is also currently the director for the California Institute of Regenerative Medicine (CIRM)-Bridge program. This program...
aims to prepare masters students for stem cell research by giving them opportunities to conduct their own research in the stem cell field. Projects range from developing new techniques for studying stem cells to more direct therapeutic applications of stem cells. When asked to explain the goals of this program, Domingo replies, “The CIRM-Bridges program aims to provide students from diverse backgrounds with courses in stem cell biology, ethics, and science writing, as well as the opportunity to work with research faculty in partnering institutions such as UC San Francisco, UC Berkeley, Stanford University, and the Buck Institute.” Domingo stresses the importance of preparing a diverse group of biomedical researchers. She hopes that the CIRM-Bridges program can contribute to a research community that will solve pressing medical needs. Current CIRM-Bridges students are studying a range of interesting questions from nerve regeneration, heart and bone repair, diabetes, cancer to induced pluripotent stem cells.

CIRM-Bridges students are studying a range of interesting questions from nerve regeneration, heart and bone repair, diabetes, cancer to induced pluripotent stem cells. This program provides students exposure to some business courses that are a part of the MBA program as well as an opportunity to conduct research either in biotechnology or stem cell science. Projects range from developing new techniques for studying stem cells to more direct therapeutic applications of stem cells. When asked to explain the goals of this program, Domingo replies, “The CIRM-Bridges program aims to prepare masters students for stem cell research by giving them opportunities to conduct their own research in the stem cell field. Projects range from developing new techniques for studying stem cells to more direct therapeutic applications of stem cells.”

Domingo’s undergraduate research assistant Rebecca Blandino appreciates how helpful and considerate both her mentor and the laboratory’s graduate students are when teaching younger students new techniques. She adds, “I really love this lab…The amount of dedication and passion for science that everyone has in this lab drives me to keep working on my project, sometimes even staying overnight just to finish an experiment. We always learn something new every day.” Rebecca Blandino is now pursuing her PhD at UC Davis. Marissa Leal, one of Domingo’s graduate students, describes the lab as a “very laidback and nurturing environment for people who love doing science and love learning science.” After graduating from the SF State master program in Cell and Molecular Biology, Marissa Leal became a physician assistant.

Developmental biology is probably years away from understanding all of the steps necessary to build muscle. But under Domingo’s guidance, her students have become highly skilled in embryological techniques and hope that their research will contribute to the diagnosis and treatment of muscular dystrophy. At this point, a reader might wonder whether Domingo has any time off from her work as a professor, researcher, and director of programs at SF State. Domingo smiles at this question and admits that, “While I don’t have as much free time as I would like,” she spends all of the moments she can carve out with her husband and two daughters, hiking, biking, or simply cooking dinner at home. She considers her greatest accomplishment to be raising her children. And she looks forward to their enthusiastic hugs at the end of every day—just one more step in their personal development and her own. ♦
As a 5-year-old dreaming big under the hazy Eastern sky, Ozer found science inspiration right in her own family. “We grew up in a very liberal household, influenced by education not religion,” she recalls. The engineers, economists and professors in Ozer’s extended family were her role models. The “brainwashing” was an early exposure to science and the zeal it engendered. Her father taught her the names of many stars and constellations and she followed his lead toward an academic career in physics when she was old enough. “My main goal, even when I was little, was to be a scientist,” she says. She honed this passion for most of her professional career—and then shared it. At SF State for over 16 years now, she has helped countless women, underrepresented and economically disadvantaged students, and other inquiring students find pathways into technical fields.

Ozer’s own path led to an undergraduate degree in applied physics from Istanbul University in 1976. While in graduate school at Bosphorus University in Turkey, she made the easy transition into the world of materials science. She focused her Ph.D. research on the technologies of thin-film deposition and surface characterization. According to Arthur Braundmeier, a retired physics professor from Colorado who shares Ozer’s area of expertise, thin-film research “is a far more practical method of applying thin films in a vacuum chamber than traditional chemical deposition techniques such as sputtering or physical evaporation methods for thin film deposition.”

Ozer’s path led her halfway around the globe to the United States after she was awarded a Fulbright post-doctoral scholarship in 1989 and became a University of Florida “gator.” “My Fulbright scholarship changed my life,” says Ozer. “I had to start from scratch” while transitioning from graduate work in physics to engineering, “while transitioning from graduate work in physics to engineering, shifting from physical evaporation methods to a newer wet-chemical deposition technique called sol-gel.”

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Braundmeier explains that the “physical vapor deposition” method of applying thin films in a vacuum chamber is a far more expensive way to coat materials than using sol-gels—that is, coating with solutions that evolve into gel-like networks. For example, the medical optics used in ophthalmology and endoscopy can be coated using physical vapor deposition, but are far costlier than those made using sol-gel. In the future, Braundmeier says, using sol-gel may also lead to cheaper solar cells. “Solar cells need to able to withstand 20 years of blowing sand and dust plus UV radiation.” Sol-gel coatings could not only help protect solar cells from these factors, but also allow “almost the entire visible wavelength to penetrate into the solar cell, creating more energy.” To this end, Braundmeier continues, “we need low cost, high abrasion resistance and we need ease of application, so the sol-gel process is certainly a contender.”

Products made with sol-gels are showing up more and more in the marketplace. Opticians use sol-gel technology to make transition lenses for eyeglasses. Fabric designers use sol-gel to produce T-shirt materials that change color. For example, on a hot day your shirt might be SF State’s gator purple, while on a foggy summer night the same shirt might turn to Giants’ orange. You might even see the most recent application of sol-gel technology on a Boeing Dreamliner or Airbus 380 dimmable aircraft windows. The reversible darkening of the dimmable windows’ transparency is controlled by a small applied UV and infrared radiation load inside the cabin, and enhances the efficiency of the aircraft’s heating, ventilation, and air conditioning systems.

In the 1990’s, when Ozer was a Fulbright research scholar, the sol-gel deposition technique was new and almost any research on the topic resulted in significant scientific publications. Ozer spent her first three months at the University of Florida in Gainesville, working long days to produce uniform coatings by sol-gel deposition. What “changed her life,” was not the laboratory struggle, but the two-fold guidance of her mentors, Bulent E. Yoldas and Larry L. Hench. First they “transferred to me their 30-plus years of knowledge. And second...they took their time explaining answers in such a way to help me realize the big picture and the science behind the process.” Ending this reminiscence in a grateful tone she adds, “I owe them both a lot!” And from “scratch” came Ozer’s two successfully published scientific papers from her time at the University of Florida.

In 1986, Ozer attended a North Atlantic Treaty Organization (NATO) sponsored conference at the University of St. Andrews in Scotland. The topic was Optical Properties of Narrow-Gap Low-Dimensional Structures. While she learned about past and current research on narrow bandgap semiconductor devices, she also noticed that she was one of only two women scientists in a room of 36. “This came as a shock, being from an urban center in Turkey. In Istanbul,” she explains, “15 percent of the scientists in science and engineering...
Devices with Anodic and Cathodic Electrochromic Layers

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**Engineering are female and 50 percent of the medical doctors are female.** Professional conferences like this one alerted her to imbalances of female- and minority-representation within many scientific communities. It also soon set her career path on a new trajectory.

Ozer began working as a consultant on science and engineering education for the United Nations Educational, Scientific and Cultural Organization (UNESCO). She traveled widely and found more evidence for the disparity of women and minorities in science, technology, engineering, and mathematics (STEM) fields throughout Europe and the U.S. Over time, she decided something had to be done about this lack of diversity and decided to dedicate her time to change this trend.

Based on her fact-finding, Ozer shared with me both reasons and potential solutions for reduced female and minority participation in STEM fields, particularly in the U.S. One significant problem: a lack of exposure to science at an early age. A solution: Young kids should have early and frequent access to local museums and science centers and receive science kits and science books in addition to their more typical stuffed animals and video games. A second problem: Gender stereotypes funnel young girls into occupations such as nursing, social science, and economics. A solution: Young people (particularly young girls) should take more science classes and see more women actively working in math, computer science, and engineering to empower their own choices. In Europe and urban centers in Turkey, Ozer says, all students must take physics, chemistry, and biology to graduate from high school. In many American schools, students may opt out of these courses and still graduate. This lack of exposure amounts to an opposite kind of “brainwashing” from Ozer’s experience as a young girl.

After completing her Fulbright Scholarship in 1990, Ozer took her new passions for engineering research and social justice back to Istanbul. She received a grant from The Scientific and Technological Research Council of Turkey (TUBITAK) to start a thin film research laboratory at Istanbul Technical University. To this day, the laboratory produces two PhD’s and at least 10 research publications per year. As Ozer was establishing the lab, she also learned more about STEM diversity in her own country outside of a few urban centers. While many urban youngsters of both sexes have access to science classes, museums, and engineering, girls (especially) in outlying and rural areas often lack the opportunity even to attend school. Soon Ozer was volunteering at local high schools as a mentor and role model to encourage kids to find pathways into science.

By 1993, Ozer’s extensive experience and expertise in both thin-film and sol-gel techniques led to a job offer from the Lawrence Berkeley National Laboratory (LBNL), a physics-oriented research facility managed by UC Berkeley. Ozer consulted with her family for a group decision about returning from Turkey to the U.S. With her son just graduating from elementary school and her daughter from middle school, they all agreed that the timing was ideal for a move to the Bay Area.
Engineering students

At SF State often spend time designing and creating new products using computer programs. As I walked past engineering labs in the Science Building near Ozer’s office, I saw numerous students huddled around computers using SAP 2000, a computer design program similar to AutoCAD. Others were testing the strength of materials and preparing for finals by supporting each other in the Engineering Study Room.

Ozer explains that the vast majority of MESA students work full- or part-time jobs to pay their way through college and most take five or six years to graduate. Money—or its absence—also explains why only 3 percent of the 193 undergraduate students in MESA will pursue a graduate degree after leaving SF State compared to 60 percent of Ozer’s undergraduates in Istanbul.

Lazaro hopes to be part of the 3 percent; he would like to get his Ph.D. in Engineering and one day work for Tesla. Lazaro tells me about attending a life-changing MESA Student Leadership Conference. “I was able to meet actual astronauts and asked them how they got there and I was able to reflect that I still have a chance.”

He continues explaining that, “Talking to people that look like you and to people that look like you about how they got there and I was able to reflect that I still have a chance.”

Lazaro hopes to be a part of the 3 percent; he would like to get into academic trouble over to see her.” I know that Ozer “will help them get through this.” Looking to the future, Hsu notes growing interest in pipeline programs that give students multifaceted support as they move from high school to career. “I think in the next 5 years, programs like MESA will grow.”

As Ozer moves through the halls, classrooms, and offices of the Science Building, she radiates uplifting energy and her mission is clearly to assist young scholars through just such an engineering “pipeline.” “Could you tell me the reason why you are doing badly in your classes?” she asks the occasional student whose GPA has dipped below 2.0. If the response includes a 40-hour workweek plus a full class schedule, she will probably reply, “You cannot work that much!” Then she will point out scholarship opportunities and suggest ways to work on campus to cut commuting time. In this way, Ozer helps potential engineers verbalize their own issues so that together they can find solutions.

“She would do anything to help out students as much as she possibly could,” says Emerson Malca, a former MESA tutor at SF State. In one of Dr. Ozer’s classes, he told her he was working his way through school and looking for a campus job. This brief conversation sent Emerson down a path from MESA tutor to co-founder and CEO of StudyRoom, an online tutoring service that allows students to connect, collaborate, and share notes and study guides.

Emerson piloted StudyRoom at SF State in the fall of 2011. Now StudyRoom is available at 1000 universities and reaches over 500,000 college students around the country, 13,000 of whom are here at SF State. "Because of the opportunity that Dr. Ozer gave me as a tutor," says Emerson, "I was able to see how powerful it was for a student to help another student.”

StudyRoom recruits tutors that can help in relevant and empowering ways. The site’s latest tutoring service is called SnapSolve: Students can take a photo of an engineering problem that is stumpimg them and receive immediate feedback leading to step-by-step solutions.

Besides tutoring, Emerson took him to science and engineering conferences and motivated him to restart a chapter of the Society of Hispanic Professional Engineers (SHPE) on campus. Emerson did so and became chapter president with Ozer as advisor. “All those leadership skills from tutoring to running SHPE help me every day in my role as CEO of StudyRoom,” Emerson concludes.

When asked to speculate on Ozer’s legacy at SF State, former associate dean Lisa White states, “Ozer’s Summer Engineering Institute—a two-week residential program in the engineering field for high school students—really reflects the extent of her commitment to precollege students. Giving, students hands-on experiences in science and engineering is important, particularly in those formidable high school years.”

Ozer utilizes the network she has built as a scientist and professional engineer. White says, and makes sure students know about those opportunities.

Like many of Ozer’s students, Mario Lazaro sounds like a permanent fan. “It’s great that she’s here helping people who are not as fortunate or doing so well in school. She wants to see them succeed,” he says. “I wish she lived forever!” Students like Lazaro, Emerson, and female students who attended the summer engineering program are exiting the “pipeline” now and becoming professional engineers who may someday assist future students to do the same. In this way, Nilgun Ozer will indeed “live forever.”

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SEI students working on electrical circuits

Below:

SEI students are learning how to write a computer program to model a mobile operating system (IOS) App.
In 2001, after graduating with her Bachelors degree in Chemistry and Spanish, Eroy-Reveles had a transformative experience at a conference organized by the Society for Advancement of Hispanics/Chicanos and Native Americans in Science (SACNAS). Numerous PhD Latino scientists welcomed her and treated her like family. They questioned why Eroy-Reveles had never considered pursuing a doctorate in science herself. Something clicked for her at that moment, she recalls, and she realized that countless universities had a need—a need she could fill. She set her sights on teaching and helping minority populations succeed in the sciences. Soon after, she enrolled in a doctoral program in chemistry at UC Santa Cruz.

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Eroy-Reveles joined the SF State chemistry faculty in Fall 2011, desiring to help students and spare them an apology like hers.

Left:

Students in CHEM 115 lab work with lab instructor Rose Lacy to identify products of reactions.

Above:

Caffeine: Students in CHEM 115 learn about how the polarity of the caffeine molecule allows for decaffeination of coffee beans.

Local communities. They are creating affirming and productive teaching and research environments at SF State and UCSF, an effort that Eroy-Reveles is deeply involved and committed to. Furthermore, they are implementing various programs that will help students from underrepresented groups in science to pursue careers in biomedical research.

Eroy-Reveles's primary role on the team is to revolutionize the chemistry curriculum as well as to promote course changes within other departments to help students form a supportive community to meaningfully connect science to their own lives. This is done by looking at what is taught, how it is taught, and how students learn best in the science classroom.

In the CHEM 115 classroom, Eroy-Reveles strives to make complicated chemistry concepts concrete rather than abstract and to put them into context. Students not only learn these fundamental chemical concepts, they apply and synthesize them, learning to see the world through the lens of a scientist and understanding how the world operates on a chemical level. In a CHEM 115 lecture this spring semester, Eroy-Reveles discussed how a molecule’s polarity affects its hydrophobicity. This led her into a real-life example of why milk works better than water to reduce the burning sensation of spicy foods. One student took the step further, guessing that vodka would be even better at calming a fiery tongue due to the liquor’s nonpolar alcohol groups. Eroy-Reveles ended up rewarding the student with extra credit points for connecting a real-world application of a seemingly abstract concept.

To further improve student learning in chemistry classrooms at SF State, Eroy-Reveles tackles a challenge of which many faculty or students are unaware, but which is a central focus of the SF BUILD program: stereotype threat.

Stereotype threat occurs when members of devalued groups experience a fear of being evaluated through the lens of a negative stereotype. Subtle situational cues, such as gender and race composition in science, technology, engineering, and math (STEM), can be powerful triggers of stereotype threat, which has been shown to result in diminished academic and test-taking performance.

Eroy-Reveles works with the instructors, including students teaching Supplemental Instruction (SI) courses, to help them learn how to foster a collaborative, supportive, and safe environment in their classroom. During a training of these “SI facilitators,” instructors learn that everyone holds implicit beliefs about groups of people and these views can influence how we work with and teach others. For example, someone may believe that they equally associate science with women and men, but their automatic association can show that they associate men more with science than women. These “implicit biases” can lead to gender bias if they are not recognized. The purpose of these trainings is to help instructors recognize biases they might hold and develop strategies to counteract these in order to encourage all students. After the training, SI facilitators overwhelmingly see the need to teach their students about stereotype threat because as one facilitator noted, “how we treat and perceive each other can have real effects and consequences.” Another wrote, “I want my students to be aware of the importance it [stereotype threat] can
make in their learning.”

Eroy-Reveles works to help all students by promoting a safe, affirmative learning environment. She keeps notebooks bearing students’ names and calls on people rather than waiting for volunteers, after giving time for students to come up with answers in small groups. This encourages participation and enhances the learning experience of more than just the few confident classroom extroverts. One student comments, “Once people engaged with one another, I felt more comfortable, which in turn helped me learn even more. Making people talk more and doing group work was highly beneficial.” Eroy-Reveles sets the example as a professor by exuding passion, which permeates all the discussions and activities of CHEM 115. A student states they feel, “Dr. Eroy-Reveles is very passionate about chemistry, and that has made them [her] more involved in class activities.” Her personal experience as a female student of color proved to her that while faculty and students may be largely unaware of the sociological challenges that come paired with academic ones, their existence can influence classroom dynamics. Luckily, so can countering measures.

Eroy-Reveles’ teaching approach includes innovative elements, as well. Along with weekly quizzes and post-exam reflections, student-learning outcomes (SLOs) are explored through group activities. Via the SLOs, which outline what students need to know or do, students work together to focus on these fundamental concepts when learning.

A student comments, “Teaching the class by going over SLO’s was really helpful because of instructing about things that are irrelevant; we were able to stay on track with what we were supposed to learn.” Another states, “The entire class was a great learning experience for me. I met a lot of new people with the same goals that I have, so it was great to look to them for guidance and help with certain things regarding my major. The structure of the class was also something I’ve never experienced in any of my classes before but it made a major difference in how I was able to learn the information.”

Taken together, her approach for improving the chemistry placement exam as well as the CHEM 115 classroom environment gives students a stronger foundation in chemistry, allowing more time and application in the classroom for the more difficult concepts. Some of the more difficult fundamental chemistry concepts include: acid-base chemistry, kinetics, and mass and molar relationships. While students enter the class with expectations of being challenged, Eroy-Reveles and her team of instructors work to create a community where it is safe to make mistakes while working together with classmates. As students begin to enroll in their upper division chemistry, biology, and biochemistry courses, a clearer, more student-centered CHEM 115 program tends to give them a deeper understanding of such fundamentals. Abstract concepts such as electrostatics, hydrophobic interactions, and reduction-oxidation should also seem more tangible and comprehensible, says Eroy-Reveles, and bolster their overall academic performance as aspiring undergraduate scientists.

Often times when a struggling student knocks on her office door, she tackles more than chemistry concepts and addresses other aspects of the student’s life that may be interfering with his or her academics. She recalls one past student that struggled in CHEM 115 despite working very hard in the class. The student routinely came to office hours and through the relationship the two developed, Eroy-Reveles soon discovered the largest factor impacting the student’s grade: the multiple jobs she worked throughout the week didn’t allow her enough time to study. “No wonder she wasn’t doing well!” she exclaimed as she recounts this story. “She didn’t have the time to perform to her fullest potential!” After helping the student successfully apply for some scholarships, Eroy-Reveles helped guide the student through chemistry and towards graduation. The student eventually enrolled in the UC Davis Post Baccalaureate Program and is now preparing to enter medical school.

Dr. Eroy-Reveles’ office is home-away-from-home for herself as well as her students. Pictures of her two young daughters decorate the walls and white boards along with chemistry structures, formulas and creative mnemonics. While she upholds the rigorous academic standards of CHEM 115, she softens the impact through her inclusive teaching techniques and also deliberately maintains this comforting environment as a place of mentorship and support. Her combined approach is raising both her colleague’s expectations and chemistry performance at SF State. One student comments “The entire class was a great learning experience for me. I met a lot of new people with the same goals that I have, so it was great to look to them for guidance and help with certain things regarding my major. The structure of the class was also something I’ve never experienced in any of my classes before but it made a major difference in how I was able to learn the information.”

In the survey results of CHEM 115, students across the board gave high ratings for concepts learned and skills learned. On a scale of 1-5, out of 47 students, nearly all gave ratings of 4 or above to rate their understanding of chemical concepts such as equilibrium, various reactions, and intermolecular forces. The survey even went further to ask students to rate their classroom attitudes such as willingness to seek help from others, connecting chemical concepts to everyday life, and interest in taking additional chemistry classes. The results for these questions were again about 4 or above. As simply put by one student, “The atmosphere in the class is cheerful, and encourages us as we work and learn together as a class. We don’t just sit down and take down notes; we talk about questions and concepts as friends.” Based on the educational cornerstone CHEM 115 represents, Eroy-Reveles’ combined teaching methods should someday read out in better overall science performance and the enhanced biomedical workforce SF BUILD is aiming to create. So far, Eroy-Reveles’ students seem to be getting the message she is intentionally putting out: “Yes, I have high expectations...but I know you can meet them.”

Capsaicin: CHEM 115 students recognize how the structure of capsaicin, the molecule in chili peppers that produce a burning sensation, allows it to dissolve more in milk compared to water. This is why people drink milk when they eat spicy food.

Page 62 Top: A student in CHEM 115 lab records her observations in her lab notebook.

Page 62 Bottom: Students in lab carefully watch to see if a reaction is taking place.

Below: CHEM 115 instructor D’Arius Hambrick walks a student through her analysis of an experiment.
In this issue of InterSCI you will learn about some of the exciting research taking place in the College of Science & Engineering (CoSE). These research projects are diverse and highlight areas from science education to computational chemistry. A unifying theme of the research discussed in this issue, which exemplify the caliber of scholarship in our college, is the engagement of our students in these research projects. Our scientific community at SF State is very proud of the fact that our students are the engines fueling our scientific success.

As the majority of research-active universities, the drivers of scientific discovery are senior scientists, postdoctoral fellows and students in Ph.D. programs. However, at SF State, undergraduate and master’s level students conduct the majority of the scientific research. This is truly impressive for many reasons. First, conducting research can be very expensive often requiring specialized equipment, expensive supplies, and a modern infrastructure. Thus, to pursue their research projects, faculty members must apply for external funding. However, to successfully compete for extramural funding they must develop very compelling research questions or hypotheses and then demonstrate they have the expertise and resources to answer them. In going through this process, faculty members must converse with external reviewers that the proposed research can be performed by undergraduate and master’s students. Obtaining external funding is very challenging given the current political climate and the lack of significant increases in federal, state, and private funding for scientific research. Despite these obstacles, SF State has been incredibly successful. In the past year (2016-2017), CoSE faculty members were awarded $23.5 million in grant funding for their research projects. The majority of these funds came from federal resources, including the National Institute of Health and the National Science Foundation. This success is a true testament of the high caliber scientific research our faculty members are conducting with our students. Among the CSU campuses, SF State ranks among the leaders in garnering external research funds with our students as they suddenly discover new career paths they had never considered before.

Research enterprise involves our dedicated staff who support the research goals of the College. Their support ranges from helping faculty and students to use sophisticated equipment to processing travel requests, purchasing supplies, and dispensing stipends and reimbursements. Conducting research is a team effort comprised of a community of faculty members, staff, and graduate students playing a key role in the process. We have an extraordinary team in our College as you will learn in reading the interviews in this issue of InterSCI.

Our students have also played an important role in our research enterprise. They have provided important scholarships to our students as well as funds that support our educational and training efforts. These generous gifts are essential to helping us with our mission in ensuring that our students graduate from our programs ready to enter the STEM workforce.

In closing, this issue would not be possible if it were not for the hard work of the students, Janet Hopson Dommer, the SCI 560 course instructor, our terrific graphic designer, Diane Fenster, and Associate Dean Robert Ramirez, whose attention to detail helped bring this issue to fruition.

Edrene Abuej is a Technical and Professional Writing (TPW) major. Abuej expects to graduate in Fall 2015 with his B.A. in TPW. Outside of class, he enjoys watching television, playing video games, and spending time with his family and friends. Graduated with a BA - Technical & Professional Writing in 2016.

Gina Calo graduated with a B.S. in Biology, concentration Zoology in 2015. She hopes to find a job that contributes directly to animal conservation and/ or spreads knowledge about conservation efforts. In her free time, she enjoys hiking, surfing, snowboarding, and spending time with her friends.

Charlie Chesney — “Charlie” to her friends— graduated magna cum laude in May 2015, earning a Bachelor of Science in Biology with a concentration in Zoology. She plans to pursue a career in conservation biology as a wildlife management field technician before continuing her education in graduate school. Charlie is best known for her love of Southern Ground Hornbills, birds which she diligently studied at the San Francisco Zoo during her last two years of college. Charlie loves her free time rock climbing, photographing birds in Golden Gate Park, and making friends with neighborhood cats.

Silvia Cruz is a Bay Area native with a degree from the culinary program at San Francisco City College. She graduated with a B.A. in Psychology in 2016. Her hobbies include surfing, archery, watching movies, playing the drums, motorcycle riding, and hiking near the ocean. She often combats the Pacific’s choppy waters for unique plant, rock, and fossil samples.

Heather Dutra was a child growing up in the San Francisco Bay Area, and has wanted to somehow help people. Heather graduated with a B.S. in Biology concentration Cellular & Molecular Biology in 2015. After graduation, she would like to start researching cures for diseases such as diabetes and cancer. She also enjoys spending time with her husband and daughter.

Laurence Henson graduated from SF State with a B.S. in Physiology (Summa Cum Laude). He performed research in the laboratory Dr. Vance VanDemark’s, assisting in studies on the poisonous Batrachochytrium dendrobatidis in several amphibian species, and investigating the effects of climate change on the pathogen’s prevalence. He hopes to one day become a physician and provide healthcare for the underserved who cannot afford treatment. As a first generation immigrant from the Philippines, he understands the obstacles immigrants face in acquiring post-secondary education. He has a passion for treating others with kindness and fairness and for helping others in need. He is also an alumnus of the Stanford Summer Health Careers Program (SSHCP), where he learned from medical school faculty and students. In his spare time, Henson enjoys playing video games and online chess, taking the occasionally jog around Lake Merced, and attempting to learn how to cook.

Stephen Kielar grew up in Ulta, NY. He graduated from the State University of New York at Oswego in 2004 with a degree in Anthropology. Afterwards, he spent almost a decade teaching environmental education at different centers across the county, most recently at NatureBridge Golden Gate in the Marin Headlands. This solidified his love for teaching science and led him to enroll in graduate work at the Science Education Partnership and Assessment Lab (SEPARAL) here at SF State. Stephen graduated with a M.S. in Marine Biology in 2015. In Stephen’s free time, he loves riding motorcycles up and down the coast, always looking forward to the next bend in the road.

Katharine Merkley Katharine Merkley graduated with a B.S. in Biology concentration in Marine Biology & Limnology (Cum Laude) in 2016. She lives in Antioch with her husband and one-year-old golden retriever puppy. After graduation she plans to continue her education, and hopes to become a biology professor. In her spare time she loves to travel, eat good food, and lounge on the beach.

Tuan Nguyen completed his B.S. in Biology with an Emphasis in Physiology and Minor in Chemistry (Cum Laude). In his spare time, you can find him writing poetry, serving in his church community, and working with under served youth in San Jose.

Chelsea Pruitt is a senior at SF State, and will graduate with a B.S. in Biology with a concentration in Zoology. Her plans include working to rehabilitate previously mistreated elephants at a wildlife sanctuary outside of Bangalore. In the meantime, you can find her attending late art at Java Beach at the Zoo and watching “Real Housewives of Orange County.”