Ed Carpenter: Maverick with a Microscopic Topic

by Chelsea Pruitt

This constant reign 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.”

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.
Carperter 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 SATs.” This unstructured approach to schooling might have dulled 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 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 these 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. Guillard. 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 ensue 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 lead Carpenter to narrow his research focus from the bigger—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.

Biological students learn that nitrogen fixation occurs when hydrogen and electrons alter atmospheric nitrogen to form ammonium, 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 Tasmania, 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...
Carpenter is a pioneer in the field of oceanography and environmental science. His research has been pivotal in understanding the impact of human activities on the ocean ecosystem. His work on plastic pollution in the ocean is widely recognized, if not universally acclaimed, and it foams over-head like a dark, greenhouse-gas-filled cloud. Plastics make up a large component of ocean pollution and this dangerous problem has grown so serious that a giant, buoyant mass of trash, dubbed the Great Pacific Garbage Patch, has formed in the North Pacific Gyre. This floating dumpsite is twice the size of Texas and its presence is a scary symbol of human-induced damage to the planet. The dramatic 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 pivotal, 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 a class at the Finca la Selva Biological Station in the northeastern Costa Rican rainforest. While doing field research, he noticed big canopy trees that turned out to be leguminous. “...So I said, ‘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 called cyanobacteria that exist on leaves of rainforest trees and also carry out nitrogen fixation above ground. Carpenter saw that the field of forest nitrogen fixation research was a little fuzzy 30 years ago. Investigation 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 looked into this. 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 four-bit-ten, 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 a species composition similar to dune zones in the McMurdo Dry valleys and other arctic deserts, but lack the overgrown researcher populations. 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 tardigrades (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 Robert Tiburon Center? Carpenter considers 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 SF State 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. Wherever 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 Gustav 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 grey 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.”