

CITIZEN SCIENTIST: Searching for Heroes and Hope in an Age of Extinction Copyright © 2016 by Mary Ellen Hannibal Reading group guide copyright © 2017 by Mary Ellen Hannibal

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INTRODUCTION

Change over Time

I was not the first to have a flow experience in the Santa Cruz Mountains. About two years ago I stood on a hillcrest above the dips and divots in the geology and looked out over the Pacific Ocean. Dr. Rob Cuthrell was talking about California Indian burning practices. Cuthrell had just received his PhD in archaeology from the University of California, Berkeley, and clearly nailed his orals—he seemed to be telling us everything he'd ever learned. I was standing with a group of citizen scientists at the location of an ancient meeting site where the Spaniard Gaspar de Portolá was given food and shelter by local Indians in 1769. Cuthrell is part of a group of scientists working alongside Amah Mutsun tribal members who trace their ancestry to the area. Together they are uncovering historical land-use practices—and working to restore them. This is not archaeology as usual.

Cuthrell is in his midtwenties, crisp and clean-cut, and that day he sparkled. Over the next couple of years, as his work at the Quiroste Valley Cultural Preserve continued, he seemed to get dustier every time I saw him. He showed us transects where the team was analyzing the density of native versus invasive plants. They had cut down Douglas fir, and the sweet smell of pine wafted in the warm sun. I scratched my head. Transects, native species? He sounded like a conservation biologist. "We can't just burn this now," Cuthrell said in his soft Southern accent. He was referring to the California Indian traditional practice of managing natural resources with fire. "We have to restore the native ecosystem first."

Cuthrell explained that the scenery, though it looked gorgeous, was full of invasive plants, some having arrived via the Spanish incursion a scant 250 years ago, others the result of subsequent ranching and dairy farming, the effects of which are still wreaking havoc though the land is now protected. "So it can't be burned until we restore the native plants," Cuthrell said. Burning the invasives could perversely enhance their populations. As I listened to Cuthrell and looked out over the landscape, I began to feel dizzy with a sense of time telescoping. The Spanish had long ago come and gone but their impact on biodiversity here was still unfolding, and consequences to indigenous people still keenly felt. We had come to this ridgetop abiding by Chronos, the ticktock by which our meeting times and dates are scheduled. But I was feeling kairos breaking into the picture. Kairos is the revelation of all time happening at once. Now was colliding with All Time.

Environmental theorist Timothy Morton has declared that "the end of the world has already occurred," dating the apocalypse: "It was April 1784, when James Watt patented the steam engine, an act that commenced the depositing of carbon in Earth's crust—namely, the inception of humanity as a geophysical force on a planetary scale."¹ The industrialization made possible by Watt is widely credited with creating climate change. Worst-case scenarios register a death knell for species as the

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eventual result-this bell is already gonging, because plants and animals are currently disappearing at a rate and magnitude equaling that which took out the dinosaurs.

Whether we stem what is recognized as the "sixth extinction" or not, a profound and incomparable shift has indeed occurred on earth, and the world that once was is no longer. The big five extinctions that have marked earth history over the past 3.5 billion years suggest that the fairly abrupt reduction of most species living at any particular moment is, if not a normal affair, at least one with precedence. Nature perhaps will take this one in stride. To line them up, the Ordovician, the Devonian, the Permian, the Triassic, and the Cretaceous events knocked out worlds then existing and made way for new ones. They were brought about by big climactic shifts, for the most part, just like we are experiencing today. So here's the big difference, as far as we Homo sapiens are concerned. The mass extinction of plants and animals currently under way is our own doing. It is the result of human impacts on earth systems. By our own actions we're threatening the very quality of life we think we're daily defending. Prior extinctions may have paved the way for humans to proliferate and dominate the worldwide ecosystem, but paradoxically our success is fueling our downfall, and it is quite plausible we are also taking ourselves out as we radically reduce the numbers of other life-forms.

The point at which humans began to have this bad effect is up for considerable debate, but looking out at the Santa Cruz Mountains I thought, "the end of the world" happened right here, when the Spanish made first contact with the Indians in 1769. Loss of native plants, animals, and indigenous lifeways reduced the efficiency of the biological carbon cycle here even before industrialization began its great transfer of carbon from ground to atmosphere. This biotic unraveling also includes a fundamental disruption of the human place in nature. I stared out at the hills and imagined the Spanish troops approaching.

On the vast ocean horizon were pointers to many of the citizen science subjects I'd been researching for this book. To my right was Pillar Point in Half Moon Bay, where I regularly monitor the tide pool with the California Academy of Sciences. For several years we have basically focused on what isn't there, because an unprecedented die-off of sea stars has wiped out virtually all of these creatures from Alaska to Baja. Closer to where I stood was Año Nuevo State Park, where I've trekked up close to northern elephant seals. The elephant seals were hunted for their oil to near extinction by the mid-1800s. Then people got into drilling for oil in the ground and spilling it all over the beaches, which is what Beach Watch volunteers are monitoring. To my left among the Santa Cruz peaks was the hilltop saved from logging in 2007 by Rebecca Moore-the gold rush assault on redwood trees in this area still goes on. Based on her work there, Moore founded Google Earth Outreach, purposing mapping and big-data capacities to empower everyone everywhere to save nature.

The work on the Santa Cruz coast falls under the rubric of a "co-created" project. The archaeologists are not taking a "me researcher, you subject" stance with the Amah Mutsun whose past they are investigating. The project has been shaped and determined equally by the PhDs and tribal representatives (some of whom also have PhDs). Co-creation is a category of *citizen science*, a term currently used to describe the widening practice of noncredentialed people taking part in scientific endeavors. Equivalent projects with indigenous people around the world are known as "extreme citizen science." What's extreme about them is that instead of subscribing to the topdown, hierarchical approach of Western science, these projects are resolutely bottom-up. They address local needs and rely on

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networking to create new kinds of knowledge to achieve realworld results. Co-created projects fundamentally question what science is, who gets to do it, and what it is for.

I listened to Cuthrell talk about breaking the fire bond that once deeply twined humans into their environment. Yet a full circle was being drawn here as well, a major effort to stitch together indigenous and Western knowledge systems, to restore the landscape and also to restore our sense of the human. The archaeologists wanted to quantify how people historically lived here; the Amah Mutsun wanted to restore ecological and cultural connections. Science is sometimes blamed for separating humans from nature, but here science was helping to heal the rift. Can it be healed? Are we nearing the utter end of the world, or is there a way forward? Cuthrell started to jump up and down, and for a second I literally thought some kind of cosmic completion was being revealed. Turned out he had stepped into a nest of fire ants.

The Silent History

Extinction is a word from the realm of science, but it isn't just about science. It's about history—what happened on the land and in the water, and why. History is based on storytelling, on narratives. The Spanish priests who established the missions here thought they were creating something—and they were—but they were also destroying something. They told themselves one story but they were living another one at the same time. Two things going on—and so it is today. We get in our cars and we go to work, and we work to fulfill ourselves to support ourselves and our families, and on a certain level we think, I am creating. But we are also destroying.

One of the problems with trying to grapple with this double narrative is that we have typically defined human history as separate from other categories. Historian Dipesh Chakrabarty points out that academics tend to "deny that nature could ever have history quite in the same way humans have it."² If we could talk to the soil, the trees, the birds flying overhead at Quiroste Valley, we would hear something else.

Humans have assumed that while our history changes in hundreds of years, the geographical environment changes only over millions of years. So there is one short history and there is one long history, and these two stories seem to run on separate tracks that only incidentally intersect. Pointing out that humankind depends on overarching narratives to make meaning and to establish power, preeminent cultural historian Lynn Hunt says that now "history's purposes are expanding as we increasingly think of ourselves as humans sharing with each other and with other species a common planetary past and future.... An alternative narrative is essential."³ She might have added that we share with other species a common fate. If the biota at Quiroste could talk, we would learn that geology, biology, and human history may be investigated by us as separate chapters but, in fact, they make up one book. And the time has come for us to learn to "read" that book.

As beautiful as the view is from here, as natural as the golden hills seem, they are a patchwork of responses to human impacts over thousands of years. Human history has made ecological history and vice versa-people, other species, geology, water, and weather have made this view, and they have done it together. Ironically we know what the landscape looked like before the Spanish got here because some of them kept fastidious notes about what they saw. The answer is: wildflowers. We didn't know wildflowers lived here in magnificent abundance until about 2001, when Alan K. Brown published a new translation of Padre Juan Crespí's expedition journal from Portolá's 1769 voyage. Crespí duly documented mind-boggling fields of

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wildflowers, not realizing that the expedition he accompanied would fatefully suppress their blooms. Now that we know they were there, we know we can bring those flowers back. The seeds are still there, waiting for us to restore a lifeway that brought them—well, to flower and fruition.

Knowing with better accuracy what we are looking at is a virtue of citizen science. Looking down to my left I could not quite see Monterey, but I knew it was there. I could imagine Ed Ricketts trolling for specimens in the tide pools at Pacific Grove. Ricketts was a nonprofessional scientist and activist (i.e., a citizen scientist) and the model for Doc in Cannery Row, John Steinbeck's 1945 novel about a crew of misfits carousing among sardine canneries during the Depression era. Generations of "Ed Heads" look to approach the world as he did, on the constant search for a holistic framework. If not a bible of citizen science, The Log from the Sea of Cortez, his book co-created with Steinbeck, is something of a manifesto. Steinbeck and Ricketts declared they would undertake their voyage "doubly open" to objective and subjective realities. Ricketts and Steinbeck sought the "toto picture" in which art, science, and experience are integrated. What I'm trying to do in this book is what they were trying to do-put it all together, the personal, the historical, the scientific.

Like Steinbeck, the writer and mythologist Joseph Campbell was also seminally influenced by Ricketts. Campbell documented a taxonomy of the world's indigenous stories, within which he discerned a common pattern, the hero's journey. The hero's journey is universal, according to Campbell, and it unites humankind across races, cultures, geography, and time. Campbell credited an expedition he took with Ed Ricketts to Sitka, Alaska, with inspiring his understanding that the myths we live by are basically biological in origin. Myth, he said, is "nature talking." With his emphasis on individual agency, Campbell is a special guide for the citizen scientist in today's fraught moment. Campbell provides a road map along which an individual destiny can travel to global impact. Because what is the role of the individual, when together humans constitute a geological force? Staid geologists now call our epoch the Anthropocene, because human impacts are discernable in the fossil record, in the same way as are the effects of an earthquake. Whatever we might do as separate people, our efforts are made practically irrelevant by the aggregate result of our activities. As Chakrabarty points out, this realization challenges the very notion of human history. We have thought that we were doing one thing–waging wars, claiming territories, defining human rights–but something bigger was going on at the same time.

Expeditions of the past hold keys to understanding our current terrain. Thomas Jefferson produced an expedition diary of sorts, in Notes on the State of Virginia. Jefferson surveys and documents the terrain, vaunting not only Virginia's natural resources but an inherent goodness he finds there. Jefferson also instructed Meriwether Lewis and William Clark in how to document the Corps of Discovery Expedition, the journey he famously sent them on to explore the western US after the Louisiana Purchase in 1803. All three of them were citizen scientists. The California Academy of Sciences was founded by amateurs. Rollo Beck's 1905 Galápagos expedition on behalf of the academy was foundational to "proving" what Darwin only posited about how life originates. The botanist Alice Eastwood saved the academy's collections in the 1906 earthquake; her lifelong collections at Mount Tamalpais in Marin County today form a baseline for understanding how climate change is impacting California vegetation. In our own time, fantastic technologies allow us all to observe with consequence. With iNaturalist on

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your smartphone, you can network with other nature fans and contribute real data that helps discern more accurately what is going on where, so that better decisions can be made about managing natural resources. This big-data dimension of citizen science is perhaps its most "science-y" application, relying on statistical analysis and computing power. At the same time, accurate data points on a map make it harder to misrepresent the uses and potential of a piece of land or a stretch of water. Using Google Maps, you can integrate historical and political claims with natural history and visualize that story on a map. Thomas Jefferson, citizen scientist, would have approved.

The Hero Departs

Myths are timeless, but they unfold in a setting that has everything to do with time—with the seasons, with cycles of animal movement, with the developmental moment in the hero's life. In spring 2014 when I gazed out over the Santa Cruz Mountains and imagined Portolá, I had no idea that within months, my father would quickly succumb to cancer and die before the year was out. After his death, I have continued to monitor wildlife at Mount Tamalpais in Marin County, to count invertebrates in the tide pool and hawks in the sky. The places where I do this have become ever more emotionally significant to me, even though the counting and the measuring are designed to be as impersonal as possible. The landscape and its creatures essentially contain me while I make the mysterious adjustment to before and after. Thank you, nature.

Some people like to call citizen science "participatory research." This comes out of a decades-long unfolding of thought in the humanities in which researchers began to grapple with the very unpleasant insight that they were treating their subjects as inferior objects, that it is impossible to take a "me expert, you study subject" view that is not condescending, incomplete, and more or less self-serving. With some horror, researchers looked in the mirror and saw themselves reiterating colonial control of indigenous and economically underserved people. A full-on identity crisis ensued. How are we gathering information and creating knowledge, and what are we using it for? Basically the cure for the dominator approach is to insert the word *I* into the narrative. We can't really remove bias completely, but we can state our position as honestly as possible, declare our selfinterest, our subjectivity. If the researcher is also a subject, and if the subject is also a driver of the research project, then maybe we can get some equity here, and "co-create" knowledge. So here is I.

CHAPTER ONE

In Which I Freak Out in the Tide Pool

At four in the morning on June 12, 2012, I drove down Cole Street in the Haight-Ashbury neighborhood of San Francisco, on my way to pick up a college intern carpooling with me to the California Academy of Sciences' first citizen science tide-pool-monitoring expedition. The hour ranked as dead of night, but in this neighborhood, an imperfect Age of Aquarius is perpetually dawning. I glided around a fire truck parked in the middle of the road. In the darkness, a quiet ruckus between uniforms and rags played out on a stoop.

The date marked the lowest tide of the year in these parts, brought on by the moon's position relative to the earth and the sun. This was the cosmic conjunction the intern and I were lining ourselves up with as we made a pretty straight shot twentyfive miles south to Pillar Point Harbor in Half Moon Bay, ahead of Silicon Valley traffic. My companion had a soft, ready smile even at this hour, and long blonde hair under a knit cap. I had determined our destination the old-fashioned way, by MapQuest, and following printed-out directions we arrived at the wrong beach. The intern cheerfully typed latitude and longitude coordinates into her smartphone and directed us by degree to the right one. Kids today!

Breaking News

Citizen science is taking off as never before, and it is needed as never before. Scientists point out that while two million species have been named by science, millions more have yet to be discovered. At the same time, the aforementioned extinction crisis is taking out species before we even know they are there. What does it really take to save nature? How do we look at this gigantic problem? Citizen science starts with and continuously returns to individual observations of nature.

The hermit crabs and brine shrimp we collected over the next three days of extra-low tides at Pillar Point would help embody a snapshot in time, physical reality as it existed in this moment on planet Earth. Every day our quarry would go back to the academy, where each thing would be officially named according to the age-old methods of taxonomy and suspended in jars of ethyl alcohol. Eventually they would be accessioned, taking their place among the twenty-two-million-and-counting specimens currently housed in vast metal cabinets in a temperaturecontrolled basement vault in the academy's fancy building, designed by Renzo Piano, in Golden Gate Park. Thus they would join august company with specimens obscure and famous, including giant pink Galápagos iguanas brought back by Rollo Beck in 1906 and coelacanth fossils, thousands of years old, deposited at the academy in the 1970s.

Ascension!

Between the beach and the big breaking waves about a quarter

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mile off was a stretch of bumpy, glistening reef, its usual blanket of water pulled back by the celestial hand. The temperature was in the midforties, cold, the air wet and exhilarating, but maybe that was coffee on an empty stomach, and lack of sleep. In the parking lot I cast about for someone to follow into the drink. The academy's curator of worms (literally, that was her job) charged forth, her eagerness to find squirmy little things barely contained, reflective patches on her jacket flashing in the moonlight. The beam of her headlamp was circled by a penumbra of sea spray and then she disappeared. She entered darkness and overwhelming sound.

Treading through several inches of water sluicing gently over lumpy calcium carbonate, a.k.a. the reef, I walked in the direction I thought she'd gone, trying not to fall, and catching a sign of her now and then. It was mostly like walking straight into an enveloping dream, its essence closer at each step yet at the same time more completely obscured. One drastic wave crash after another punctuated the hurtling roll of the ultimate white noise. The constant plague of the tide pool-deep thoughts-crept in with the mist. At an edge of land and water that is only periodically revealed, I felt time at its source, unmediated through clocks and cell phones and the contrivances of our busy-ness. The seasons of course manifest the earth's changing relationship with the sun as the earth spins on its own axis and simultaneously revolves around the sun. Within this comprehensive movement, the earth is also doing a push-mepull-you with the moon and the sun, and the resulting effect on rising and falling sea levels is known as a tide. Thus the tide pool monitoring at Half Moon Bay follows the cycle of the moon, but this operates at a scale that cannot be neatly followed by a regular schedule. We visit Pillar Point during the lowest tides that occur at hours that are reasonable for most people to be awake.

So sometimes we meet several times in a single month to count up invertebrates, and sometimes a whole month will go by with no low tides at a decent hour.

According to Joseph Campbell, the hero's journey is based on and analogous to the sun's daily round, in which both "fall cyclically into the watery abyss" and then arise again.¹ It involves a cycle of personal realization in which the nascent self heeds a call to adventure, and, following it, departs from the known and comfortable world. Trials ensue; the hero is lost. There is an encounter with a transcendent beneficial force, and the hero has a revelation that paves the way for eventual reconciliation with those he has left behind. The hero gains something-wisdom, a gift, something his people need. Newly equipped, he goes home, restoring his tribe in the process of becoming his own man. The hero's journey is literal and involves physical trials, but it has a psychological origin. Campbell referenced Carl Jung's concept of the "night sea journey," which involves diving down into unconscious darkness as a necessary prelude to rebirth. In other words, we live our lives and tell each other stories that at the molecular level are a response to this fundamental natural rhythm of sun set, sun rise.

I had a notebook in my hand and binoculars around my neck, and I stared into the darkness as if on an epic quest for ... what? What was I looking for? The sky seemed abruptly to have had enough of my dithering and dramatically lightened up around the glowing moon, which retreated like an aging sovereign before the rising sun. It was day!

As I stood still to suss my next step, my sight was filled with a metallic melding of greens and reds and telegraphed one unified entity, the tidal reef. But the merest closer look changed everything. Distinct and dense life-forms took shape. Glowing purple sea urchins were arrayed like a wall of living burrs on three-foot shelves of reef dipping down under impossibly luxurious fronds of feather boa kelp. Gelatinous globs of sea anemones sat there with pieces of shell stuck all over them as if you had just spilled a box of cornflakes onto Jell-O molds—this was their SPF, the way they prevented sunburn when the water receded and blew their cover. Close up, colors that blended at a distance were in stark contrast, black and white, fluorescent violet, as many greens as if every pod in a field of peas were a different hue. Twelve-inch fish shifted past in surging rivulets of water. Something else moved: what, where? Everything was insanely alive, now you see it, now you don't. I thought, it's the light, it's the water, it's changing every second, it's always doing this whether I'm here to witness it or not.

For those grappling with this profusion of life and its orderly disorder, the standard orienting text is Between Pacific Tides by Ed Ricketts and Jack Calvin. Originally published in 1939, Ricketts and Calvin's book was the first to adequately document more than five hundred species found along the West Coast from Sitka, Alaska, to Ensenada, Mexico. The volume helps make sense of the panoply. Species are organized by their home addresses, ribbonlike zones discerned basically by how much water covers them when and how often, depending on the tide. This provides a basic lesson in ecology, because the creatures are adapted to the conditions in which they live. The urchins, for example, with their spiny grip on the reef, live in the midintertidal zone where the lowest tides expose them only for short periods of time. Even in semidarkness, these zones can be discerned by the citizen scientist. Stanford University Press waffled for years before publishing the book, mostly because it was revolutionary in its approach. Marine invertebrates had only ever been classified by phylogeny, or body type, an academic system hardly helpful to an initial orientation to the subject. Ricketts

additionally was the first to include information about waves, tides, habitat, and predation in his inventory of critters, always presenting them as part of a holistic ecosystem.

Over the course of his life, Ricketts collected specimens from tide pools all along the coast, and many of these specimens provide a basis for comparison to help understand what we find in those places today. The academy's citizen science project at Pillar Point in a sense is paying Ricketts forward—not that he collected right here, but because participants are helping to fill in the puzzle pieces of how creatures are distributed along the coast and how those distributions have changed over time. The academy's project is but a node in a larger program run by the Bureau of Ocean Energy Management, which brings together universities; federal, state, and local agencies; and tribal governments, among others, to monitor the whole coast. Even at this level, Ricketts' influence is still felt, since his historical collection at Sitka, Alaska, provides a baseline for the northernmost site the bureau surveys.

Let Me Go

In the tide pool I was riveted by fat pink sea stars sitting like satisfied gangsters and seemingly unconcerned by their exposure; gulls would peck at them but the sea stars simply grew replacement limbs. I stared at one about a foot in diameter, with a sixinch crab stuck like a pottery shard glued by Julian Schnabel to its gullet. I was actually watching the sea star digest the crab. Later in the morning my intern friend crouched nearby. Like me, she was practically babbling with pure joy, pointing out this thing and that thing, and then, regrettably, she picked up a giant pink sea star. Only a very young person would think about physically interacting with this exaggerated form. She grinned at me, holding out her hand, draped with what I grew up calling a starfish. However, these creatures are not fish. Sea stars have an ancient lineage and strange, unique features. Their skeleton is wholly internal like our skulls, constructed out of stony, hard tissues called *stereom*. Their bizarre internal organs pump water through their bodies and move thousands of tiny tube feet for locomotion and eating. They belong in the phylum Echinodermata of the kingdom Animalia, while fish cohabit the phylum Chordata with humans and other backboned things. Plenty of scientists call sea stars starfish, so you're allowed.²

The intern decided to put the sea star back into the water, but it didn't want to go. It clung with all those tiny feet to her skin like Velcro drenched in superglue. She was brave while I helped pull the sea star off her and plunked it back down onto its rock, seemingly unperturbed. "I'm never going to do *that* again," she said.

Neither of us could have known it at the time, but it was possible she would never again have the opportunity to observe a giant sea star in its lair. In June 2012 our team documented approximately seventy-plus sea stars in each delineated transect. A transect is simply a measured-out plot, sometimes square, rectangular, or circular, depending on the research question and the terrain. A year later, surveys turned up five to none in some transects. Citizen science is being deployed big time to help professional monitoring operations track the tide pools and figure out the epic affliction of twelve species of sea stars along the Pacific coast, documented from Sitka to Baja, Mexico. A sea star wasting disease is causing the biggest marine die-off yet known to human awareness.

I first talked to Dr. Peter Raimondi, chair of the Ecology and Evolutionary Biology Department at University of California, Santa Cruz, about the sea stars in March 2014, at which time he sounded fairly sanguine. After all, Raimondi had seen epidemic die-offs before. He had helped identify *Candidatus Xenohaliotis californiensis* as the cause of a "withering syndrome" that decimated black abalone in the 1990s. The bacterium attacks the abalone's gut and it stops producing digestive enzymes. Hedging against starvation, the abalone metabolizes its own body mass, which eventually shrinks the foot by which it clings to the substratum, until the mollusk cannot hang on any longer. Foothold has a special meaning for intertidal dwellers, and the abalone that can no longer moor itself is soon eaten by predators. The die-off was severe enough that the black abalone has been designated an endangered species. So far there is no evidence of recovery in any of the affected areas, which are mostly in central California.

The sea star die-off is of bigger dimensions than the abalone'sorders of magnitude bigger. While one species of abalone has nearly been vaporized, twelve species of sea star are going away fast. The abalone's range is fairly restricted, but sea stars have been observed falling apart and eventually disintegrating from Alaska to Baja. And while every denizen plays a role in the practically infinite complexity of tide pool interaction, the sea star is arguably the star of the show, figuratively as well as literally.

As unrelenting as these creatures evidently are, sea stars play a critical role in keeping things balanced in the tide pool. One of the most important ecological revelations of the past several decades was made by University of Washington ecologist and zoologist Robert Paine, who set out to quantify the effects of top predators on the rest of the ecosystem. He removed sea stars from a plot off the coast of Washington, while leaving other sea stars to their brutal devices in a control plot. The plot without hungry sea stars quickly encrusted with more and more mussel beds, until the mussels ate all the kelp, and with no kelp around, a panoply of creatures that depended on it disappeared. This top-down effect is called a trophic cascade, and parallel examples of its workings have been identified in all terrestrial and marine environments. *Trophic* is from the Greek and means "food." *Cascade* is from Latin and means "to fall." A trophic cascade operates like a domino effect, where an initial impact at the top of a structure has a direct effect on the next level of the structure and the effects keep going all the way to the bottom. Without the sea star to organize the cast, the show of life at the intersection of water and land may lose its script altogether.

The wasting had had local, seasonal outbreaks before, in 1978, 1982, and 1997, taking down sea stars in spring or summer and then literally chilling out when the water temperatures did. "We started to focus in the summer of 2013," Raimondi said, "but looking at some earlier reports, there were signs we didn't catch. In the summer, we were up in Alaska and saw the sea stars wasting away—I'd seen this before." The first account of sea star wasting came from an aquarium in Vancouver fed by fresh water. "Then it started moving south. It's marched down the coast. We thought it might be one of two things. Either it was associated with some big water issue, a local current or weather pattern, not an El Niño but something smaller. Or it could be a classic epidemiological spread over time—but that's hard to get your head around unless there are very strange currents going on in some places."

Among the potential causes that have been worried over and ruled out are pollution from plastics, ocean acidification, and radiation from the 2011 Fukushima nuclear disaster.³ Raimondi countered these postulates, respectively, by noting that affected areas range from the pristine to the totally degraded; ocean acidification is affecting local places but as of yet has established no general pattern; and any radiated debris that might arrive at the affected areas eventually hasn't yet. Nor does he see this as a

direct result of climate change, since when the outbreak began, the Pacific was in a cool phase (it has since turned very warm). On the other hand, collateral climate change effects (along with the warm water) might very well have something to do with it. Ocean currents may be shifting due to temperature changes, and general warming trends could be hampering the sea stars' immune systems. Raimondi told me the abalone die-off "turned out to be a bacteria hitchhiking on the currents, but there were no spared populations in the zone of impact. This die-off initiated by hopscotching (affecting some populations but skipping over others). This is the part that gets super mathematical and for me is super interesting—to find a pattern in something that seems patternless." By August 2013, the populations that had been skipped over in the disease hopscotch were observed to be afflicted or completely decimated.

The ocean acidification angle, however, bugged me. In February 2015 I sat on a panel in honor of a terrifying and beautiful series on ocean acidification published by the *Seattle Times*. In "Sea Change: The Pacific's Perilous Turn," reporter Craig Welch and photographer Steve Ringman told a complicated story through multilayered narratives, still photography, and video. Among other things, Welch and Ringman reported on the collapse of the oyster industry in the Pacific Northwest, where the mollusk can no longer form a hard shell. One family operation they profiled now raises their oysters in Hawaii, then ships them east.

I was seated next to Dr. Ken Caldeira of the Carnegie Institution for Science–as Welch put it, Caldeira is "the godfather of ocean acidification," which is caused by the same thing that causes warming atmospheric temperatures: ratcheting CO_2 levels. We know that sea star wasting started as higher CO_2 levels in the oceans warmed its temperatures. I turned to Caldeira on the dais. "Why can't we say ocean acidification is affecting the sea stars?" He said, "We can. Ocean acidification affects echinoderms."

By August 2014, the tally of sea stars dead and gone had reached the millions, and the disease showed no signs of abatement. The consolation of a known cause was not in sight. "It's scary," I said to Pete Raimondi. "Yeah," he admitted. "It's really, really creepy." Raimondi may not want to call the apocalypse, but since this is in fact the most extensive marine die-off yet known to contemporary history, the rest of us might at least want to call it a disaster. The term has a special resonance for the event, as *dis* is Latin for "apart," and *aster* is "star." The sea stars literally fall apart when they get this disease. Dis was a Roman god of the underworld, an association that flavors the term as if it were deity-ordained.

On the upside, sea star wasting comes at a time when we can observe and monitor it as never before. Pete Raimondi's Pacific Rocky Intertidal Monitoring Program has been surveying marine diversity for more than twenty years and incorporates data from a previous effort that goes back ten more. The program is focused on the collection of data in a uniform way by professional scientists across geographic areas, but in many places these efforts are augmented by citizen science.

"It's really a new addition for us," UC Santa Cruz research specialist Melissa Miner told me. Miner has worked with Raimondi since the inception of the rocky intertidal program. "We've thought about it for a long time. We wanted to add some aspect of citizen science to what we do, because there's huge interest in it. Some of our funders have been calling for it for a long time. But a lot of what we do requires expertise." It's hard to tell one species of sea anemone from another, and forget it

when it comes to sea worms. "When the sea star wasting arose it became clear that this was a good way to involve people. On the open coast sea stars are pretty easy to identify. Sea star monitoring requires little gear and site setup is flexible."

Miner told me that Raimondi had been "a reluctant participant" in any monitoring whatsoever early on. "He came of age at a time when what you did was experiments in the field, and that was exciting. You had a question and, after not so long, some kind of answer. With monitoring, it's very long-term; you don't start with a question. You see what transpires. But now he's really come full circle. He realizes the importance of long-term data and he pushes to get it."

"Is this it?" I couldn't help but persist in asking. Miner knew what I was talking about. In July 2014, the prominent journal Science had produced a special issue called "Vanishing Fauna" about the accelerating rate of species extinctions. In the central piece of the issue, Stanford University environmental scientist Rodolfo Dirzo and colleagues showed how losing so many species was affecting the state of global ecology.⁴ Plants and animals are not just along for the ride here-they actually create the healthy functioning of planet Earth. Then there is that persistent shadow provoked by scientific query, a potential "tipping point" in earth processes. It is possible that we will lose so many species that the way ecosystems operate will change, and not for the better. Loss of species can lead to accelerated rates of disease transmission from insects and birds, for example, to humans. Scourges like Ebola and Zika getting a faster ride on the conveyor belt between hosts. And one of a multitude of ongoing impacts on species loss could induce some kind of large-scale unraveling that would more directly threaten life as we know it.

"Is this it? Losing all these sea stars—are we about to watch something horrendous unfold?" "A lot of people want to assign this disease event as a sign of larger-scale issues in the ocean," she said. "They're talking local extinctions, but I wouldn't conclude that yet."

"Local extinctions" refers to populations and doesn't mean the entire species everywhere goes away for good. But since "local extinctions" in this case refers to the entire West Coast of North America, the potential loss cannot be called anything less than staggering. The Pacific Rocky Intertidal Monitoring Program is now enlisting people to document juvenile sea stars. With data on how many young ones are populating the die-off areas, scientists may be able to figure out whether a recovery is under way. It sounded like good news that there are juveniles in many of the monitored tide pools. "But they are susceptible to the disease also," Miner cautioned. So we will watch and see if they grow, or disappear.

Seeing but Not Saying

In September 2014 my parents were having lunch in New York City after meeting with their financial adviser. My father felt a terrible pain in his shoulder and thought he was having a heart attack. The emergency room tests diagnosed pneumonia, and his progeny dispersed around the country had us a mutual, relieved laugh. "Money always gives him a heart attack." Late October, follow-up screens delivered the news that it was more than pneumonia. The story was: lung cancer, but he was going to be okay. "He's strong as a horse," my mother said. He had been biking ten miles a day all fall. The plan was to pummel him with radiation. "I'll get weak but then I'll get strong again, likely by late January," he told me. I flew from California to New York.

The story that he would be okay did not change–until the last minute, when it changed forever. Till just hours before he died on December 6, the story was: he's weak from the radiation

IN WHICH I FREAK OUT IN THE TIDE POOL 23 THE EXPERIMENT © COPYRIGHT MATERIAL and he will be getting stronger. I marveled at my own ability to go along with that story and to believe it fully, even as I also ran the other story in my head, the one that was actually happening. I had seen my mother-in-law die of cancer. I wanted to talk to my father before he started to decline from radiation. He would be a different person after treatment and I wanted a full dose of the father I knew, if not in his prime, then pretty close to it.

It takes all day to get to East Hampton from San Francisco. A close friend picked me up at Kennedy International Airport and I arrived at my parents' at about 8:00 pm. My father was sitting up in bed. With my mother we touched down on the treatment plan, the radiation under way. We talked about the melanoma he had survived decades before. "I've confronted death," he said. "I can do this."

Catching my parents up on my kids, my husband, my work, I burbled on for a few moments about the biologist E. O. Wilson. I had had a writing assignment focused on extinction and Wilson is the author of a concept key to understanding it. I told my parents how excited I was to talk to Wilson, who has exemplified the scientist engaged with social issues for many decades. From a place of happy report I quickly plummeted, as I noticed my father looking at me quizzically. He's confronting death, I thought, and here I am bringing up the ultimate end-extinction.

The next day we had our last real conversation. He had radiation in the morning and sat up at the kitchen table for lunch. "Maybe after tomorrow's treatment Mary Ellen and Carly should meet us for lunch at Bobby Van's," my father said. Carly is my niece. Bobby Van's is a legendary steakhouse that, like everything in the Hamptons, has become something it wasn't, but in the old days, it was where the writers hung out. You could see William Styron and James Jones and Willie Morris drinking together. James Salter sometimes, always looking healthier than the others. Those were the days.

"No Bobby Van's," said my mother.

We sat on the couch together. We said what the doctors said, over and over again: strength after weakness.

"The only thing I want to do," and I knew he would say this, "is finish my book." After the success of his first novel, *Chocolate Days, Popsicle Weeks*, my father wrote several more that didn't do as well. The novelist's byline, Edward Hannibal, was fated to general obscurity. Five kids. He went back to work in New York City, in advertising, and commuted home on the weekends. There was some talk of living like other people did, in the suburbs. But there is no ocean in Westchester.

On the couch I thought: I am already reviewing his life as he is still living it. He recounted the comments the Ashawagh Hall Writers' Group had about his current book project. He had been trying to find a second voice for the narrative. "I've got too much in one voice," he said. "I've finally figured it out, I know what I want to do."

On the drive to East Hampton from Kennedy, my playwright friend had told me about a similar creative hurdle. "Tracy rehearses big corrective speeches to her husband and daughters in the kitchen," I told my father, "and she says all the nasty, gangster things she's thinking but wouldn't actually say to them. She realized she could have a character do that—talk to herself, say things you would never say out loud."

"Ah," he said, appreciating this. "What you would never say out loud."

We talked about how it would be good for him to take a few months off from working on his book. Which you are not going to get to finish, I did not say.

When I was a child my father told me he recognized his calling as a writer from a young age. "I was always observing. Even while talking, living, going through every motion, I was watching myself and the situation. That's a writer. Always observing." He wrote novels on a manual Royal typewriter, in the hunt-andpeck style. Next to the tall metal typewriter on his big wooden desk sat two big piles of paper: the novel in progress, and a carbon copy of it. With unwavering discipline he ascended the attic stairs at 9:00 AM, came down for a one-hour lunch at noon, then typed until 5:00 PM. Under the eaves of the small attic room where he worked, a fly seemed perennially to dive-bomb the window whether it looked out onto bare winter branches or rioting summer green. I apprehended the act of writing through a sense of his concentration, wondering at the magic of those firm black letters marking emotion into paper. I looked at that inconceivable stack of neatly typed pages and wanted to produce my own.

Talking with him on the couch, where he sat stiffly in pain but as completely preoccupied with his work as ever, I watched the situation. He watched me watch the situation. As long as he could hold his concentration and funnel words through it, he was alive. This gaze that we were sharing, I thought, is our last mutual recognition. We observed each other observing each other. We both knew what was happening.

Losing the Audience

In February 2015 I was on my way to a regular tide-poolmonitoring expedition at Pillar Point. The low tide occurred at an early afternoon hour and the sunlight was lemony and bright. This trip had special significance for me, as it was the first time I would be visiting the tide pool since my father's death. I drove down Highway 1 from San Francisco and remembered bringing him with me on a monitoring trip the year before—I could just see his black rain boots and hear him chatting up the other citizen scientists. The memory made me pull the car over to the shoulder of the road.

Of course he loved the tide pool. He was an ocean man and lived near it in what had once been a small summer resort on eastern Long Island and was now an enclave of human glitz. But the ocean was still there. We moved to East Hampton upon his early success as a novelist, at age thirty, in 1969. The place had a literary tradition and he had an entry ticket. John Steinbeck famously lived in nearby Sag Harbor and had died just the year before. I was nine years old with four younger siblings. Later, as adults, the five of us found our own ways to the beach. In those early years we frequently piled into various station wagons and headed there. I remember bursting from the car and charging straight into hurling, hurricane-anticipating waves, fully dressed.

The Pacific crashed below me on Highway 1. It's a very cold ocean up here in Northern California—I would not jump into it without a wetsuit. I looked down over a promontory, and below the cliffs a few human forms moved slowly along the beach. The swirling waves were pounding and making the sand, and erosion was making the ground that's now soil and in which plants grow. Up from the water's edge crept all the terrestrial life-forms—I was watching creation and it was gorgeous. So the bodies die. I have never taken to the concept of reincarnation but suddenly it seemed like magical thinking to believe my father had just vanished into thin air. The whole person, the nearly eighty years of unfolding, developing personality—had that all evaporated? My father was Catholic bred in the bone and he was not afraid to die. On his deathbed he narrated his exit, in a way, and it was fascinating, he was fascinated himself with what was going on. But

what *was* going on? Today, I thought, I will not report back to my father what I find in the tide pool. He isn't there anymore. I brought him news from a world beyond worlds that yet could be known, not just by identifying species but by living and narrating the experience, and he was always into it. He was no longer there to hear the story. Should I just go home?

Apertures of loss in my throat and chest were waypoints to a vanishing horizon now lacking the animating force of my father. What did my witness of the tide pool matter without his appreciative audience? I dreaded the solitude of my own observance, the anticipation that today I would see but not say. Soon, though, I got back to the real reasons for going to the tide pool, having to do with my own small effort to do the right thing. It struck me that the anemones and the crabs needed me to go look at them and to note their existence. If only to say, my father is dead but you are still here. (And to thank them for that.) Also, people were waiting for me.

It was a small group out there that day, just Alison Young from the Academy of Sciences and a couple of interns. We walked out the half a mile or so along the beach to the tide pool and then began our slow progress across the reef to our transect site. Water sluiced around my ankles and life-forms darted and squirmed. Nature could console me. Death in the tide pool is a regular affair but its life goes on. The individual is both important and not. Ecology is about relationships and I still had a relationship with the tide pools. The constant drama went on, the spawning and the hiding and the sudden eating, but it was also predictable and orderly. And consistently so beautiful, inducing, as Joseph Campbell called it, "aesthetic arrest," or the gasp-stop of transfixed attention. In *The Log from the Sea of Cortez*, Steinbeck wrote: "It is advisable to look from the tide pool to the stars and back to the tide pool again." So I would look to the tide pool again.

An intern upended a rock and giddily proclaimed she had found a young sea star. But she had found an adult in the process of disintegrating. Perhaps reflecting my mood, the tide pool seemed awfully empty not only of stars but of many other species. Few crabs, sparse sea anemones. The wild riot of color and interaction and the usual diversity of nudibranchs was reduced. Nudibranchs are psychedelic sea slugs that wave electriccolored gastrointestinal fronds in the water like drag queens with feathers, advertising to predators that they are poisonous so don't eat me. The vagaries of circumstance affect what you will see on any given day in the tide pool-the depth of the low tide, the intensity of wind, the changing light obscuring or revealing species like the occult red octopus. To discern a meaningful pattern, you need to have data collected in a uniform way over decades. I peered into the quadrants we'd drawn with tape measures around GPS points and I began to be downright creeped out, not by the absence in the transects but by an incongruous presence.

At first the sightings of *Okenia rosacea*, a candy-pink nudibranch colloquially known as Hopkin's rose, elicited delight. This sea slug looks like a piece of cake decoration. And then there was another one and another one and another one. One of our party found a coiled pink tape of *Okenia rosacea* eggs. It was as if we were watching the species proliferate under our very noses. This species shouldn't be here. It was like walking into a redwood forest and finding flamingos sitting in the branches.

"I thought Okenia rosacea were super rare," I said to Rebecca Johnson back at the academy in Golden Gate Park. Johnson is an invertebrate zoologist and a nudibranch expert. With Alison Young she co-directs the academy's citizen science program. Her cascading brown curls and soft, almost remote voice put one in mind of the nineteenth-century beginnings of the academy. Yet

her multiple roles reflect our moment in time. Johnson coordinates and supports academy connections to local, state, and federal projects that monitor the California coast. It's worth taking a moment to call out the online community OceanSpaces (oceanspaces.org). This is an effort to network citizen science and professional monitoring of the coast, to visualize the findings at disparate yet connected places, and to provide a forum for people to talk to one another about what they are doing. Most citizen science today exists in local silos or in remote digital databases, and if we are going to save nature, we have to integrate them.

Johnson told me we were witnessing an *Okenia rosacea* "bloom," and it could possibly have to do with the anticipated El Niño weather event.

"So many?" I said. We frowned at each other. We were thinking and not saying the same thing.

"Have you heard about the Cassin's auklets?" Johnson asked me. Yes. This tiny seabird was dropping dead, straight out of the sky, in record numbers.

What exactly is happening is a double narrative. There is the current California drought unfolding along something of a "normal" story line. Drought is what happens here, always has. And there is a thwanging, thwacking, hard-to-pin-down perturbation to the historical weather patterns that cause drought, and that is global warming. In a sense, the finding of an out-of-range species perfectly illustrates why the academy is spearheading a citizen science initiative. As global warming and habitat loss affect nature, we have to track the pieces of the puzzle of what and how changes are occurring. Citizen science is not only about collecting data; it's about making a bridge between nature's drama and people like me. The hopeful sense is that if people like me observe what's happening up close and personal, and start to see patterns, then we will all be galvanized to do more to help nature. But at the moment I was freaking out. The coast of California includes more marine sanctuaries than any other location on earth, and still the species were disappearing. I had a very unpleasant thought, which was: Maybe citizen science can't help after all. Can it?

"Things are changing," Jaime Jahncke told me. "Something different is happening right now." Tall and deep-voiced, he hails from Peru and is director of the California Current Group of Point Blue Conservation Science. The California Current is the ocean system that more or less rules what happens to marine wildlife along West Coast shores. I have accompanied Jahncke out in the ocean, taking the water's temperature, documenting density of plankton and krill, and making other measures by which the state of the ocean is understood. Jahncke additionally heads up Whale Aware, a citizen science project that enjoins people cruising in the blustery deep to document when and where they see the cetacean giants, to help direct ship traffic away from them.

"So is the ocean melting down?" I contacted Jahncke after my own meltdown at Pillar Point. I am not a hysterical person but at some point, hysteria is actually called for. Not only were the sea stars and the Cassin's auklets dying off in unprecedented numbers, so were huge swaths of forest in the Sierra Nevada Mountains. The death of the trees was related to the drought we were undergoing, which was related to what was happening in the California Current. The Marine Mammal Center in Sausalito, the world's largest rehabilitation facility, was overwhelmed with starving and beached northern elephant seals and Pacific harbor seal pups; it rescued more in the first four months of 2015 than in the whole of 2014. On April 30 it rescued a sea lion that had crawled under a car at the corner of Marina Boulevard and

Divisadero Street in San Francisco, just blocks from where I live.

I knew Jahncke was not going to say yes, the ocean is melting down, despite his own measurements in 2014, according to which "the upper fifty meters of the ocean were two degrees Celsius warmer" than the previous highest water temperature, documented in 2008. Two degrees is a lot.

"I mean there has to be a point at which we call this thing," I said to him, appealing to the human emotion quelled but not eliminated from the heart of a scientist. "I know I know I know that yes we are in a drought and yes there is a way to actually quantify the extent to which it is due to human-caused climate change, but that there are also big ocean patterns over long periods of time that could be responsible for this, and it could have some resemblance to normal if we knew better what normal really is." I paused for breath.

Jahncke's research focus is on the California Current, which circulates clockwise off the West Coast of North America. Its impacts are so big it creates what is called the California Current Large Marine Ecosystem, which includes the terrestrial coast and watersheds.⁵ The earth rotates in an eastward direction, and the water flows up to the Arctic region in the north and down to the Antarctic in the south. Wind plays its part. Blowing across the surface of the water, the top layer moves at a 45-degree angle from the wind, creating a spiral down into the water column and pulling up deep, colder water. Jahncke has told me that while what I just asserted is "correct like a textbook, the net movement of water for the complete spiral is 90 degrees," and I believe him. Whatever the angle, the spiral produces what is called "upwelling." It churns up dead and decomposing stuff from the deep, mostly detritus from decomposing plankton and other organic matter. These nutrients are put to use near the surface of the water by phytoplankton that use them to help photosynthesize, thus creating the bottom of the food chain upon which all the subsequent layers will feed. The Cassin's auklets and the marine mammals were dying in record numbers because the drought had vastly reduced the amount of krill at the bottom of the ocean food chain and they were starving. "But the sea stars don't have to do with the drought," I said to Jahncke. Their food sources were still there, but they were dying, too. "Jaime, what are we going to do?"

Quietly and in his somehow comforting deep accent, Jahncke said, "We keep doing things like helping to keep whales out of ship propellers. We keep trying to keep creatures safe and systems in place so they can help us withstand this as it comes down."

In addition to Jahncke I contacted Dr. Julia Parrish, executive director of the University of Washington's Coastal Observation and Seabird Survey Team. Parrish is a dynamo, named by the White House as a "Champion of Change," and she expressly studies the anthropogenic, or human-caused, influences on seabird health along with physical and biological measures. Her COASST project is a standard-bearer for citizen science, producing ironclad data and retaining a passionate cadre of volunteers. I asked her specifically about higher levels of CO₂ in the ocean and wondered why we can't just come out and say ocean acidification is killing sea stars.

Parrish was measured and deliberate. "Scientists don't already know everything," she told me. (Too bad!) "We can't determine all causal factors for something immediately. We measure, we compare, we test. In the case of elevated CO_2 levels, we're far more sure of the physics and chemistry–the warming, the acidification–than we are of the follow-on biological consequences. We *are* picking up biological signals," she admitted, "massive mortality events–no one denies these."
Not only has my father disappeared, life itself would seem to be disappearing. Not only does the center not hold, to paraphrase William Butler Yeats, neither does any periphery hold steady. I was momentarily envious that Yeats could see civilization ending in Irish-English conflict and that Joan Didion, who famously picked up his theme in Slouching Towards Bethlehem, could get depressed about Los Angeles. How pale and evanescent were their clarions of doom compared to what is going on now. If the basic materials of life are disappearing, then the violence of the postcolonial British Isles and the dull disaffection of Hollywood all get swept away into the same dustheap of inconsequence and all those human struggles are trumped by this gigantic squashing. This is not the unfolding of "endless forms most beautiful," as Darwin called evolution, but an inverse sucking away. Local extinctions lead to regional and universal extinctions. We have been told and told again that climate change impacts and habitat loss impacts have concentric waves of negative effects and this is it. Apocalypse right now.

You Can Taste It

My brother Jack's eulogy in Most Holy Trinity Church was exactly as its subject would like it if he were cognizant and not snoozing in a covered coffin at the front of the room. Jack told the packed pews about my father's versions of reality. "Once, at a party, I overheard my father tell someone a story about something that had happened to me. But he was telling it as if it had happened to him. Later, I said, 'Dad, that happened to me, it didn't happen to you.' He said, 'Oh, I know, bud. But it would take too long to set up that way. The story just works better if you tell it first person.' Another phrase that got a lot of traction in the Hannibal household was, 'Nothing spoils a story like an eyewitness.'" I laughed with everyone as Jack told these most familiar stories. Jack touched down so lightly on my father's contradictions, he seemed to resolve them. *Nothing spoils a story like an eyewitness*. How many times had I heard that? Yet, Jack went on, "Dad had a slit-eyed, thousand-yard stare that he would level at you whenever he suspected you were lying, high on somethingor worse, if he thought you had just used a word incorrectly." My father did not have a problem with maintaining these two different standards-entertain when the moment was right for it, and be honest when it counted. But of course it was all up to him to decide which moment called for what.

The Church was a major disappointment for my father. He loved going to mass, and so did my mother, especially when Father Huntington preached. But Huntington retired and one too many fire-and-brimstone sermons succeeded him. Decades of prevarication and deceit and child abuse on the part of the hierarchy repulsed my parents. Still, the basic Christian tenets stuck. Jack recounted the moral teachable moment when Pope John Paul II forgave the man who tried to assassinate him. "I asked Dad why he was doing it and Dad said because there wasn't a sin man could commit that the love of God couldn't forgive. I then asked why the man wasn't being released from jail. Dad said, 'Because you can't shoot the pope."

Jack talked about my father's faith, and said that Christianity provided both a context for his life and the lens through which he saw the world. I might have said the same thing even a week before he died. Jack had arrived at Southampton Hospital from North Carolina in time to say good-bye to my father, but didn't have time with him in the days leading up to it. My other siblings, my mother, my daughter, and I spelled each other keeping him company. He wanted to be read to—not the Bible, but the short stories of Ernest Hemingway. After every story he paused

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and discussed how Hemingway "did that," created the narrative. I read him "The Butterfly and the Tank" (one of Steinbeck's favorite Hemingway stories), and he said, "Ho ho, I'm sorry I know that now," as if exposed for the first time to the death of beauty by violence. "I read it to him yesterday," muttered my mother, walking by.

Although Hemingway was his favorite writer, there were others, like Jack Kerouac, or Anthony Burgess, whom I might have guessed he would have chosen for the deathbed. After a while Hemingway gets bleak. But other writers sound garish and inconsequential when life has indeed come down to its essence. My twenty-year-old daughter read Fitzgerald's "A Diamond as Big as the Ritz" to him and I found it excruciatingly beside the point. When she finished he said, "Fitzgerald writes about class, and that's okay. But Hemingway"—he put his hand up and framed space between thumb and index finger— "Hemingway gets to what's going on behind the words."

I had not been inside this church for years, though throughout my childhood and even on many Sunday mornings in my twenties, I sat in the pews. In memory the church is darker; they've lightened up the interior, which I grumpily do not like. The presiding priest was reasonable and authoritative. In this ritual of death, the Catholic Church shines. I remembered Father Huntington-tall, thin, white-haired, and patrician. He had been a Protestant English professor at Harvard University when one day, gazing at children on swings in Cambridge, all went black before his eyes. An indeterminate time period ensued. When his sight was restored he saw Jesus on the cross. This was one of his best stories, and sometimes it played in my mind as if it happened to me. I don't remember whether he saw Jesus superimposed on the playground, or if the vision came and went. The quotidian world was restored. A bachelor, Huntington converted to Catholicism and became a priest.

While my own conversion experience isn't about Jesus, it is certainly connected to the creation. In The Varieties of Religious Experience, William James describes two kinds of conversion experiences: basically, fast and slow. He writes that they are essentially the same thing; the fast conversion seems to come out of the blue, but in fact it doesn't-the incremental promptings toward eureka are just more hidden from awareness. I'm still in the process of a green conversion, and the seeds for it were planted right here. Western science traces the roots of its first questions to Christianity, which explained through storytelling what science seeks to explain with data. Like California Indian liturgies, Christian rituals also enact a covenant with Creator, and they also acknowledge an indwelling spirit that can be felt even if not always seen in material expressions. And for all of the contradictions in the way it is practiced now and has been in the past, Christianity posits that humans have a moral responsibility toward life. As a citizen scientist I adhere to no doctrine but the laws of nature, finding like Emerson and Thoreau that mountaintops and river mouths make excellent pulpits. My observance is accomplished through counting up nudibranchs in a circle transect, and in my intention to help nature keep on keeping on, I consider myself a co-creator.

As the protocols of my father's funeral played out, my eyes drifted predictably out past an opening in the stained glass windows, where I could see the Most Holy Trinity school across the lawn. A handful of us were excused from East Hampton Middle School on Wednesday afternoons to walk here across town for Catholic doctrinal studies. We were preparing for confirmation—with baptism, communion, marriage, and death, one

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of the sacramental rituals of the Catholic faith. This class was most often taught by a volunteer, a mom. When I was in the sixth grade, one of these moms instructed us about the host, the small wafer congregants receive on the tongue at the crescendo of mass. "The host stands for Jesus," the mom told us. I raised my hand. "It *is* Jesus," I corrected her. I was a very obedient student and in those days sass was not the behavioral option for kids that it is today. She argued with me, which now seems ridiculous. I held my own. I didn't quote Flannery O'Connor ("Well, if it's a symbol, to hell with it") but recited other authorities– essentially, my father. She asked me to leave the room.

My parents, who despite their bohemian, groovy, we-livein-an-artists'-colony demeanor were ardent Catholics both educated by nuns and my father by Jesuits at Boston College, were very pleased with my righteous insurrection. We had a powwow at the rectory with a junior priest (not Father Huntington) and the facts were presented. My father cleared his throat and stated that wars had been fought over this not-insignificant detail that the host is the literal body of Christ. The mom looked at me—we both knew she was going down, but her look said, do you really believe that in this flat bland cracker you get a bite of Jesus?

I had indeed worried over this profound detail for quite some time. As a child consuming the host I did not feel I was being aligned with death, resurrection, and redemption, as was being preached every Sunday. But I did have a strong sensation I got something every time that host dissolved on my tongue. At my father's funeral mass I got up and took communion, as the language for it goes. I remembered him at that meeting, leaned forward in a metal chair, mouth curled in anticipation of a good doctrinal smackdown. The young priest chuckled nervously and corrected the mom. That moment of surety felt connected to this moment of surety. The wafer melted. Jesus had long taken up imaginative residence as a historical figure for me, but at my father's funeral that sensation still arrived, of "all things visible and invisible," as the Nicene Creed has it. This sense of something more than physical things, yet apprehended through them, was part of John Steinbeck's quest in nature; in *The Log from the Sea of Cortez* he called religion an "attempt to say that man is related to the whole thing, related inextricably to all reality, known and unknowable." He commented that Jesus said this and so did Charles Darwin, and that their worldviews were "bound together by the elastic string of time."

Reading the Leaves

The sticking of some people to the creation story of Genesis to explain how life started here on earth is frequently bemoaned as a big impediment to dealing more realistically with how life-forms come and go. If life comes from a magic place and time, then we have no real responsibility toward it-and that is, indeed, a problem. But those of us who fully sign on to evolution should not just throw away the story of Genesis. In fact, the Christian explanation for creation provides the template for all subsequent Western inquiries into time, place, and purpose. The Garden of Eden and Noah's ark have starring roles in the story of life as understood by early European naturalists, many of whom tied their scientific inquiries directly into their expressions of faith-which included the belief that the spirit of God is embedded in the physical world. The Garden has a special resonance for California, since people thought they would literally find it here, and in a way they did.

You know the story. Adam and Eve transgressed God's wishes and were subsequently thrown out of the paradise called Eden, not only losing the ultimate real estate but also now subject to mortality. Adam and Eve started out in a timeless place, a

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heaven on earth. They ended up vulnerable to pain and death, and they received an expiration date. The idea of Eden eventually translated into something symbolic, but over quite a long period of time people took it literally and were on the hunt for the paradise of Adam and Eve. Where did it go? Eden had vanished but scripture implied it was just around a critical corner somewhere. John Prest, in The Garden of Eden: The Botanic Garden and the Re-Creation of Paradise, writes, "Throughout the Middle Ages the Garden was believed, somehow, to have survived the Flood, and in the great age of geographical discoveries in the fifteenth century, navigators and explorers had hopes of finding it."6 They were unsuccessful, of course, and expanded their thinking on the subject. Maybe Eden was lurking somewhere hidden on the earth, or maybe the original creation had been scattered by the Flood. Expeditions thus began to be sent out to bring pieces of the original creation back home, where they would be reconstituted in "in a Botanic Garden, or new Garden of Eden."

For more than two thousand years the first formal European gardens were square, divided into quadrants representing the four corners of the earth. With the discovery of the New World, the four corners came to stand in for Europe, Asia, Africa, and America, as these continents became known. The great seventeenth-century gardens additionally parsed the quadrants into separate beds, each the home of a particular family of plants, and each plant had its own fastidiously determined place, which Prest likens to assigned seats at a family dinner table. If this expressed an idea of God's progeny, the gardens also reflected a belief that God's mind could be studied and known through the plant life. Laid out in figurative pages set for reference, the garden was thus an encyclopedia. Better than a book because the plants were real. These assembled reference

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guides revealed the many faces of Creator, and each family of plants represented a specific act of creation.

In the encyclopedic approach can be discerned the beginnings of modern science—the information collection, the careful ordering of relationships. Basically, the botanic garden was a living database. Faith and facts continued to be deeply enmeshed through the 1700s, when Carl Linnaeus developed a way to wrestle with new species brought back to Europe by the thousands in the age of exploration. In establishing the binomial system of naming—thus *Homo sapiens* or *Deppea splendens*—Linnaeus organized creation into a kind of spreadsheet, laying the ground for taxonomy and the study of evolutionary relationships, though of course he did not see his work that way. Linnaeus put the names of species in a big hierarchy, once again framing the natural world in a supernatural context of perfection as conceived by God, and headed up by God.

This all may seem very long ago and far away, but some basic formatting laid down by the botanical garden idea and by Linnaeus is still in use today, though it has been revised. Citizen scientists are frequently asked to do what research scientists do all the time in the field, which is count things up and/or measure things within the confines of a transect. Counting up hawks as they whiz by on their annual migration over the Golden Gate Bridge, my fellow citizen scientists and I take stations at the four cardinal directions and rotate once an hour. The tide pool count of nudibranchs and sea stars similarly takes place in a transect outlined as a representative microcosm of the whole reef. The transect is always a representative part of a whole, just like the original botanical gardens were microcosms of Eden.

The story of Noah's ark continues the story of the Garden of Eden—where do you think that olive branch brought by the dove came from? Linnaeus opined that the ark had landed on Mount Ararat in Turkey and the pairs of species on it had headed out from there to the places where they were found in his day.⁷ The two-by-two counting of species represents the basic scientific concept of the reproductive pair.⁸ Linnaeus kept closely to idea that God's perfect mind was expressed on earth. This is actually similar to indigenous belief in a creator evident in all nature. But as the biblical Garden of Eden was a deathless place of eternal spring, Linnaeus's emphasis on "perfect" meant permanent. He felt that plants and animals were exactly suited to their environments now and forever. The problems that arose out of this idea are among the very first questions that developed into the concept we call biogeography.

Much citizen science is exploring biogeography at ever more specific scales. The basic question is: What are the conditions of life in a particular place that make it habitable by the species living there? The problem facing Linnaeus—how did creatures get to places past landscapes that would have killed them?—is faced today by many species on the move as the climate conditions they are habituated to are changing due to human impacts. One of the biggest negative consequences wrought by global warming is that it is changing seasonal timing. Spring comes earlier and winter has been virtually eliminated in parts of the world. Linnaeus thought God transcended the temporal dimension and so provided a constant wellspring by which nature lived. It turns out that time and seasons are in large part running the show.

Linnaeus is a herald of the Enlightenment, the transition in intellectual history in which thinkers and social activists sought to discern fact from fiction, to emerge from a mindset guided by inherited beliefs to a reasoned picture of things based on quantifiable observation. Aficionados of *Star Trek* may recall the 1988 episode "Datalore," which is a parable of sorts for this ongoing struggle. Data is the true-blue, real-deal twin whose evil sibling is Lore. Lore impersonates Data for bad purposes but doesn't get things quite right. Data wins in the end, and blasts Lore into another universe. This is what the Enlightenment and subsequent scientific endeavor has attempted to do-get Lore, or storytelling, out of the picture. Although Linnaeus was a devout believer in Genesis and Creation with a capital *C*, he provided a template for tracking relationships that were explainable by natural history rather than by divine fiat. Darwin's great insight that species rise from one another revises this into a genealogy, transforming a hierarchy of relationships with God at the top into a family tree. Darwin's thought was made possible by Linnaeus, even though Darwin basically did to Linnaeus what Data did to Lore.

Initiation

Darwin personifies the hero's journey, having pretty much failed to fulfill expectations of him before being given a big second chance on a surveying expedition to be undertaken by Captain Robert FitzRoy of the HMS Beagle. Darwin's job was to keep the respected but depressive leader company. He was encouraged to collect and observe natural history, though the Beagle had an official naturalist. For Darwin, the trip was undertaken in the spirit of a Wanderjahr, that tradition in which mostly young men of a certain (upper) class travel on either end of a formal education to supplement book learning with lived experience. Joseph Campbell later extolled such interludes as pivotal in the making of the hero's life. We call it a gap year. Inspired by Prussian naturalist and explorer Alexander von Humboldt's Personal Narrative, Darwin kept a diary of the expedition. Slated to be gone for a generous two years, the ship embarked from Plymouth Sound in the English Channel in 1831 and did not return until 1836.

The avowed purpose of the *Beagle*'s trip around the world was to map the South American coast, determining longitudes and thus improving navigation in the service of those twin objectives of empire: warfare and commerce. (FitzRoy's resulting maps were used until World War II.) Darwin had no real duties aboard the ship, and he suffered from horrible seasickness. Years later he offered prescriptive advice for the burgeoning scientist in a chapter on geology in the British Navy's *Manual of Scientific Enquiry*. He exhorted the aspirant to read, to observe, and to compare. And indeed, Darwin read, he observed, and he compared what he had seen and heard to develop the text that would eventually be called *The Voyage of the Beagle*.⁹

Darwin's reading aboard the Beagle included the first volume of Charles Lyell's Principles of Geology, and the impact of this work on his thinking was like the subject, seismic. One of Lyell's main points is that the processes that made Earth are yet in present motion. There is a constant interplay between internal heat forcing the uplift of mountains and then weather eroding them down. This has gone on through time and continues to go on. Lyell supported the contention of James Hutton, a Scottish farmer who first proposed this idea, known as uniformitarianism in contrast to the catastrophism exemplified by Noah's Flood. Lyell held to an idea of "centers of creation" to explain how different assemblages of plants and animals were to be found in different parts of the globe, and Darwin dutifully kept his eyes open looking for such centers. While he was in Chile, the usually invisible motion of earth processes took a diva turn in the forefront drama of a major earthquake, and Darwin experienced firsthand the forces asserted by Lyell.

My copy of *The Voyage of the Beagle* is collected in a single volume called *From So Simple a Beginning*, in which E. O. Wilson has assembled and written introductions to Darwin's big four,

also including On the Origin of Species; The Descent of Man, and Selection in Relation to Sex; and The Expression of the Emotions in Man and Animals.¹⁰ Of its total of more than 1,700 pages, Darwin's Galápagos chapter in The Voyage is only twenty-four pages long. It is a catalog of eye-opening wonder and appreciation. It is equally literary as it is scientific. John Steinbeck and Ed Ricketts looked to The Voyage for inspiration in conceiving The Log from the Sea of Cortez, which they would produce about one hundred years later. Darwin, Steinbeck wrote, "wanted to see everything, rocks and flora and fauna; marine and terrestrial." This is in contrast to the general scientific approach of drilling down to a single study subject becoming common by Steinbeck and Ricketts' time. "Out of long long consideration of the parts," Steinbeck wrote of Darwin, "he emerged with a sense of the whole."¹¹

He didn't know it at the time, but in The Voyage of the Beagle Darwin was providing a prequel to his eventual book On the Origin of Species. His language is from the world of storytelling rather than that of science, and his details about the life-forms he sees often have a gothic tone. Upon reaching the Galápagos, Darwin reported spending the night on Chatham Island (an older name for San Cristóbal Island), of which he observed, "The entire surface of this part of the island seems to have been permeated, like a sieve, by the subterranean vapours." "The day was glowing hot," he reported, and ambulating over the inhospitable landscape "very fatiguing; but I was well repaid by the strange Cyclopean scene. As I was walking along I met two large tortoises.... These huge reptiles, surrounded by the black lava, the leafless shrubs, and large cacti, seemed to my fancy like some antediluvian animals." The Cyclops is from the realm of myth and "antediluvian" (before the Flood) refers to Noah. Darwin thus situated his Galápagos observations in a timeless prehistory, with reference to the Christian creation story itself.

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Darwin was pretty much a creationist while aboard the Beagle, but in the years after he got home he cogitated on what he had seen at the Galápagos and credited the place with instigating his theory of evolution by natural selection. He revised the raw materials and then the published versions of The Voyage, each subsequent edition more deliberately laying out the pathway to his eventual synthesis in On the Origin of Species. At the Galápagos he saw strange and wondrous creatures but he also observed time in operation the way Lyell described it. As a storyteller does, he put the interactions between surface and depth-in his case, volcanic rock and oceanic currents-in a temporal framework, "once upon a time." Reading the rocks, Darwin noticed the older Galápagos islands had eroded enough to find vegetation developing on them, while the younger islands were still "covered with immense streams of black naked lava," with nothing yet able to find purchase for growth.¹² He connected the long story of the past with the short story of what was happening now. Volcanoes and earthquakes-not God-made new centers of creation upon which new species were found. The new species were related to those nearby on the South American mainland, and their differences marked the intersection of past and present.

Similar-but-different is the initial setup for speciation, which can occur when populations are isolated from others of their own kind. This is the part where new characters come on stage. Darwin saw that the volcanic islands must have recently punctuated "the unbroken ocean... Hence, both in space and time, we seem to be brought somewhat near to that great fact—that mystery of mysteries—the first appearance of new beings on this earth."¹³ Darwin the collector provided an ongoing inventory of his catches: twenty-six land birds, eleven "kinds" of waders and waterbirds, twenty-five species of beetle, and so

forth. He updated the reader on the analysis of the ornithologist John Gould, to whom he entrusted his avian quarry, and on the progress of the botanist Joseph Dalton Hooker, who wrote up a flora of the islands. Both Gould and Hooker worked far from the Galápagos, back in England, on specimens sent and brought back by the *Beagle*.

In The Voyage, Darwin said it took him a while to appreciate that "the different islands to a considerable extent are inhabited by a different set of beings." He realized this was so when the vice-governor of the Galápagos told him he could tell which island a given tortoise hailed from just by looking at it. "I did not for some time pay sufficient attention to this statement, and I had already partially mingled together the collections from two of the islands." The "specimens of the finch tribe" were also unfortunately mixed up by Darwin before he fully got that the key to figuring out what makes a species so lies in knowing exactly where it comes from. If Darwin had had a smartphone and the iNaturalist app (to be discussed in greater detail later), he could have emailed photographs of the finches to Gould. Gould wouldn't have even asked which island each bird came from, since iNaturalist would locate them instantly in both space and time, by means of latitude, longitude, and clock.

No Species Is an Island

Most of the scientists signing on to conservation biology, from whence springs citizen science, came from a branch of evolutionary science focused on populations. In this they were, and are, Darwin's heirs. How could populations of plants and animals on the islands be similar to but not the same as many corollary species on the Ecuadoran mainland? The British naturalist Alfred Russel Wallace was pondering populations on islands at the same time Darwin was, and the two of them came to the

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same conclusion. The volcanic islands had emerged with no species on them, and gradually, immigrants from the mainland (and other places) colonized them. Darwin and Wallace saw that extinction must play its part in the establishment of new life, by taking out the old and thus creating space for newcomers. This is where characters exit the play and don't return for a curtain call. Over the long time frame, the interaction between immigration and extinction basically establishes island populations in the numbers and places we find them. This is the constant, realtime drama of life. We no longer live in that sort of real time– ours is turbocharged.

We call the theory of evolution by natural selection Darwinism, but as science historian Janet Browne suggests, we might be calling it Wallacism, if Alfred Russel had been more assertive about getting credit for his observations, and also if he had come from a higher social class.¹⁴ Wallace is a kind of poor country cousin to Darwin's wealthy leisured gentleman, but the financial necessity Wallace felt and Darwin did not had a positive outcome for the field of biogeography. After his famous trip to the Galápagos, Darwin more or less spent the rest of his days cogitating in his backyard, while Wallace passed years in far-flung destinations the world over. Darwin exemplified the genteel nineteenthcentury naturalist and is a citizen scientist exemplar. He built his monumental case for natural selection based on years of painstaking observation, under the aegis of no institution, and he did not have an advanced academic degree. Wallace is also a model citizen scientist. He had no formal education at all. Like Ed Ricketts, he made money by collecting specimens and selling them. Having worked as a mapmaker and a surveyor, Wallace prefigures the way much biodiversity science gets done today.

Traveling the globe mostly as a freelance collector, bringing back specimens to wealthy sponsors at home in England, Wallace was, as Darwin was also, an inveterate observer, and he documented who lived where. Tallying up the geographic distribution of animals, eventually he discerned six regions spanning the globe with assemblages of flora and fauna that were distinct from one another. Although his contribution to the theory of evolution remains relatively obscure, the term Wallace's Line still sticks,¹⁵ to describe what science writer Jared Diamond calls "the sharpest and most famous boundary in the world."16 Wallace's Line divides the Pacific and Asiatic faunas, but each of the six sites has equally distinct residents. Diamond says, "Early European naturalists... were astonished when sixteenth-century explorers of other continents began bringing home exotic hummingbirds and lemurs rather than animals from familiar European groups. Why don't climatically and structurally similar habitats on similar continents support similar species?" Since God must be up to something here, it was proposed that these areas represented six different Edens, where God had "exercised creative imagination differently at each site."

Wallace figured it out otherwise though, discerning that land bridges had appeared and disappeared over periods of increased glaciation throughout the long history of Earth. Animals and plants that were once connected to each other became isolated and, with time, distinct from one another. Wallace's book on the subject, *The Geographical Distribution of Animals* (in which he also grappled with the extinction of the Pleistocene megafauna), and its sequel, *Island Life*, both made big contributions in the unfolding of evidence to support the natural selection idea and also laid the groundwork for the formalization of biogeography as a science rather than a religion.

The Art of Losing

Plans were changed. I headed to New York to take the helm of

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Thanksgiving, arriving a few days ahead of other family members set to convene. My parents had been intending to spend the holiday with my sister Ellie, in Richmond, Virginia, where her household included young twins. "I want to go to Virginia," my father told my mother, upon getting the cancer diagnosis. Since travel was out of the question for him, Ellie and company would come north. "I guess this is the end of the deliveries," my mother said. Ellie had been sending See's chocolates every day and the piled-up boxes in my father's office had developed a presence. "She'll bring more," I said.

My brother Eddie and his wife, Natalie, are chef-owners of the Glass Onion Restaurant in Weaverville, North Carolina. They are open for Thanksgiving so Eddie would come the day after. My brother Jack and his wife, Luciana, were in the process of moving from Los Angeles to North Carolina. Since the story of my father's illness was weakness before strength, and since we had collectively decided my mother needed company and help, we made a schedule of coverage. Eddie and I would overlap one day and he would take over my duties for ten days. Then once Jack was settled in his new home, he would come for ten days. Then Ellie would somehow get enough babysitting coverage and come back. My sister Julie, who lives several towns over, would end up doing the most because she would fill in all the interstices of coverage. Our schedule extended through March, when strength was promised to return with the robin. I planned to come back in spring to enjoy the renaissance of vitality all around.

Ellie rolled in with her twins and her affable husband, Neil, and Julie came over with her daughter, and the small house started to rock and roll. Ellie and Julie read to my father, and the twins made brief appearances in his room. "I don't want to freak them out," my father said, looking stiff and slightly bloated up on his pillows. One of the twins crawled onto the bed and curled up next to him. The child intuited the heart of the matter, allowing us silent recognition and even joy in this. My father's delight in the twins equaled the wide-open hilarity of a daily delivery of chocolates.

All was well. My sisters read to my father from the Finca Vigía edition of Ernest Hemingway short stories. This volume strings the stories together without any information about how they were originally collected. For example, it annoyingly dispenses with any explanation for why there are vignettes about bullfighting in front of the stories from *In Our Time*. But my father knew his Hemingway and he loved these vignettes. The more bloody and direct they were, the better. "When he started to kill it was all in the same rush," wafted from the sickroom into the hallway. "Ho ho ho, that's a great line!" he bellowed.

Downstairs I cooked and cleaned and didn't sit as much with my father as I had before people started to arrive. There were a lot of bodies in the room. I realized I was replicating a historic family pattern. I'm the oldest. I got my father to myself before my siblings came along and never liked being part of the big circus of zinging interactions my father loved being the center of. Leaving the room had long been my MO. I should go back upstairs, I thought, this is no time for reversion to type.

My daughter arrived from college in Massachusetts on her Thanksgiving break. She sat with him. "Poppy asked me if I have any attachments," she told me. I rolled my eyes. She was twenty years old, of course she had "attachments"! "He said he doesn't have any attachments," she reported, and my stomach fibrillated. My father never had a single intimation of Zen. He was not one for equanimity. He tended to outbursts and reconciliations. What was he talking about "no attachments" for?

We were all living a moment of which we could not quite take the measure. We were all observing ourselves and watching my

IN WHICH I FREAK OUT IN THE TIDE POOL 51 THE EXPERIMENT © COPYRIGHT MATERIAL father watch us, and we were reading Ernest Hemingway short stories out loud all day long. There was a swirl of telegraphed messages as yet not cohered. We were baking and cooking and preparing. My daughter, Eva, said, "This is like a Virginia Woolf novel. *Mrs. Dalloway.*" "What about Hemingway?" I asked her. She commented that Hemingway's voice in the house was like the theme of war threading through the party-making day in *Mrs. Dalloway.* Alone with him I reported this observation to my father who beamed with pleasure. He liked for life to line up with literature.

Eva and I left on Sunday for New York City, where I hoped we could have a bit of fun before she headed back to school and I headed back to my husband and son in California. As much as I wanted her to soak up time with her grandfather, the stressful atmosphere seemed a bit much for someone who was shortly to face microeconomics again. I wanted her to have a break. In allegiance to the narrative of "weak now, strong later," we cheerily said good-bye to my father.

"We're going into the city, Dad," I said.

He had gotten progressively more immobile and he made a scowling face.

"I'm coming back," I said.

"When?"

"In a few months," I replied, "or maybe earlier."

"That's too soon!" he laughed. The bastard. I laughed too.

Eva stepped forward. "Good-bye, Poppy, I'm heading back to school." His eyes filled with tears and he averted his face. He would not look at her. Why wouldn't he look at Eva? *He knows he will never see her again.* Even as he was doing it, he couldn't bear to say good-bye to the future. I registered this somewhere in my body but silenced the thought. Time stands still. We don't know when the future ends. Waiting at Kennedy for a delayed flight home days later, I got a phone call from my brother Eddie, who had taken over the majordomo role from me as planned. My father was at South-ampton Hospital with pneumonia. This was good news, because now the pneumonia would be treated and it would stop interfering with his recovery from the radiation.

"Great," I said.

In everyone's life there comes a time to sob in an airport terminal and this was mine. I folded into a plastic seat like disintegrating paper. We were just going to hold on to this narrative until the end! But I knew the ending. Tears consumed me. The dividing line making a double narrative of what was going on was there no longer. I would not see or talk to my father again. People looked at me and did not look at me at the same time. A child stared for a long moment but then was not interested. I was grateful to this instinctive ability to acknowledge and to not acknowledge. I was not fooled by grief's advance scout. The full invasion was on, beginning already to redraw the map of my life.

CHAPTER THREE

The Wild Garden

While hunters avidly set to West Coast waters, depleting them of whales and sea otters, terrestrial California was spared the churning drives of empire until the late eighteenth century. But when the Spanish did hit California, the impact was seismic.

Motivated by news of the encroaching Russian fur trade, in 1769 the Spanish Crown directed Captain Gaspar de Portolá to follow up on the starry-eyed report of a perfect bay in California, made 167 years earlier by Sebastián Vizcaíno. "Discovering" Monterey Bay in 1602, Vizcaíno had come upon "the best port that could be desired," capacious and wind-sheltered.¹ "The land of this country is very fertile," reports the expedition diary, "and has good pastures and forests, and fine hunting and fowling. Among the animals there are large, fierce bears, and other animals called elks, from which they make elk-leather jackets.... On the beach was a dead whale and at night some bears came to feed on it."²

Portolá went looking once again for an imperial stronghold. Alan Brown, whose 2001 translation of Padre Juan Crespí's diaries of the Portolá expedition have deepened and revised how we understand the landscape today, writes that in looking for landmarks, the exploring party referred to Vizcaíno's testimony and several other sources "so constantly, in fact, that the descriptions became burned into the explorers' minds."³ Vizcaíno had reported a bay large enough to hold the Spanish fleet. Looking for what was an exaggeration, and noting the small size of Monterey Harbor when he reached it, Portolá thought they must not have yet arrived at Vizcaíno's grand bay. He kept heading north.

By the time he reached the Whitehouse Creek watershed, about a mile inland from the coast at Punta del Año Nuevo, Portolá and his men were exhausted and running low on supplies. Crespí documented the occasion: "Here we stopped close to a large village of very well-behaved good heathens, who greeted us with loud cheers and rejoiced greatly at our coming." He further documented a "very large grass-roofed house, round like a half-orange," and wrote that it was large enough to contain the whole village.⁴

The men were fed and given native California tobacco. The Spaniards reciprocated by giving the Quiroste people domesticated tobacco-prefiguring the biotic exchange about to take place on a larger scale. Led by Indian guides, Portolá and his men continued up the coast and a few days later "discovered" San Francisco Bay from a ridge above present-day Pacifica.

"The Spaniards were lost, at the end of their rope," California State Parks archaeologist Mark Hylkema told me. "The Quiroste headman could have turned them away. Instead he decided to host them."

The Spaniards soon began to establish missions along the coast, disrupting an Indian way of life that had evolved with the California landscape for thousands of years. In short order the landscape began to be cleansed of its top predators, wolves and grizzly bears. Fire, an agent of transformation used by Native Californians to manage their food supplies and their cultural life, was looked upon by the Christians as holy on the one hand and demonic on the other. The Spanish imposed themselves on the landscape and on the people and understood neither. Burning was forbidden.

The landscape and the indigenous people went into a steep decline, and the impacts from these biotic and abiotic disappearances continue to have negative repercussions today. In 2015 I drove into Yosemite National Park and saw firsthand why Governor Jerry Brown declared a "tree emergency" here. Literally millions of dead trees stood red and desiccated on a drought-stricken landscape. If indigenous burning practices had not been interrupted lo these several hundred years, the state might not be in its current danger of literally going up in smoke. Among other things, low-burning intentional fires cleared out duff and debris and thus moderated the intensity of lightning-strike fires when they did occur.

Can't Bear It

An original citizen of California, the grizzly is now found here only in effigy and depicted on the state flag. Descended from a bear lineage that goes back twenty million years, the grizzly evolved approximately 1.5 million years ago, in the company of the Pleistocene megafauna. By comparison, the grizzlies were little guys and gals, their three- to eight-hundred-pound profiles dwarfed by the six-ton woolly mammoth, for example, or the elephant-sized giant ground sloth. These big, big ones began to disappear from North America at around the same time the first people arrived in the Pleistocene. The largest animals went first, over the course of a few thousand years, eventually leaving the grizzly to take the top tier in body mass. Historian Peter Alagona says, "By ten thousand years ago, they were the secondmost-dominant land animals in California, after humans."⁵ The word *dominant* is problematic—for one thing, the wolf was still in the neighborhood when we had grizzlies, and arguably had a bigger effect on the rest of the food chain—but for the moment, we know what he means.

One persistent apologia for the California conquest by Spain had it that the imperial power was actually doing the Indians a favor by dispatching grizzly bears with relative ease. Grizzly bears raided stores of grain and nuts that took months to collect. It is likely that any downed animal, like a deer or elk, obtained again by long labors, was fair game (literally) for any grizzly bear lurking around, waiting to push the hunters off their kill. But the grizzly was also woven into the worldview of the people, addressed by Indians continent-wide as "great-grandfather." This position of anteriority, procreation, and respect is shared in European associations with bears as well.

Today, we can articulate another framework around the role of the top predator grizzly bear in historical California. There were more grizzlies in California than anywhere else on the continent (with the exception of what is now Alaska) for the same reason there were among the highest population densities of indigenous peoples here anywhere north of Mexico: the fantastic panoply of different kinds of terrains upon which to make shelter throughout an annual cycle of varied but overall temperate climate, and the attendant abundance of food sources. They contributed to the functioning of the ecosystem in myriad ways. Their life cycle was deeply twined with that of salmon, the fish we most associate with their diet. Throwing salmon carcasses willy-nilly all over the place, grizzlies provided fertilizer for riverbanks and food sources for smaller mammals, invertebrates,

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birds, and microbes; they created a bridge between aquatic and terrestrial nutrient cycling. Digging the ground for tubers and bulbs, they aerated the soil and stimulated the growth of plants– just like we do when we're digging up bulbs in our gardens. They dispersed nutrients from berries and nuts they consumed, and in defecating at a different location from where they ate them, helped dispersal. On the California coast, grizzlies chowed down on beached marine life, and probably aggressively dove in to nab seal pups, thus helping to cycle ocean nutrients inland.

Grizzlies get close to top billing in the trophic cycle, like sea stars do, but their generalist ways distribute their effects. To remind you, the trophic, or food cycle, describes the direction of impacts between the top of the food chain and the bottom. The sea stars wasting away in the first chapter of this book are top predators in the intertidal, controlling, for example, sea urchin populations and preventing those spiky critters from decimating the kelp. Now that so many sea stars are among the disappeared, the sea urchins are indeed devouring the kelp. In terrestrial North America, scientific focus has landed more frequently on the wolf as the kingpin in the cycle, though grizzly bears are often considered right along with them.

In sum, life is better for grizzlies when wolves are around, because wolves keep the population of herbivores under control, which thus preserves more berries for the bears; grizzlies also take advantage of the wolf's hunting prowess and frequently push wolves off a kill. The wolves don't mess with the grizzlies, and wait until the bear leaves the carcass before having at it again. So to my quibble with calling grizzlies and humans the "dominant" life-forms after the disappearance of the megafauna: number one, there were wolves in California at the time so let's not leave the valedictorian out of the yearbook; number two, plant ecologists and entomologists, to say nothing of microbiologists, will be clearing their throats and saying "excuse me" about the relative primacy of their own beloveds in the way ecosystems work. At the same time, I'm bothering with this at such length because carnivores with the biggest body masses are going extinct at the highest rate today and the impact of losing them penetrates to all layers of biotic and even abiotic interactions.

Grizzlies still roam parts of the lower forty-eight in Washington State, Idaho, Wyoming, and Montana. Citizen science efforts to help them keep on keeping on include a program to monitor camera arrays with a nonprofit called Conservation Northwest. Remote cameras keeping tabs on where they are ironically help reduce the biggest threat to grizzly health, which is proximity to people. Check out this Flickr stream of photo-captured bears and their big-toothed brethren: flickr.com/photos/conservationnw. We Californians have to content ourselves with helping our remaining top carnivore, the mountain lion, make it from here to there. Citizen scientists working with De Anza College instructor Julie Phillips helped identify Coyote Valley in the heart of Silicon Valley as a wildlife corridor, documenting among other wildlife movement the comings and goings of mountain lions. They got "safe passage" in Coyote Valley until the landscape comes up for review again in 2040.

All Consuming

Over a range of ecosystems from terrestrial to aquatic and all over the globe, the top-down impact in the trophic cascade is made by a carnivore. This is what trophic cascade biologist Robert Paine showed with the sea stars in the tide pool. Biologist James Estes did equally well-known work testing the idea in deep open waters, with sea otters. They figured out that when these top predators were removed from their environments, the ecosystems they were part of fell apart. But think about trying to figure this out with terrestrial top predators–like the jaguar, for example. Not easy.

Thus when in 1990 John Terborgh found himself thinking hard about why and how terrestrial predators go extinct at faster rates in fragmented habitat, he had no way of actually testing his ideas until a friend told him about Lago Guri, a man-made lake in eastern Venezuela. Terborgh's thinking started with island biogeographic theory.⁶ IBT, again, is the scientific template provided by E. O. Wilson and Robert MacArthur that allows conservation biology to study how isolating pieces of landscape leads to higher rates of extinction.

Terborgh is one of the world's preeminent tropical rainforest ecologists. He founded and directs the Center for Tropical Conservation at Duke University's Nicholas School of the Environment. Primarily interested in the ecological interactions that create diversity, he was initially drawn to the tropics because here "there are still intact ecosystems. Everything is massively disturbed in North America. I wanted to study how nature operates independent of the interventions of human beings." In fact his most well-known work is based on a massive human intervention, a dam built at the confluence of the Orinoco and Caroni Rivers in east Venezuela in 1986. The Guri Dam created an artificial lake fifty miles wide and five hundred feet deep; the highest peaks in the countryside poked above the water, instantly creating islands of different shapes and sizes. The created islands would pose an opportunity to monitor extinction as it unfolded on them, according to the precepts of the island biogeographic theory, which provides that the smaller and more isolated an island, the fewer the species you will find on it.

Terborgh was convinced that island extinctions don't just happen via passive processes, like random fluctuations in

numbers, but are also driven by ecological processes, particularly those instigated by big-toothed carnivores. "I remember when I first became aware of how important predation is," he told me. "In the early 1980s I collaborated with Louise Emmons, a really tough field person," and currently an adjunct research scientist at the Smithsonian. "We set up a project to study jaguars in Peru. The results of that study forced an understanding, a recognition on my part, that what these very rare animals are doing has a huge impact on everything else that goes on, by regulating prey populations."

At the time, he said, "The popular idea was that predators were not taking down healthy adult animals but the weak and the sick, harvesting nonessential, disposable if you will, elements of the population; therefore, not exercising control over the population itself. That idea came out of rumor and misinformation, maybe more than anything else because of the scarcity of these animals. If you've seen a mountain lion in the US, you've seen something most people don't. They're there, and they have a very powerful effect. But they're super good at being invisible."

Terborgh and Emmons radio-collared jaguars to keep tabs on their movements and collected scat to see what they were eating. Their data led them to construct a diagram of the animals' effect on the species farther down the food chain. Jaguar prey include mammals like peccaries (piglike) and capybara (a large rodent), and reptiles including snakes, lizards, turtles, and crocodiles. "And the prey do all kinds of things to the plants, threatening them by eating lots of seeds, and benefitting them by swallowing those seeds and moving them to other places. All these processes structure how the whole collective works."

The creation of the islands at Lago Guri provided Terborgh with a ready-made site to study the effects on the ecosystem of removing the top predator. "Although it was an obvious experiment-remove all the predators and see what happens to the prey-it had never been done. Lago Guri constituted a fortuitous, multibillion dollar experiment"-one far beyond the reach of scientists, with their perennially limited budgets, to create. Terborgh went to Lago Guri in 1990; in the four years since the islands had been created, the carnivores at the top of the region's food chain (including jaguars) were already gone. Even the largest landscape remnants did not have enough prey to support a top predator. As described by the title of his 2001 *Science* paper on the subject, "Ecological Meltdown in Predator-Free Forest Fragments," what he found was a nightmare world of consequence unfolding among the remnant species on the islands.

At Lago Guri, Terborgh and an international team of scientists ascertained that while there were no top predators on the man-made islands, the next level of the food chain, the so-called mesopredators (meso means "middle"), had increased in number on medium-sized islands. Now unchecked by jaguars, for example, capuchin monkeys proceeded to devastate bird populations through nest predation. Herbivores similarly boomed in unhappy numbers. Howler monkeys that historically lived in groups of three to seven were now found in numbers thirty times as high. They were also starving. In response to so many monkeys eating the greenery, besieged trees laced their leaves with toxins; the monkeys ate the leaves and vomited. Leaf-cutter ants that chew greenery to make fungus farms reached populations one hundred times higher than their mainland densities; their exponential impact denuded the forest, eventually killing the trees. Thus from the loss of the cryptic carnivore, the entire food web basically collapsed.

"What John did was take Bob Paine's keystone species idea into the terrestrial field and change the scale," Justin Brashares, a professor at UC Berkeley, told me. Terborgh was perhaps the first to associate the ecological impacts of species interactions with the size and placement of habitat. Brashares is part of what is now a second or even a third generation of scientists looking at trophic cascades, and he is an author, with Paine, Terborgh, and many top-tier researchers, of the 2011 *Science* paper "Trophic Downgrading of Planet Earth." Jim Estes is the primary author, and he notes that species interactions can be invisible until perturbed, and that the loss or the addition of a species can take years or even decades to become apparent. He also notes that "populations of large apex consumers have long been reduced or extirpated from much of the world."

Brashares updated me on some of the pushback directed at the concept of top-down forcing. "There are those who hold that the system works from the bottom up," he said. "I am willing to accept that top-down doesn't regulate every ecosystem everywhere. Some communities may be regulated bottom up. But today trophic science is looking with a more nuanced view."

Brashares devised a study that takes at its starting point neither the top nor the bottom of the food chain, but the middle. "We are looking at what happens when hippos are hunted out of the ecosystem, or when dramatic changes in rainfall or agriculture impact water levels and cause hippos to disappear." Hippos are herbivores. "They are amazing ecosystem engineers," Brashares said. "They go out each night and eat all these nutrient-rich grasses, and then defecate everything into their water. Rich, diverse aquatic communities result. There are all sorts of ecological consequences when the hippos are gone. You have a dramatic change in the aquatic system, which affects vertebrate communities from birds to otters."

In other words, starting with an impact from the middle, both the bottom and the top of the whole food chain are affected by change in this interaction. As Estes and colleagues write: "The topology of ecosystem dynamics is now understood to be nonlinear and convoluted." And subsequent levels of impact can lead to "tipping points (also known as thresholds or breakpoints), around which abrupt changes in ecosystem structure and function ... occur." Elsewhere in the article, he writes, "Connectivity ... holds that ecosystems are built around interaction webs within which every species potentially can influence many other species." Bottom, top, and middle: it's all connected.

Querying Jim Estes about the impacts of trophic cascades, I asked him a simple question. We do without top predators in a lot of places—in California we still have mountain lions, but no grizzlies or wolves, which historically were here. (And the historical range of the jaguar was as far north as Monterey.) "Things seem to work okay without them?"

Estes considered my question with a certain freighted forbearance, putting me in mind of poet and feminist Adrienne Rich's utterance, "A wild patience has taken me this far." "I would respond to this question by challenging the legitimacy of the claim that things seem to work okay without them," he told me calmly. "I suspect that in many cases this is a false perception, based largely on the facts that we only 'know' systems without the big predators and we have no clear basis for judging what their losses might have meant. For example, it is becoming increasingly clear that the Lyme disease epidemics in the midwestern and northeastern United States are linked to changes in coyote populations. So are midwestern and northeastern ecosystems working okay? I've often wondered if California's chaparral wildfires were as intense in times past when the full complement of Pleistocene megaherbivores was roaming the landscape. These are issues we are just beginning to think about and understand."

Estes also commented, "Many of the things we have done to the earth might be remediated, at least to some degree. Species loss, however, is not one of these."

Light Eaters

Another perspective on the reverberating impacts of taking large-bodied mammals off the face of the earth is described by paleontologist Anthony Barnosky in his 2014 book, *Dodging Extinction: Power, Food, Money, and the Future of Life on Earth.* Paleontologists, of course, dig up fossils and study both the objects and the strata in which they were found, and put together the story of life as it has unfolded on Earth over time. They are the ones analyzing how many megafauna lived when and where, and when they disappeared. Barnosky calculates that historically, 350 species of megafauna could have been supported on Earth at the same time, based on the amount of energy produced by plants and algae.⁷ Those are the primary producers, the leafy green stuff that is turning energy from the sun into sugar and carbohydrates–embodying energy, which is then transferred to the organisms that feed on it.

Every time one animal eats another, there is a net loss of energy in the transaction. So you start out with a certain amount of available energy from the sun, and after plants use it to grow, they contain a bit less energy than the original power of light. Then herbivores eat the plants, and now *they* embody energy that came originally from the sun, and a certain amount of interest is taken off that original power number once again. So you can see that by the time we get to the megafauna at the top of the ancient food chain, there's only a certain amount of energy left to create and sustain their big bodies. Barnosky explains, "It is possible to estimate the body size of an extinct species, how many animals there were on average in a square mile (or kilometer), and how many square miles (or kilometers) the entire geographic range of the species covered." Then you can add up the total weight of all the individuals of all megafauna species therein.

To talk about how much energy is produced by the sun and then harnessed by photosynthesis, Barnosky trots out a word that I frankly had to spend some time contemplating on Wikipedia: exajoule.8 This is a unit of power named for physicist James Prescott Joule, and he got quite a lot more kinds of joules named after him as well. Beginning with the nanojoule, which Wikipedia helpfully says is "1/160 of the kinetic energy of a flying mosquito," we move on to microjoule, millijoule, kilojoule, megajoule, and gigajoule before getting to exajoule, which is one quintillion joules. Now we are in Aladdin's cave, with all those joules. It's easier for me to think of an exajoule as a ten-to-the-eighteenth-power joule, I don't know why. Wikipedia says the 2011 Tōhoku earthquake and tsunami in Japan had 1.41 exajoules of energy in its 9.0 "on the moment magnitude," which is a phrase Hemingway might like. There are more joules, too, including the yottajoule-they all pretty much sound like bad jokes. The thermal output of the sun is four hundred yottajoules per day.

By the time the sun's energy is converted by photosynthesis, there are approximately 728 exajoules available per year, which, Barnosky said, "have been more than enough to power the global ecosystem on land, and all the species in it, before humans became so abundant on the planet." We know it's been more than enough because for millions of years, some energy that could have been available for powering on died and decomposed, eventually becoming coal in the deep layers of terrestrial earth and oil in the deep underground of the oceans. Barnosky says that megafauna biomass stayed about the same for hundreds of thousands of years on earth, and then with the Pleistocene dieoff ten thousand years ago, dipped way down. By about three hundred years ago, the biomass was back up to pre-die-off levels, but "instead of all that weight being distributed through many big-bodied species, an enormously large proportion of it was made up of human bodies and the livestock we breed." We took over the predominance of energy available to make biomass into other life-forms and we made it into ourselves, and cows. This sounds like some horrible science fiction scenario-people and cows replacing every woolly mammoth and saber-toothed cat, and now well on their way to replacing every lion, tiger, bear, and whale. If only it *was* a bad dream.

"Then something remarkable happened," Barnosky relentlessly continues. "Megafauna biomass suddenly began to skyrocket, in just three centuries rising to the level we see today—to nearly one-and-a-half *billion* tons—orders of magnitude higher than it was for all of the time humans have been on Earth. About one-fourth of the 'extra' biomass is us; the other three-quarters are our livestock." How did we do it? By breaking through the photosynthesis barrier. By using more than the sun has to offer. The timing is coeval with the industrial revolution, by which we learned to dig up and drill up those reserves of photosynthesis past, and burn it up. *Finis*: "The human race currently needs more energy just for itself than has normally been available to power the entire terrestrial ecosystem."

Barnosky is one of the scientists I habitually trail around, so he knows me. "Congratulations, Tony," I emailed him upon reading his book, "you are better at telling a horror story than Stephen King. The hair is standing up on my neck."

He wrote back that his work is "meant to be hopeful," because it's quite possible for us to get off fossil fuels and to thus stem extinction. "The key perspective," he said, "is that it's essential to integrate other species into human-dominated systemsbecause that now describes the condition of most of the planet." It's also essential to reintegrate that gift from the gods we have so parsimoniously withheld from our ecosystems: fire.

The Burning Bush

In July 2015 I again joined Rob Cuthrell, then into his second year as a PhD archaeologist, and members of the Amah Mutsun Native Stewardship Corps in the Santa Cruz Mountains. They had been camping for weeks, but the dusty Cuthrell somehow managed to maintain his fresh demeanor. We waited while the chairman of the Amah Mutsun, Valentin Lopez, led members of the corps into a shielded green space to smudge the site and to pray. Smudging is a ritual that involves burning dried sage, one of the culturally important plants historically grown here. Cuthrell walked in advance of our vehicles on the small dirt road branching off from a larger one that snakes up the mountain. The California Department of Fish and Wildlife had recently directed this protocol to prevent running over red-legged frogs and San Francisco garter snakes, both endangered species. It felt like a counterpoint to the Mutsun ritual, a way to viscerally enter the place with respect.

The workday commenced. What might have looked to a passing hiker like any weed-whacking crew was part of a model effort to integrate what is sometimes called "traditional ecological knowledge" into current-day natural resource management. Whooshing machetes opened up new spaces of sky as towering stalks of poison hemlock were felled. The hemlock has been crowding out a potentially healthy population of tarweed, a member of the sunflower family with ethnobotanical significance for the Mutsun. Historically, many Native Californians burned the still-green tarweed near the end of the summer. The scorched mature seeds could thus be crushed and mixed into pinole, a porridge-like staple of coastal diets. These plants have grown here for thousands of years.

Lopez and I stood and talked while the stewards worked. Lopez is tall and gently authoritative. His right eye drifts as if keeping tabs on another dimension. He has more than once reminded me that today's California Indians live in two worlds. They are pretty much always tacking back and forth between past and present, between traditional and contemporary modes. On this landscape, the double vision includes native plants that have persisted here despite centuries of invasions and land-use conversion, a twined history they are helping to parse.

Dividing Line

The landscape at Quiroste was initially recognized for its historical significance by archaeologist Mark Hylkema. Logged, ranched, and farmed for decades, the property was donated to the parks in the early 1980s. Hylkema had a bee in his bonnet from reading expedition-based documents of Spanish encounters along the coast, and set about locating the remains of what Crespí called Casa Grande, the large roundhouse structure where the Quiroste hosted the Spaniards. Hylkema was motivated because, as he put it, "Here is where prehistory became history." Today, the site is frequently referred to as Metenne, the name of one of several villages that were part of Quiroste territory. Working with Crespí's expedition diaries, Hylkema eventually located multiple sites on the valley floor of Whitehouse Creek that evidenced ancient Indian presence. "That's a lot in one place," he told me, so he zeroed in. With the help of students from Cabrillo College, in 2002 Hylkema radiocarbondated building material and plant remains, which showed that one of the major sites in Quiroste Valley was occupied at the
onset of Spanish colonization. The site and environs were thus protected as part of a 225-acre Quiroste Valley Cultural Preserve within Año Nuevo State Park. Hylkema turned to Chuck Striplen, then a UC Berkeley doctoral candidate and a member of the Amah Mutsun Tribal Band, to help explore the site. While there are no known living descendants of the Quiroste people, the Amah Mutsun trace their lineage to historical polities in the area. Striplen, now an environmental scientist and a visiting scholar at UC Berkeley, assembled a multidisciplinary team, including UC Berkeley archaeologist and California Indian scholar Kent Lightfoot, to begin on-site investigation. The ongoing collaborative research at Quiroste includes the Amah Mutsun, researchers from disciplines such as ethnobotany and fire ecology, and state agency natural resource management professionals.

This is "extreme citizen science" in that traditional Western archaeology is being expressly "co-created" both to answer academic questions and to facilitate present-day goals for local people.⁹ The archaeologists are figuring out the lifeways of precontact indigenous people, and studying their impact on the ecosystem. The Amah Mutsun are after something more. Lopez recounts that in 2005 tribal elders came to him and said, "We have to get back to taking care of the land. Creator never rescinded our obligation to it." Lopez laughed. "Can you imagine, these people with minimum-wage jobs if they have them at all, who don't own any land themselves, saying we have to steward it? Now where were we going to do that?" He added that saying no to tribal elders was not an option. When Hylkema and Striplen invited the tribe to participate at the Quiroste site, Lopez saw an opportunity.

Details, Details

In 1770 Junípero Serra took up residence and his position as

THE WILD GARDEN 113 THE EXPERIMENT © COPYRIGHT MATERIAL "Father Presidente" of the Alta California missions (differentiated from the Baja missions). The phrase missionary zeal describes his lust for harsh piety. Many Europeans still equated California with Eden, but for the place to actually suit their outlines of paradise, it had to be cleansed of top predators-good-bye, grizzlies and wolves-and quenched of fire, and its population of heathens had to be baptized. Kent Lightfoot calls the mission complexes "massive enculturation machines-monumental agricultural and craft centers" where the padres "would attempt to transform California Indians into Catholic peasants." Serra never wavered in his belief that he was doing the right thing by "saving" the Indians, and according to Alan Brown approached the missionary career as "heroic."¹⁰ In addition to his passionate emotionality, Serra was analytic and strategic. He considered Crespí's expedition journal to be a critical tool in marketing the mission system to the Spanish back home.

Journalists who bridle at editorial reins may sympathize with Padre Juan Crespí. Serra considered Crespí's fastidious expedition notes overwritten and suggested he trim the "minutiae." Today Crespí's minutiae bear priceless testimony to California precontact: he described plentiful bears, redwood forests that seemed to go on forever, fields carpeted with wildflowers, and fires burning as Portolá's expedition traveled up the coast. Crespí responded to his boss: "Then you do not want me to tell things just as they are, or as I saw them?"¹¹ Serra eventually changed his tune, and three days before he died let his biographer know that he wanted Crespi's work extolled. Serra implored greater distribution of the expedition diaries to Spanish readers who would "be inspired to come here! Merely reading the journals would suffice to move no few of them to leave homeland and native province, and take up the voyage to come and labor in this vineyard of the Lord."12

In the sixty years of its existence, the mission system did profound damage to the indigenous California way of life and the biodiversity the Indians cultivated. Suppressing California Native burning practices and inserting grazing and farming on the landscape further suppressed native plants and invited invasives to take over. Like invasive rodents, invasive plants are transplants to areas where they did not coevolve with predators and so outcompete the natives. Typically getting hold of a disturbed landscape—where a road has been cut, for example, or where land has been converted to agricultural use—they crowd out native plants. And so go the native invertebrates like butterflies, and here we go through the food chain again, like removing steps on a ladder: good-bye, native reptiles, amphibians, birds, and mammals.

The Indians lost their customary food supply and medicines. Many were forced into the mission system for simple survival; their labor on behalf of the Spaniards was largely coerced. The Native population was further assaulted by exposure to diseases brought by Europeans who had developed immunities to them. Records from the San Juan Bautista Mission (near Hollister), to which many Amah Mutsun trace their ancestry, document 3,396 baptisms, 848 marriages, and 19,421 deaths between 1797 and 1833.¹³

Mexico won independence from Spain in 1821 and, as it took political control, directed secularization of the missions. Land ownership cohered around large rancheros, and many of the mission Indians went to work on them. One outcome of this period is that original tribal identities and territories were further occluded, as people moved around to survive. Many Amah Mutsun people settled in San Juan Bautista. The infamous gold rush began in 1848, multiplying the European American population here and speeding the commodification of what in 1850 became the state of California. In a frenzy of moneymaking and environmental degradation, natural resources were grabbed up and laid claim to. Indians with ancestral rights to the land were now impediments to American Manifest Destiny. On January 7, 1851, California governor Peter H. Burnett delivered an annual message to the legislature, synopsizing a violent impasse between the white settlers and the Indians. "We have suddenly spread ourselves over the country in every direction," he reported, "and appropriated whatever portion of it we pleased to ourselves, without their consent, and without compensation." He asserted, "That a war of extermination will continue to be waged between the races until the Indian race becomes extinct, must be expected. While we cannot anticipate this result but with painful regret, the inevitable destiny of the race is beyond the power or wisdom of man to avert."¹⁴

Homeless at Home

"The first five years of my life I spent living in tents," Lopez had told me on an earlier occasion. "Our people were very poor. We did the crops and sheep shearing and moved from ranch to ranch. Some of those land owners in Hollister and Gilroy knew that we were the Natives of the missions, so they allowed us to set up tents on their ranches when we didn't have a place to live."

Lopez was born in 1952 and grew up in Morgan Hill, about seventy miles south of San Francisco. When he went to school, "We were to say we were Spanish or Mexican but not Native American. As children we didn't understand that, but we knew there was an important reason behind it so we obeyed." Lopez's grandmother's grandmother had told her she remembered indentured servitude in the missions, the official order to exterminate American Indians, and the practice of kidnapping children and placing them in orphanages.

As Joseph Campbell might put it, Chairman Valentin Lopez is a specially achieved individual. Frequently first on the docket of Bay Area conferences that have to do with wilderness, nature, or open space, he inaugurates these proceedings with a prayer. It is a sight-plaid-shirted, Carhartt-trousered biologists with heads bowed. His life path illustrates the hero's journey par excellence, though it does not entail leaving home. Lopez's quest has to do with recuperating knowledge, practice, relationship, community, and identity right in the place where these were lost. Lopez's dilemma was that since the Amah Mutsun do not have federal recognition, they have no tribal territory upon which to exercise their responsibility to the creation by caring for the environment. This is an existential quandary and a practical problem. Identity may be a birthright but it is also daily established through observances and actions on behalf of the natural world.

The Amah Mutsun have found multiple creative solutions to their challenge. Lopez has helped cultivate relationships with many local, state, and federal entities, including Pinnacles National Monument, the California Department of Parks and Recreation, the US Bureau of Land Management, and others. The Amah Mutsun have initiated restoration projects at Pinnacles, where they participate in the condor recovery program. (The condor is sacred to many indigenous people; it is a bird strong enough to carry the dead to the afterlife.) In 2011, the Amah Mutsun conducted a controlled burn there.

In 2009 Lopez and Striplen conferred with Rick Flores, curator at the University of California Santa Cruz Arboretum. Lopez told Flores that "tribal members had lost a lot of knowledge pertaining to plant uses and management," and they agreed to work together to re-create forty acres that replicate historical coastal ecosystem zones. Both tribal people and the general public are invited to participate and learn here. Flores told me he sees the work "as a form of environmental justice and a way to heal from colonization. This work is also about the sociocultural resilience of the Amah Mutsun and serves as a counterpoint to the discourse of historical trauma. They are still here." Becoming land stewards once again, Flores said, they are increasingly taking a place in "contemporary environmental planning and decisionmaking processes" from which they have historically been excluded.

At nearby Pie Ranch in Pescadero, cofounders Nancy Vail and Jered Lawson have provided the Amah Mutsun with space to cultivate a native garden. Vail and Lawson were "compelled to understand what it means to live on stolen land, how we can be in solidarity with Native peoples, and what our collective responsibility is going forward." Vail told me she is very much interested in "demonstrating how traditional land stewardship and modern organic agricultural techniques can be woven together," adding, "It's all a work in progress."

With the nation's first nonprofit devoted to nature protection, the Sempervirens Fund, Lopez has established the Amah Mutsun Land Trust, one of the first of its kind in California. And of course there is the work with UC Berkeley, to analyze and interpret the Quiroste site while simultaneously nurturing the area back to health.

While people without PhDs are contributing here, at the moment mostly by helping to remove invasive species, the project exemplifies "extreme citizen science" because its parameters revise the traditional frameworks around which archaeology and even conservation biology are undertaken. As the research is revealing the details of how human land use and habitation have driven historical ecosystem patterns and processes, it is also shedding light on the ways academic viewpoints have reflected political agendas. In the case of California Indians, academic blindness to their agency on the land is hard to extract from the historical drive to separate them from that land. As today's California Indians reinstate traditional natural resource practices, they also reassert a place for the human in nature that is positive—"co-creative" in helping to increase, and not deplete, wild species.

The Gift That Keeps Giving

California Indians pruned, coppiced, sowed, and weeded to intervene in the life cycle of plants and animals and to direct their growth and reproduction. But fire was their central management tool. Indians deployed a complex system of lowintensity staggered burns to provoke new growth of plants for food, medicine, and material goods, including baskets, canoes, and housing structures. They maintained different areas at different stages of succession. Newly burned areas attracted specialist bird species; freshly sprouted fields drew deer and other hunted animals within striking distance. Shrubby growth appearing a year or so after a burn was home to small mammals that were hunted and trapped. Mature forests were kept healthy with low-intensity burning of duff and other natural debris.

Multiple strands of evidence from the archaeological work at Quiroste point to the conservative conclusion that burning was practiced on this landscape for at least a thousand years prior to Spanish colonization. And that the fire regime had a significant impact on "the structure, diversity, and vitality of local terrestrial communities," according to an article by Lightfoot and others.¹⁵ Archaeobotanical results show a high proportion of woody plants that can cope with low-intensity landscape fire, including redwood, California lilac, and alder. Lightning-strike fire is relatively rare on Northern California coasts, so the evidence points to frequent human-instigated burning. High proportions of grassland-associated food-plant remains are a further indication of intentional burning and contrast with the scrub and Douglas fir woodlands that characterize the valley today. Analysis of the density of microscopic glass-like structures called phytoliths that are left behind by some species of grasses also points to more of a grassland ecosystem than is found today, with fire as the likely mechanism for keeping shrub and tree encroachment at bay. And wind-borne charcoal particles from wetland sediments provide direct evidence of landscape fires.

The Indians carefully calibrated where and when to burn. Reproductive strategies of native perennial wildflowers evolved with fire; their seeds were important food sources. Hot flames ruptured seed casings and so promoted vegetation growth. The smoke from fire not only conveyed heartfelt prayers to Creator, but brought new life to some species that germinate as briefly as one minute after exposure to its nitrogen dioxide. Fire is intimately connected with water. Especially relevant to the state of our landscape today is the way that burning sustains the health and the breadth of wetlands. Burning around wetlands creates more edge habitat for more species, boosting nutrients that percolate through the hydrological carbon cycle to support fish, amphibians, and invertebrates. Wetlands act as sponges and filters of contaminants in the watershed, which are sequestered in the vegetation. Burning the vegetation and stimulating new growth can renew a wetland's capacity to clean the water. And fire keeps meadows open, enhancing their capacity for holding water and staving off drought.

The Christian view has appreciated fire as an agent of transformation, assigning its qualities of purification and flame to the Holy Spirit. But the Spanish and eventually the Americans did not see that this metaphorical formula has an organic inception. Fire plays a central role in the geological carbon cycle, breaking down the woody and leafy products of photosynthesis into oxygen and nutrient-rich ash. In California and other dry places around the world, fire is the primary driver of decomposition. To stop fire is to stop what looks like destruction but is part of a cycle of regeneration. Fire reboots the system of life. As California Natives applied this central force of ignition with analysis and design, so they took responsibility for the human role in sustaining creation.

Twined with its centrality as a landscape-management tool is the significance of fire as the nexus of the California Indian cosmogony. "Hummingbird brought fire to our tribe," Lopez told me. "It was a gift from Creator." The Mutsun creation story recounts that after Eagle, Raven, and Hawk failed to, Hummingbird successfully wrested fire from underground badger people. This most tenacious of birds secreted an ember that flamed, and the result flashes in the bird's throat to this day. "We use fire in all our ceremonies, in our sweats, offerings, and prayers. And we have fires that are dances-we dance around the fire," Lopez explained. "The smoke carries what is in our hearts and minds, our prayers, to Creator, and is sacred for that reason." Significantly, fire is not just a gift received, but one that must be given back to nature as well. Lopez has repeatedly reminded me that while the science being discerned at Quiroste is all well and good, the real project here is about "stewardship."¹⁶

The Quiroste work has big implications for how we understand the role of humans in shaping the ecosystem here. It also has relevance for understanding the Anthropocene. Climate scientists predicting impacts from temperature and precipitation changes use models of human-driven land-cover change "that in general don't incorporate our knowledge of human history and how people used the land," according to University of

THE WILD GARDEN 121 THE EXPERIMENT © COPYRIGHT MATERIAL Chicago anthropologist Kathleen Morrison. Morrison told me that most of the literature on the Anthropocene doesn't "look at anything further back than two hundred to three hundred years ago," but humans have been changing the landscape for thousands of years. Morrison is spearheading the mother of all spreadsheets, an academic project called LandCover 6K, which aims to reconstruct land cover and land use back into what Mark Hylkema referred to as "prehistory," or the long time frame in which indigenous people impacted the structure of the landscape and which has been pretty much ignored by those outside the fields of archaeology and anthropology until now. Global change is coming about not just because we are burning fossil fuels, but also because of aggregating impacts from burning, cutting down forests, farming, and a myriad of other land use practices that impact the climate by way of biogeochemical and biogeophysical processes over time. The Quiroste work potentially bears on Morrison's project because it quantifies land-cover changes that resulted in altering those biogeochemical and biogeophysical cycles.

Parallel History

The Spanish, and eventually the Americans who followed, looked on what many considered an Eden and did not notice that the paradise here was human-made. There is no "natural" world for the Indians to return to but rather a highly managed landscape maintained by techniques to be recovered and reapplied. The history of plants, animals, and whole landscapes is often ignored or forgotten even by those who seek to care for these today. But successful restoration of ecological functioning in California requires careful understanding of how people and landscapes have been intertwined—and cast asunder—over vast periods of time. The gaps in our understanding of how the ecosystem functioned precontact is not a problem for science alone, because it is nested in generations of cultural assumption. One perhaps surprising example is provided by that literary lowrider, American novelist Henry Miller, who takes as his reference point the Christian Garden of Eden to celebrate place in *Big Sur and the Oranges of Hieronymus Bosch*.¹⁷ The 1957 title references Bosch's painting *The Millennium*, depicting a raving paradise: "[Big Sur] is the California that men dreamed of years ago, this is the Pacific that Balboa looked out on from the Peak of Darien, this is the face of the earth as the Creator intended it to look." Shortly dismissing any pre-Christian claim to the place by the Esselen Indians whose homeland he extols, Miller pays forward the prejudiced idea that this Eden, the very center of creation, is a European discovery. It has no past prior to Balboa.¹⁸

In terms of not seeing, even the naturalist John Muir sought to remove the sight of Native Americans like a mote from his cosmic eyeball. Muir observed Miwok people in the Sierra Nevada in 1869, noting an old Indian woman dressed in calico rags. "Had she been clad in fur, or cloth woven of grass or shreddy bark ... she might then have seemed a rightful part of wilderness; like a good wolf at least, or bear." As Kat Anderson, whose magnum opus, Tending the Wild: Native American Knowledge and the Management of California's Natural Resources, has been a classic since it was first published in 2005, puts it, he was "unable to fit them into his worldview." With that attitude he helped to construct a philosophy of human-free wilderness-the enforcement of which was already degrading the ecosystems he loved to serenade. Muir may have known well how to read the rocks of Yosemite, but he did not understand that the wildflowers he found enrapturing were there largely as a result of active Indian management. "To both use and conserve nature,"

Anderson avers, "requires complex knowledge and practices, far more complex than leaving nature alone."¹⁹

World Fire

Indigenous burning practices are not limited to California, though every region, time period, and tribe has a unique story to tell. Anthropologists Doug Bird and Rebecca Bliege Bird are investigating common histories and contemporary experiences with fire among California Indians and Aboriginal Australians, such as the Martu people with whom the Birds have lived and worked over the past twenty years. The Birds collect data for their own academic purposes, and the Martu and other tribal people use that same data to help establish and defend territorial rights—these mutual goals make the project a "co-created" one.

Species, as has been noted, are going extinct all over the globe at a rate and magnitude one thousand times faster and bigger than "normal," and they are going extinct fastest in Australia. Australia has experienced the same loss of the top predator we have going on in North America; to review the drill, big-toothed mammals like dingoes (wild dogs) in Australia have a forcing effect on the rest of the food web, and when you take them out of the picture, the herbivores become overentitled to greenery and decimate it. Hosts of smaller species that depend on healthy vegetation start to blink out. Invasive species get a green light to come on into the ecosystem and start accomplishing their own outcompeting of natives. The view from North American conservation biology is that increased human use of the land, mainly by ranchers and farmers who actively remove predators to safeguard their livestock, is knocking the trophic kingpin off the pyramid and instigating a downward cascade of ecological disaster. But there are some interesting complexities in the Australian situation. The areas of the country with the least amount of ranching and agriculture-the least human impact-are experiencing the highest rates of extinction. In the central and western Australian deserts, moreover, endemic mammal losses are highest, but the dingo population hasn't changed. And where the Martu live and burn, species extinctions are in fact fewer and slower than elsewhere. When I saw Doug Bird's illustration of how this comes to be, my jaw dropped.

Most scientists' diagram of a trophic cascade starts with a top animal predator, depending on the ecosystem-a sea otter, or a wolf. At the top of Bird's PowerPoint slide: a Martu tribal member about to start a fire. "That's a person," I said. I made him laugh. "I can never understand why conservation biologists leave humans out of the picture," he said. Martu cultivate "seral stages" of vegetative growth after fire. In the first stage, newly burned ground exposes monitor lizards, which they hunt and eat; the second stage brings young sprouts of vegetation after the first summer rains, which produce seeds and fruits as the grasses mature, also harvested by Martu, and become fresh forage for other species. The grasses die, and spinifex, the so-called climax vegetation on the landscape, takes over. Lizards and small mammals find ground cover again. The Martu moderate a steady supply of different food types for themselves through this system, but they also create diverse types of habitat and forage for the other species on the landscape. The hunters thus provide seasonal larders for their prey, who thrive in balance with the environment. In five to ten years, the spinifex can "carry a fire," and it is burned again. If it is not burned now, the spinifex dies, dries out, and becomes susceptible to big, destructive conflagration. As Bird writes, "When Martu say that hunting and gathering is necessary for the perpetuation of life, it's not only an esoteric statement... it is based in a sound ecological theory of trophic interactions."

The Beauty-Death Transaction

Still, there is something fundamentally difficult to accept about predation and fire, and it has to do with pain, blood, and destruction. Physically, those are hard enough to bear, but it is perhaps even harder for us to grasp the terrible impersonality of death. Joseph Campbell was all about being as specific a person as one can be in order to finally let go of all ego identification in as fulfilled a manner as possible. He was constantly describing the paradox of expressing individuality while participating on behalf of the common good. This is the job description of the citizen scientist. But sometimes the details one documents are hard to stomach.

In spring 2013 I walked around Audubon Canyon Ranch in Marin County, where two species of egrets were nesting. Some of these prehistoric white birds were already sitting on eggs due to hatch around Mother's Day. On my way up the short loop to the main observing spot, I stopped at a lookout over Bolinas Lagoon. The low tide made it a mudflat. The docent offered me a telescope and a look at an unusual duck. "But what's that there?" I said. It looked like two deer were mucking about at the shore, but something was not quite right. I picked up a pair of binoculars. A small female deer was wobbling around with a bloody haunch. Her companion was not another deer.

"Life is, in its very essence and character, a terrible mystery," Joseph Campbell said, "this whole business of living by killing and eating."²⁰ It took me a few minutes to register what I was seeing. The doe–there were no antlers or antler buds on the animal's head–was clearly injured, but not otherwise discomfited. She took a few staggering steps. And a fluffy coyote lifted its head and lunged straight at her bloody wound.

Eating. The deer seemed tolerant. The coyote prodded its prey, taking a moment to keep the doe within its control but

then, with seeming nonchalance, the coyote stepped away to chew more thoroughly. I was transfixed and repulsed. This was the trophic cascade in action. No wonder we can't stand to really think about it. "It's so weird that I'm seeing this right here on the lagoon!" I said out loud to the docent, who was staring with an open mouth.

In the not-too-far distance, a big sandbar was ringed with sunning black ellipses-seals-punctuated regularly by little black commas-their young. The way they curved and the way the sandbar curved was just like the way the reef and the cliffs curved. The scene was perfect.

"Formerly you had a dreamtime paradise," Campbell said. "No time, no birth, no death—no life. The serpent, who dies and is resurrected, shedding its skin and renewing its life... is the primary god, actually, in the Garden of Eden," he said, explaining the Sumerian origins of the story in Genesis. "When you look at the beauty of nature, and you see the birds picking around they're eating things.... The serpent is a traveling alimentary canal, that's about all it is. And it gives you that primary sense of shock, of life in its most primal quality. There is no arguing with that animal at all. Life lives by killing and eating itself, casting off death and being reborn, like the moon."²¹

I continued on the trail to watch the egrets. There were plenty of them, snowy egrets and great egrets, doing their plumage showing, rearranging the twigs in their nests. Another docent said, "The males and the females spend equal time sitting on the eggs. They share all the household duties." The egrets were so pure white, their feathers so soft and luminous against the dark redwood branches, it cooled my mind to watch them. Until I remembered that when the chicks hatch, Mom and Dad will look on while the two biggest siblings kick the smallest hatchling out of the nest. I returned to check on the doe-coyote drama below. The doe was dead, and a turkey vulture was having at it. "A man got out of a car to see what was going on," the docent told me. "The coyote scooted away." The docent then went on to tell me the deer had gotten stuck out in the mudflats earlier in the day and a sheriff and humane officer had lifted her out on a canvas tarp, depositing her safely on land, so they thought. He told me it was likely the coyote had chased her into the mud to begin with, but the officers hadn't known about that. Perversely they had helped the coyote kill the deer—indeed we are so often doing something other than what we think we are doing. The docent shook his head at nature red in tooth and claw, and remarked that even the benign-looking seals herd fish up onto the mud where they can't get away. And then I left Audubon Canyon Ranch to find ... lunch.

Joseph Campbell's elucidation of the alimentary canal in the Garden of Eden may be one of his most significant connections between myth and science. Here in perhaps the central story of Western civilization lies a deep intuition about how nature works, what is really going on here. It is a lot about consumption—not just food we put in our mouths but the other natural resources we break down and convert into energy.

The energy transfer is day to day and also over longer time. My father has *passed*, I have mused to myself in the time since he died—I know the term refers to his soul now gone on to some other place, but it also describes a transfer of energy, those carbon molecules of his body now breaking apart and reconstituting as earth, water, and sky. One impact of his death is that it has bumped me closer to the category of "older generation." The word *generation* meaning both the making of energy and the embodying of it. We're all just carbon carriers with big burdens in our hearts. Campbell also said that the universal story of the hero's journey got started when *Homo sapiens* became hunters. Agriculture was a collective undertaking, but hunting relied on an individual who had to go do something life-threatening. Hero myths helped hunters identify with a larger purpose for risking their lives, invoking power and meaning for the journey out with a spear. Many indigenous practices include a liturgical ceremony acknowledging a downed animal's connection with its forbears, also acknowledging the intertwined fates of human and animal ancestry, bound by the sacred act of killing. It's an intimate act but also, as with the doe and the coyote at Bolinas Lagoon, fundamentally impersonal.

Native American prayers over the killed animal acknowledged the generational transfer of energy, and an ecological balance. We market the hero's journey as self-determination, but what a pale project compared to the comprehension of our place in the trophic whole. Are we the heroes? The large carnivores that we have done such a good job of reducing, grizzlies and wolves among them, are animals that leave their natal home, light out for a huge territory, find a mate, and establish a new base of operations. Animal movements were likely the impetus for Homo sapiens, who followed them, to create the first maps. Today, as we examine the data points of their activities, we understand that their movements across the earth impact deep down into biotic and abiotic functioning of said planet. The life history of a wolf or a mountain lion thus creates the blueprint of a cosmic hero's journey, extending past spatial and temporal boundaries to encompass one history.

CHAPTER NINE

Innocence and Experience

By the time I graduated from college and headed into my own literary life, my father was deeply ensconced back in the advertising world from which he had had a ten-year hiatus. We went out for simple lunches or dinners every couple of weeks in New York City. He paid–I made so little money, these meals provided me with a serious nutrient boost, as a conservation biologist might put it. I reported to him the highs but not all of the lows of my first job as assistant to the editor in chief at *Esquire* magazine. Eventually, grasping for meaningful copy beyond the typing pool, I was handed the monthly column of a European playboy to edit.

Esquire in those days was revered among the literary establishment partly for publishing what was called "new journalism," in which the reporter included himself as a subject of the story (very few women broke into this world)–the observer as participant. My boss was a young businessman who had bought the magazine. While respectful, he did not feel beholden to the old *Esquire*. What I absorbed from working with him was that he wanted to empower people as he had empowered himself, to realize their full inner potential and to create their own lives. He recruited "New Age" California writers to the pages. The old guard who still worked there were not amused. Neither camp was particularly concerned about my European playboy (which was why I got to edit him), who wrote with flat ease about tennis, drinking, and beautiful women. Then he went on to beautiful women, drinking, and tennis. Editing him was like mowing a lawn.

I was in my very early twenties and he was around forty. Here's how my interactions with him went. Me: "X, I'm afraid I'm going to have to cut your copy-by a lot." X: "Fine. Mary Ellen, will you sleep with me?" Me: "No. Do you want to review it before it goes to the copy editor?" X: "Please, if you would sleep with me... it would be such a very good idea, I want to sleep with you." Me: "Do you want to review the text before or after the copy edit?" X: "No. Please, go to bed with me." Sometimes he modulated his voice, rolling the tone. Mostly not. X: "Please ... if you would only ... " Me: "Talk to you next month!" Once I found myself in a taxicab with him. I was leaving a party and he hopped in. We drove downtown and he kept up his pleading. I realized I did not want to be standing next to him at the door to my apartment building. At a stoplight I bid him good night and stepped out of the cab. Our professional relationship was not impacted.

There was a lot of typing of manuscripts I was not otherwise involved with, lots of picking up dry cleaning and fetching lunch; there was a garden variety of casual sexual harassment, and this was the literary life. Then one day I got a phone call from a woman I had gone to college with but didn't know well. She had tickets to a lecture series at the New School she couldn't use, and I was the only person she could think of who might be interested. The tickets were for three separate lectures by Joseph Campbell. I was impressed that the price of the tickets nearly equaled my monthly rent. If I had had to pay for them myself, I wouldn't have been able to eat for several weeks. What a biologist might call an "extra resource allocation" could be called in Joseph Campbell's term a boon received as an *aide de journey*.

Campbell's Hero with a Thousand Faces was by then a cult classic but I hadn't read it. A few years later journalist Bill Moyers produced a PBS series on Campbell, The Power of Myth, and it made Campbell world famous. George Lucas credited Campbell with inspiring his Star Wars movies and thus fueled a trend that continues today for screenplays to be written and evaluated according to the concept of "story structure" as articulated by Campbell's hero myth. If you would like to see some nifty diagrams of the hero's journey, Google "Joseph Campbell and Marketing." You will see that his story structure is also currently in wide use as a key to selling products, oneself, or both. A favorite Campbell aphorism in use by best-selling author Paulo Coelho and to herald a Pinterest board is: "Follow your bliss and the universe will open doors for you where there were only walls."1 From the commercial to the esoteric, the stories we tell today, the stories of our time, if you will, are in large part shaped by Joseph Campbell's storytelling.

Photos of Campbell and tales of his youth depict a very handsome young man, though at the time I saw him he was in his late seventies. He was tall and robust, but somewhat indistinct, like any businessman in a suit on his way to Grand Central Station. The lecture hall at the New School was packed. Campbell stood on the stage and talked. That's all it was—a man and a voice. The audience was riveted, including me.

Campbell's main point was that life is not about telling ourselves a story, it is about *living* a story. He exhorted his listeners to follow their "bliss" into a deeper plane of authenticity and experience. As he later told Bill Moyers, "Most people living in that realm of what might be called occasional concerns have the capacity that is waiting to be awakened to move to this other field." He told Moyers about teaching at a boys' prep school, where the students would consult with him about their career paths. (This would be the Canterbury School in Connecticut, where Campbell was a student before he was a teacher; he matriculated alongside the writer John McPhee.) "A boy would come to me and ask, 'Do you think I can do this? Do you think I can do that? Do you think I can be a writer?" Campbell responded that if the boy could withstand ten years of obscurity, the answer was yes. "Then Dad would come along and say, 'No, you ought to study law because there is more money in that, you know.' Now, that is the rim of the wheel, not the hub, not following your bliss. Are you going to think of fortune, or are you going to think of your bliss?" At one point at the New School he recounted a Sarah Lawrence College student's response to his hero's journey lesson (he taught there for decades). "Professor Campbell,' she said, 'I understand it. I get what you are saying and I know how to attain wisdom.' 'Terrific,' I replied, 'all you've missed out on is your life." His delivery was so spontaneous I was truly surprised, reading him later, that he repeated this anecdote regularly in slightly varied forms. At the time, like many in the audience, I felt he was speaking directly to me.

Campbell later located the decisive moment in his own heroic journey to a period of eight months during the Depression, in which he hung out with John Steinbeck and especially Ed Ricketts in Pacific Grove on California's Monterey Peninsula. In one way of looking at it, the friendship between Steinbeck and Ricketts was a long conversation about art, science, and what it means to be human. In 1932 Campbell entered the conversation, influencing it and being influenced by it. "A beautiful time," Campbell called it. "I'm coasting along, trying to find where I am.... Ed Ricketts was an intertidal biologist. We'd go out and collect hundreds of starfish, sea cucumbers, things like that, between high and low tides, furnishing animals for biology classes and schools."² Elsewhere, he recalled, "It was Ed who was especially important to me.... From our long talks about biology, I eventually came up with one of my basic viewpoints: that myth is a function of biology. It's a manifestation of the human imagination which is stirred by the energies of the organs of the body.... In other words, myth is as fundamental to us as our capacity to speak and think and dream."³ As Campbell later said to Jungian analyst Fraser Boa, "Ed Ricketts was the heart of it all."⁴

The Journey Begins

The story of Ed Ricketts is a case study of the hero's journey eventually articulated by Joseph Campbell. Whatever else he did or didn't do, Ricketts followed his bliss. And plenty of others to this day follow their own, in his footsteps. As evolutionary biology continually references Darwin, a subset of literary seekers, often aspiring to integrate science with its sister humanities, find in Ed Ricketts a powerful touchstone. On several expeditions, including the one to Sitka, Alaska, with Campbell and another to the Gulf of California in Mexico with Steinbeck, Ricketts collected specimens that inform how we understand change over time. But Ricketts was equally interested in subjective questions of meaning and purpose as he was in objective data points, and in this he is of significant relevance to us today. Science alone is not going to save nature; context is everything.

In full-on searching-young-man character, Ricketts made three departures from traditional education (he never received a college degree). Starting at Illinois State Normal University in 1915, a year later he was doing stints as an accountant in El Paso, Texas, as a surveyor in New Mexico, and as a Medical Corps technician at Camp Grant in Illinois. Next he matriculated at the University of Chicago but, initiating a pattern he would repeat, left there to escape the consequences of a dalliance with a married woman,⁵ and in 1916 commenced a *Wanderjahr* through Indiana, Kentucky, North Carolina, and Georgia, mostly on foot. In 1925 he penned a charming recollection of his walkabout in the South, "Vagabonding Through Dixie," published in Travel.⁶ (Ricketts' walkabout was also described in Steinbeck's 1945 book, Cannery Row.) Ricketts, who was visibly armed, recounts being taken for law enforcement more than once. "As I entered a little country church one Sunday evening, I overheard a youngster telling his companion, in a hoarse whisper, 'Thar goes a Rev'noo Off'cer."

Coming across John Muir's *Thousand-Mile Walk to the Gulf* in a Savannah, Georgia, library, Ricketts decided to follow the legendary naturalist's suit and "whenever it was convenient, I spent the night in a 'City of the Dead.' There was always good shelter and a level place to pitch my tent." As Muir writes of the practice: "On rising [one morning] I found that my head had been resting on a grave, and though my sleep had not been quite so sound as that of the person below, I arose refreshed."⁷

John Muir is another citizen science prototype and merits a substantial aside. He made at least one highly significant contribution to science, in 1871 establishing (without an advanced degree) that Yosemite Valley was created by glaciation. This was contrary to official consensus at the time. He resisted the category but was thought of by professionals as one of California's foundational scientists.⁸ Muir advocated for direct experience. "No scientific book in the world can tell me how this Yosemite granite is put together or how it has been taken down. Patient observation and constant brooding above the rocks, lying upon them for years as the ice did, is the way to arrive at the truths which are graven so lavishly upon them."⁹ At the same time, Muir also reprised the practice of devout Europeans by interpreting nature in terms of physical texts. Writing for the *New York Tribune* in 1871 (his first publication for pay, \$200), Muir compared Yosemite glaciers to a weather-beaten book: "And though all were more or less stained and torn, whole chapters were easily readable. In this condition is the great open book of Yosemite glaciers today; its granite pages have been torn and blurred by the same storms that wasted the castaway book."¹⁰

In 1921 Ricketts returned to the University of Chicago, where he spent the next two years. One of his professors made a deep, permanent mark. Ricketts took hard to the ideas of zoologist Warder Clyde Allee, which made their way into Steinbeck's work as well. Allee was a proponent of "the organismic-community concept" and emphasized that the individual doesn't count for much in ecology, but the group does. A practicing Quaker, Allee sought to integrate ethics and science and argued that animals benefit from living in cooperation. He asserted that "the two great natural principles of struggle for existence and of cooperation are not wholly in opposition, but ... each may have reacted upon the other in determining the trend of animal evolution."¹¹ Allee expressly looked for biological grounds upon which to argue the benefits and naturalness of cooperative human societies, posing the idea in counterbalance to the every-organism-for-itself way of looking at Darwin's definition of natural selection. Allee melded

INNOCENCE AND EXPERIENCE 295 THE EXPERIMENT © COPYRIGHT MATERIAL observations of tide pool interactions into a social vision,¹² and they are reflected back in Ricketts' lifelong musings on the nature of tide pools and everything else.

From 1915 to 1921, Allee conducted an intertidal survey at Woods Hole in Massachusetts along the lines that Pete Raimondi and Melissa Miner are doing on the West Coast today, and for which at the time there was little precedence. As discussed earlier, Joseph Grinnell was famously (now) in the process of surveying terrestrial California in a highly replicable way. The utility and even necessity of surveying like this was not generally known at the time and Grinnell was prescient. Ricketts probably learned the concept of the biological survey from Allee, but neither of them used their data in the highly quantitative manner Grinnell pioneered and which present-day scientists pursue with greater accuracy every year. Allee was after a behavioral result, or one might even call it a spiritual result-he sought to show that cooperative behavior in "lower" animals is characteristic of living matter itself.¹³ This is not how today's biologists would frame their questions in a survey. Joseph Campbell would have been right at home with this sort of biological and aspirational synthesis. Ricketts revered Allee and considered his the "last word," and according to his friend Jack Calvin, Ricketts and other Allee students "got a holy look in their eyes at the mention of his name."14

While he attended classes, Ricketts worked at Anco Biological Supplies, part of a fishing-tackle supply company, an experience that likely prepared him for the business model on which he built Pacific Biological Laboratories with Albert E. Galigher in Pacific Grove, California. Ricketts arrived there in 1923 with his wife, Nan (Anna Barbara Maker), and young family in tow. Galigher would soon step out of the business, and Ricketts soldiered on alone.¹⁵ "What Ed did for a living," as described by Steinbeck biographer Jackson Benson, "was to collect, prepare, and ship animals to schools to be used for exhibition, experiment, and dissection in high school and college biology and zoology classes."¹⁶ He gathered most of his specimens from the Monterey intertidal, but also took collecting expeditions to farflung parts of the West Coast.

The year he published "Vagabonding Through Dixie," 1925, Ricketts also published a catalog of specimens for sale from Pacific Biological Laboratories. Thus he prefigured the interest in and expression of two modes of experience that later he and Steinbeck would attempt to fuse in The Log from the Sea of Cortez, the travelogue and specimen list memorializing their expedition around the Baja Peninsula. Ricketts' foreword to the lab catalog begins Big Picture: "Monterey Bay is the fusion point of faunas from the North and South, and the ranges of a number of characteristic species of both regions overlap in these waters.... One can find almost any combination of rocky coast, sand beach, or mud flat within a few miles. Rich pelagic hordes approach the shore." He concluded the foreword with a most unusual caveat for the time. "It should be borne in mind, (and this applies especially to local marine forms), that we must, above all else, avoid depleting the region by over collecting.... Monterey Bay is probably richer in individuals and species than any other region of like size in the United States, and it would be unfortunate if such a situation were to arise here."17

Revisions

The mind meld that would form around Ed Ricketts in the thirties began with the arrival of Jack Calvin to Carmel in 1927.¹⁸ Both bookish and adventurous, the teenaged Calvin had traveled by square-rigger to Bristol Bay in Alaska to work the canneries and to fish the Nushagak River. He wrote two young adult novels based partly on these experiences, *Square-Rigged* (1929) and *Fisherman 28* (1930). "They're both out of print," Lisa Busch, executive director of Alaska's Sitka Sound Science Center, told me, "and we're trying to get a commercial publisher interested in reissuing them. They're fantastic seafaring adventure tales."

Busch is among those who believe Jack Calvin deserves a higher place on the marquee for his part in writing the book Ed Ricketts often gets total credit for producing. Busch is a coinvestigator on a project funded by the North Pacific Research Board, named for the title in question: "Between Pacific Tides: Revisiting Historical Surveys of Sitka Through Ricketts, Calvin and Ahlgren."¹⁹ It's a model citizen science project, providing multiple tiers for involvement, on the one hand delivering hard-core science and, on the other hand, in the words of Busch, "delving into the whole history, the whole time-and-place-andpersonality aspect from which scientific thinking emerges."

Jack Calvin was married to Sasha Kashevaroff, one of six daughters of a Russian Orthodox priest from Alaska. Sasha's sister Natalia, or Tal, married Ritchie Lovejoy, a local Monterey artist who contributed most of the original drawings for *Between Pacific Tides*. Calvin, Lovejoy, and the Kashevaroff sisters were, with Steinbeck, among Ricketts' closest friends. (Another Kashevaroff sister played a key role in his life as well, to be discussed anon.) The swirling overlap of friends, bylines, and expedition companions attests to the open-source, collaborative nature of Ricketts' relationships.

On the science side, the project established the historical survey sites where Ricketts and Calvin combed the tide pools at an important juncture in the development of *Between Pacific Tides*, which was an innovation in its day, since Ricketts organized his subject by where you find creatures in the various intertidal zones—he intuitively reflected Joseph Grinnell's nuanced

concept of the niche. Ricketts collected specimens in Sitka with Calvin and Campbell, and these now represent a baseline point of comparison with specimens documented from the same location, decades later. Today's Sitka project is structured to feed rigorously obtained data into a scientific database. "The Sitka people wanted to take some of Ricketts' and Calvin's old journal documenting what they had looked at, their classic intertidal surveys, and to do a comparative study between then and now," Pete Raimondi explained. "They asked if we were interested in re-setting up their sites." Raimondi was thrilled with the idea, partly because a rocky intertidal monitoring site in Sitka would appreciably extend the range of his Pacific coast monitoring program. With Miner and the Sitka folks, Raimondi set up resurveying sites in Sitka in 2011 and has monitored them every year since.

On the cultural side, the resurveying of Sitka has to do not just with tracking ocean changes and adding data points to the larger coastal project, but with deepening the appreciation of Sitka as a nexus of art, science, and history much in the way we appreciate Monterey. "Calvin and Ricketts made a seminal contribution to marine biology here," Busch told me, "but Sitka itself is not fully aware of its role in the history of science."

Calvin and his wife, Sasha, were frequent tide pool companions of Ricketts in Monterey, and Calvin especially encouraged Ricketts to integrate his collecting observations with scientific context and to publish a beachcomber's guide. Ricketts took up the idea and enlisted Calvin to help. What Ricketts wanted to produce though was vastly more ambitious in scope. Ricketts scholar Katharine Rodger told me that Calvin undoubtedly helped with the first drafts of the book. Ricketts was "ultimately an open-source kind of a guy, and freely turned his work over to other people." Rodger added, however, "The book was Ricketts'

INNOCENCE AND EXPERIENCE 299 THE EXPERIMENT © COPYRIGHT MATERIAL by design and organization. It was born out of his mind. Ricketts was the one thinking about ecological organization and the environment."

Calvin was a good writer, full of humor and unexpected detail. A 1933 *National Geographic Magazine* story about his and Sasha's honeymoon trip, "'Nakwasina' Goes North: A Man, a Woman, and a Pup Cruise from Tacoma to Juneau in a 17-Foot Canoe" is the stuff of today's Patagonia clothing company catalogs.²⁰ A central grist of the journey was the canoe itself: "She was never manufactured, that canoe; she was created . . . built with the painstaking care that goes into a fine violin." Jack, Sasha, and Kayo traversed one thousand miles by sail and by paddle, making their way up a coastline of lichen-like intricacy.

Among the Calvins' adventures were several attempts on the part of commercial fishermen to rescue them; when assured that the little family of travelers in their slender bark were in fact doing this on purpose, there was often "consternation aboard the gasboat; sometimes polite disbelief." Sometimes they paddled after dark, and in an episode that Calvin refers to as a "tragi-comedy," Kayo awakened them one night. Calvin writes: "I hauled an arm out of my warm sleeping bag and plunged it down into six inches of cold salt water. We were floating, except for our shoulders!" Hurriedly pulling themselves and their belongings onto land, in the dark they fell asleep on the closest hard, flat spot, to be awoken again by "two great moons, shining side by side," and a voice demanding why they were sleeping in the middle of the highway. Calvin left Monterey in 1932, eventually to found Alaska's oldest conservation group, the Sitka Conservation Society, which among other nature protections today enjoins citizen scientists to help monitor human impacts on the Tongass National Forest.

Stanford University Press contracted to publish *Between Pacific Tides* in 1936 but did not actually do so until 1939.

Contemporary scientists reviewing the manuscript objected to what we now recognize as its revolutionary approach in presenting species as inextricably associated with the places in which they are found. The book bore both Calvin's and Ricketts' bylines. Subsequent additions have added a panoply of contributing names including Steinbeck's, reflecting new edits, new forewords, all contributed by those eager, it would seem, to share a literary moment with Ricketts. Not only does a push-mepull-you ensue around the question of authorship of Between Pacific Tides, so does a corollary disputatiousness arise around the Ricketts-Steinbeck relationship. There are those who resent Steinbeck's portrayal of his friend in Cannery Row, basically finding it reduces him to a shallow sybarite, when the actual Ed Ricketts was pleasure-loving but also dead serious and seriously accomplished. Others take issue with the authorship of Sea of Cortez, though Steinbeck himself defended Ricketts' contribution. There's something compelling about owning a particular memory of a particular person: it restores to us our own personal past, otherwise to be washed away by the incoming tide.

Party Animal Aggregations

Monterey in the 1930s represented a special data point on the space-time continuum. John Steinbeck and his first wife, Carol, waited out the Depression in his father's cottage in Pacific Grove. In 1929, Jack Calvin was living in Carmel. Steinbeck and Calvin had known each other at Stanford and now reconnected.²¹ (Steinbeck never graduated from Stanford, but no one has ever held the lack of a degree against a novelist.) It was at one of his frequent dental visits that Steinbeck is reported to have met Ed Ricketts,²² though other accounts put the fateful meeting at Jack Calvin's house.²³ Carol described Calvin's house as "very friendly," a spirit that thrived in the general Depression-era poverty experienced

INNOCENCE AND EXPERIENCE 301 THE EXPERIMENT © COPYRIGHT MATERIAL by all. Carol recounted the simplicity of making a party at the time: "You would gather in a ring, sitting on the floor and drink a jug of wine." Carol also noted Ricketts' neatly trimmed beard and remembered him dancing around the fire at the Calvins'; she remarked that people took him for a "Christ-like father confessor," though her description summons more of a devil.²⁴

However they met, Steinbeck and Ricketts began one of the most famous of literary friendships; Ricketts was thirty-three and Steinbeck twenty-eight. They were something of an odd couple; the famously ornery Steinbeck seems to have been soothed by the warm, expansive Ricketts. In addition to the intertidal invertebrates, Ricketts focused on a broad array of enthusiasms, including music, poetry, literature, and philosophy. Steinbeck shared these interests and was also primed to talk biology.

Years later Steinbeck recalled being strongly influenced by the work of William Emerson Ritter, a major marine scientist whose ideas shaped the agenda at Stanford University's Hopkins Marine Station when Steinbeck took classes there in the early 1920s. Like Allee, Ritter emphasized a holistic view of ecology and extended his ideas into philosophy and social systems. Ritter articulated a superorganism idea, asserting that nature in all its separate parts and in its aggregate constitutes "one gigantic whole," the parts of which are "mutually constitutive of each other. Structurally, functionally, and generatively, they are reciprocals of one another."25 In the long dialog that was the Steinbeck-Ricketts friendship, the ideas of Allee and Ritter flowed continuously. Where contemporary science tends to slice and dice nature ever more finely to isolate what is going on in it, Allee and Ritter represent a time in the history of ecological thought when the impulse was more toward integration. Science has bounced back and forth between these dichotomous endpoints; hearkening to our theme, between

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data and lore. Steinbeck and Ricketts loved the lore, but in their own way, they wanted to base their stories on data.

In terms of the story structure Joseph Campbell would eventually articulate, Ricketts modeled the heroic figure in many Steinbeck novels, especially *Cannery Row* and *Sweet Thursday*, both of which featured "Doc" as the central wise character, standing apart but not uninvolved with the melee around him. *Cannery Row* and the man behind the simpler outline have inspired generations now of professional and amateur marine biologists. Steinbeck structured the novel as a series of vignettes that unfold concurrently, like detailed intertidal zones revealed at low tide. He imbued important characters in nearly all his books with the wise forbearance of his good friend. Jim Casy in *The Grapes of Wrath* utters the very Ricketts-like aphorism, "There ain't no sin and there ain't no virtue. There's just stuff people do."

As Ricketts devoted his daily attentions to the species organization in tidal pools, in the early 1930s Steinbeck found a similar coherence among people, which he called "the phalanx." Steinbeck's phalanx bears relationship to the collective unconscious as limned by Carl Jung, a shared memory of, in Steinbeck's words, "a time when the moon was close, when the tides were terrific." The individual does not have this memory, but the whole group of *Homo sapiens*, larger than the sum of its parts, does. "Religion is a phalanx emotion and this was so clearly understood by the church fathers that they said the holy ghost would come when *two or three were gathered together*. [Steinbeck's emphasis]" He described the differentiation of self from surroundings as "an emotion." Steinbeck scholar Susan Shillinglaw calls out this discernment of single and group man as a Steinbeck preoccupation, emerging in virtually everything he wrote.²⁶ Ricketts' own writings include two essays that attempt to penetrate biological thinking with a philosophical tincture, "The Philosophy of Breaking Through" and "Essay on Non-Teleological Thinking." Like Steinbeck, Ricketts yearned to describe an emergent quality, a "new thing growing synergistically out of component parts." Ricketts saw this new thing as transcending dualities of all kinds, "form and function, matter and energy, material and spiritual," in Ricketts' words, which are in the end vehicles purposed "toward an integrated growth."²⁷ Ricketts repeatedly invoked the holism of Allee and Ritter, explaining in 1940 that "the whole consists of the animal or the community in its environment, the notion of relation being significant."

Ricketts' worldview is also key to Steinbeck's ecological vision. Both Ricketts and Steinbeck sought a holistic comprehension of the natural world. Humans take a place in this integrated world but do not dominate or determine it. Our contemporary woes are orders of magnitude more dire than those they recognized, and this fundamental impulse to resize the human form on the landscape has become imperative.

Ricketts inspired passionate company while alive and now in retrospect. Katharine Rodger, who edited his letters and assorted other writing projects, laughed telling me that "most of us working on Ricketts are nut jobs. I am approached by so many people who are like..." She laughed again, her thought trailing off.

"Like a sketchy assortment from Cannery Row?" I asked.

"Exactly," she answered. Even for a generous reader not inclined to judge too harshly, Ricketts is hard to read. "I've talked to physicists and I've talked to philosophers, and it's pretty clear Ricketts did not really understand the 'unified field hypothesis' or non-teleological thinking," Rodger said. As Shillinglaw observed, Ricketts was looking to encapsulate his mode of looking "doubly open"—in his wide embrace, the objective, the non-objective, and everything in between, which he expansively called the "divine geometry."²⁸

Teleology describes the idea that there are final causes in nature that determine how things come to be. Darwin, for example, is the ultimate non-teleological thinker, since natural selection by definition does not have a goal. "I don't think his value is in scientifically quantifying these things," Rodger added. "He was about trying to figure life out. Without sounding corny, he was looking for the answer to the universe." He found hints in Bach, Whitman, and personal interactions. Although he described Ricketts' mind as "without horizons," Steinbeck also once commented that a part of Ricketts was "walled off." Accessible and inaccessible at the same time can indeed be a recipe for charisma, and this indistinctness may actually be at the heart of Ricketts' appeal. It also suggests an emotional dimension to his quest for "breaking through."

I do love this anecdote about Ricketts' response to a recital by John Cage at one of the Carmel parties. Cage arrived early because he "wanted to fix the piano," which entailed placing two large knives, a piece of wood, and empty tin cans among the strings inside it. The audience of classical music lovers expected something other than what they got, and reacted hard. "Older people looked bewildered, almost as if in agony. Younger people more familiar with jazz, however, seemed elated and on the verge of applauding." A classical music aficionado, Ricketts sat on the hearth, "his head in his hands." He did not declare yay or nay in the heated discussion that followed Cage's playing, but said, "What a future that boy must have to get a reaction of such intensity and magnitude."²⁹

Existential Forensics

Pacific Grove in the 1930s was something like East Hampton

INNOCENCE AND EXPERIENCE 305 THE EXPERIMENT © COPYRIGHT MATERIAL in the 1970s. The vibe was festive, with a higher purpose, and among the parties and the fun, lasting contributions were being created by foundational artists. One partygoer at Ricketts' lab remembers it as a place where the spirit was "'let's dig, let's find out'—a spirit which was in large part generated by the presence of Ed."³⁰ This communal coherence is something today's "Ed Heads" refer to with nostalgia and would like to re-create. I had forgotten that my own childhood was imbued with the same sort of heightened tone until it was grieved by the community at my father's wake.

"No food? No wine? No water?" I asked my mother, disbelieving, and wondering why anyone would want to come to such an event, when the day after it there would be a mass and then a reception that would furnish forth. "This is the way they do it," she whispered as I walked with her into the duskdarkened funeral home to make the macabre delivery of my father's favorite turtleneck in which he would take his final rest. I asked these questions again of the employee behind the desk. He shook his head and did not look me in the eye. Peering past him I watched someone else's wake going on. An old man's head reposed in an open coffin. About twenty people milled around talking to each other. Nobody had a glass or a plate. Okay, I get it, I thought. My father's wake will be attended by the most dutiful of friends, and then we'll see everyone else at church and at the party afterward.

The next evening my mother, my siblings, and I stood in front of the closed casket. The funeral home took up residence in a building near the house I'd grown up in on Pantigo Road. When getting dropped off at home by friends, I'd always guided them, "It's three houses past the medical center." Perhaps this was the very space where I'd stood getting my gashed thumb bandaged up, reciting letters on an eye chart, sticking out my tongue and saying "ah." Like pretty much every other square inch of East Hampton, the place had been completely made over into something it wasn't before. For years when I visited, I spent a lot of time squinting to reconvert the evidence of my eyes, miles of gigantic mega-mansions, back to the open fields of my youth. I disrobed the fancy window displays of Main Street to re-see the plain pharmacy and the homely newspaper store.

The past lived in my mind but it was not here anymore—as Thomas Wolfe put it, you can't go home again. I'd long given up feeling sorry for myself about it. People all over the world have been and are being disrupted from their homes and, comparatively, it was not a tragedy that East Hampton abandoned itself long ago. Watching the beauty go had been painful, but this place sat on a spit of land jutting into the Atlantic. A climate change-fueled hurricane was probably online for rearranging the real estate listings. Joseph Campbell did not include this dimension of the hero's journey in his schema. *Homo sapiens* are migrants and we often leave a place because we have to.

People started to arrive. Relatives from out of town. Friends from New York who had made the three-plus-hour drive. Neighbors. Despite the earnest hugs and the glassy eyes, it started to feel more like a wedding than a funeral. It seemed that not only everybody I knew, but everybody each of my siblings and my parents knew, waited patiently in what had now formed into a line. People I had not seen or frankly even thought of for decades materialized. Fishermen, artists, bankers, restaurateurs. The younger brother of one of my siblings' close friends had somehow turned into a middle-aged man who said, "Sorry for your loss. I had a big crush on you in high school." "I had no idea," I said, wondering if I should thank him, and was instantly transported back to the cinder-block walls of East Hampton High School. The image was jarringly deepened by the next in

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line. "Mr. Sarlo!" I exclaimed to our militaristic principal, who had not aged an iota past a few more gray hairs in his buzz cut. He told me to address him by his first name and I said, "Okay, Mr. Sarlo." The line started to extend beyond sight.

Eventually people were turned away; friends told me later about waiting for two hours and not getting in. I had no sense of an endpoint to the bodies coming through the door and snaking around the somber, shadowed room. It was a river of individuals bearing data points of memory. It was a map in reverse; the destination, the end of this life, had been attained, and we were reviewing how we got here. I was happy to see each of them, though the processional put me in mind of Dante's *Purgatorio*. Was my father beloved? It wasn't that—people had affection for him and his outsized personality. He represented East Hampton back in the day, the artsy, community-cohered enclave where farmers and poets steamed lobsters together on the beach. A time that was gone but, for this one moment, repossessed.

"Mary Ellen." Loudly, as if to geolocate me with his voice, Leif Hope presented himself with his daughter Nissa. A pair who had aged and yet not. Hope was a landscape and portrait artist who stood with the masculine assertion of his heyday, thumbs tucked into big fists absently awaiting the paintbrush. While famous writers, including John Steinbeck, contributed to the intellectual life of the Hamptons, the nature of the place was established by visual artists. In the late decades of the twentieth century, the ghost of Jackson Pollock yet presided, the paint-splattered floors of his house open for view. Pollock famously said his art was about the rhythms in nature. Many painters made and remade realities in the ocean-saturated light. Leif Hope had come to East Hampton in their footsteps; my father had come here in their footsteps. Here was Nissa, for whom I had babysat with her brother Erling, as pretty a fortysomething as she had been a child curled on the couch, and when she put her arms around me we were both back there, carrying the freight of childhood—as Rilke avers, the place beyond which is not the future.

Like the wildflowers carefully documented by Padre Juan Crespí as the Spanish approached Santa Cruz, these individuals swayed in the suns of memory. And yet here they were again, re-emerging to make one collective salute to everything each of us had gained and lost in the nearly fifty years my father lived in East Hampton, creating it all one more time. As John Steinbeck might put it, the phalanx produced something more than the sum of its parts. Ed Ricketts would have recognized a breaking-through. And Joseph Campbell would have said that the most important moment in a hero's life is his death.

The Boon

The party in Pacific Grove was in full swing when Joseph Campbell dropped into it. Sidelined by the Depression, Campbell drove across the country in a decidedly undirected way. Years away from recognizing his calling as world mythologizer, Campbell was assiduously working at becoming a fiction writer. Landing in Pacific Grove, he quickly met and hit it off with Steinbeck and Ricketts. The eclectic conversation on their first evening together covered religion, art, fireplaces, and Los Angeles. Campbell stayed up and listened while Steinbeck read to him from a novel he had been writing for five years, To a God Unknown. Steinbeck's second book explores a pagan connection between man and the land disrupted by Christian doctrine. This would be catnip for Campbell, who mused: "I had the curious feeling ... as I met Steinbeck and he walked towards me. I thought I was seeing myself."³¹ In Campbell's description, both men were "serious and sturdy," and were once mistaken for brothers.

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Campbell fell fast and easily into the rhythm at Pacific Grove. There was target shooting at Point Lobos and collecting trips to Santa Cruz. There were deep-into-the-night discussions of essential matters, let's-get-together-and-read-a-book parties. In a story that became a cornerstone of his own creation myth, Campbell confided to Ricketts that he was at an impasse. "I said to Ed, 'I've just been saying no to life." Ricketts advised getting drunk and mixed up a brew with laboratory alcohol. Campbell heartily embraced his initiation: "I was twenty-eight at the time and in perfect shape, and I dragged them all under the table ... until about two o'clock in the morning." One taste of the house brew quickly curtailed a police inspection of the scene. The evening included a foray to town to watch "a chap" in pursuit of the world's record for roller-skating on a flagpole, which is actually kind of hard to visualize. "It was my party to start me off in life!" Campbell exclaimed, and said Steinbeck wrote about it in Cannery Row.32 Campbell might have also recognized himself in Steinbeck's Sweet Thursday, which features Joe Elegant, a solipsistic cook laboring over a novel called The Pi Root of Oedipus. This stab at Campbell was not without cause.

Campbell came to Carmel ready to experience life, having studied it assiduously. The perspective he brought to Ricketts and Steinbeck was not yet fully baked, but the ingredients gathered and mixed; in a diary from his late teens he wrote: "It seems to me that God meant man to study science," repudiating those who "scorn science as a heresy and seek all their knowledge in the Bible," and concluding: "I do not doubt that Christ's miracles were many of them a perfect application of a perfect science."³³ He began college at Dartmouth studying biology, but transferred to Columbia, where he studied English literature.³⁴ Campbell flirted with the subject of anthropology, and listened in on lectures by Franz Boas at Barnard College next door.³⁵ Given that Campbell's life work would eventually focus on world mythology, emphasizing a common humanity across race and time, one wonders that he didn't stick with Boas and help launch American anthropology. Evidently he was meant to stand alone and not as part of a collaborative tradition.

Campbell went on to get a master's degree in medieval studies—and here is one of many affinities with Steinbeck. Over his lifetime, Campbell would round up basically every cultural tradition he could get his hands on to reveal the ubiquity of the hero's journey in the historical human psyche, but the Arthurian legend he focused on in his master's thesis most comfortably fit around his own broad shoulders. It also fit around Steinbeck's shoulders. Steinbeck's last major literary effort would be a retelling of the Camelot story, which he abandoned without finishing. Campbell had helped disrupt the marriage of John and Carol Steinbeck, acting the Lancelot role with King Arthur and Guinevere, almost as if playing to a mythic script.

Where Steinbeck's sensibility was nursed in the landscape of a particular place, California, Campbell's background was more cosmopolitan. His father was a salesman for an apparel company and did just fine until the Depression hit. The family valued education and traveled together as a matter of course. On a 1924 ocean crossing to England, Campbell found himself on board a steamship with a teenaged Jiddu Krishnamurti, who would go on to become a world teacher of individual fulfillment and transformation without organized religion. Campbell brought Krishnamurti's thinking into the Steinbeck-Ricketts circle, where it was highly influential. He later explained that Krishnamurti's teaching "had to do with integrating all the faculties and bringing them to center. He used the image of the chariot drawn by the three horses of mind, body and soul. This was exactly in my line."³⁶

INNOCENCE AND EXPERIENCE 311 THE EXPERIMENT © COPYRIGHT MATERIAL In a little tuck of the cosmic weave, Krishnamurti would later become friends with Robinson Jeffers, whom Campbell never met but whose poetry became an instrumental source for the group convened in Pacific Grove. The apotheosis of the questing friendship between the three men and Steinbeck's wife, Carol, came by way of Jeffers. Bursting into her house she exclaimed to the three men: "I've got the message of 'Roan Stallion'!" Each of them recognized in his own way that Carol had put her finger on exactly the problem of mankind and exactly its remedy as articulated in Jeffers' poem:

Humanity is the start of the race; I say Humanity is the mold to break away from, the crust to break through, the coal to break into fire The atom to be split.

Robinson Jeffers is the poet of "inhumanism," arguing that people need to uncenter themselves from the picture of life on earth and understand themselves as part of a teeming multitude of other living things, part of a natural world that existed before *Homo sapiens* and will exist after us. Jeffers' work is a focal point for the Dark Mountain Project, an amalgam of artists, writers, and activists in England who state that they have "stopped believing the stories our civilization tells itself. We see that the world is entering an age of ecological collapse... [and] that writing and art have a crucial role to play in coming to terms with this reality."³⁷

In "Roan Stallion," Jeffers echoes Herman Melville but subverts Ahab's dark directive about breaking through the mask of the visible world to kill the life force behind it. Jeffers finds affirmation where Melville locates destruction. It was Jeffers' version of the mask and not Melville's that would inform Campbell's *The Mask of God*: "Slit eyes in the mask; wild loves that leap over the walls of nature." There is something in Jeffers' poem for Steinbeck, too, who constituted the phalanx from, in his own words, "arrangements of atoms plus a mysterious principle."³⁸ The stallion itself, merged with mythic dimensions, is an explosion of beautiful life out of matter, and tragically sacrificed to human ego assertion, which is "the mold to break away from." Ricketts took the title of his essay "Breaking Through" from the poem. Campbell quoted it his whole life.

The Circle Is Broken

When later in life Campbell talked about this time, invariably he painted it in ecstatic terms. "We were all in heaven," he said. "The world had dropped out. We weren't the dropouts; the world was the dropout. We were in a halcyon situation, no movement. Just floating. Just great . . . So I'm coasting along, trying to find where I am. . . ." Campbell recalled experiencing kairos, the merging of the single moment in time with the all of it—the supreme moment. In a separate instance of explaining his own kind of flow experience, Campbell put it this way: "It was like a symphony, with everything coming from a single center that I was hearing and discovering."³⁹

The happy group was soon to break apart mainly due to what was perhaps a full-on affair or perhaps just a sweaty flirtation between Campbell and Carol Steinbeck. To the reader going along with Campbell's biography, this dalliance comes as something of a puzzle. Campbell was by many accounts fabulously good-looking, and women did toss themselves at him with regularity. He would seem to have mostly resisted. He managed long friendships with women who at certain points in their acquaintance would likely have been quite pleased with more from him. He was given to scrupulous behavior, not a casual betrayer. "We were all more or less in love with each other, I guess," Campbell wrote in his journal. "It was almost like a little fugue of loves."⁴⁰ There was a public scene in which Campbell and Carol made out rather at length outside a party, of course attended by everyone else in the gang, including Steinbeck, who watched for a moment then returned to the house "in disgust."

Long discussions and resolutions ensued, including several civil if fraught confrontations between Steinbeck and Campbell. These people were all young—Ricketts was the senior statesman at thirty-five. They were thrashing around together and figuring things out. Campbell had found himself the "experience" at the heart of art and of the hero's journey. Following the medieval script, now he would play Lancelot to Steinbeck's Arthur and declare his exalted love.

Campbell confessed to Steinbeck that his love for Carol was beyond physical desire. "Maybe you are in love with an idea that isn't Carol at all," Steinbeck replied. And so they talked, and drank coffee. According to Shillinglaw, Steinbeck breached the impasse, in June 1932 ordering Campbell "out of town at the point of a gun–literally."⁴¹

Ricketts was in his own hot water at the time, and was attempting to disentangle himself from an ill-advised affair with the seventeen-year-old Xenia Kashevaroff, sister of Tal Lovejoy and Sasha Calvin.⁴² (Further cultural currents burbling here—Xenia became a nude model for the photographer Edward Weston and was long married to, and then divorced from, the musician John Cage. Cage wound up with Merce Cunningham.) Ricketts was about to embark on a collecting trip to Alaska with Jack and Sasha Calvin aboard the thirty-three-foot *Grampus*, a former navy launch, and the idea came up for Campbell to go along. After all these theatrics, it was time to address the reality of the tide pools again. And get out of town.

Decades later Campbell reminisced about the trip. "We would go out in a little canoe that Jack had, and every time there'd be a good low tide place to gather them, we were gathering *Gonionemus*. It was a beautiful trip.... Nobody had any money.... For the four of us it was twenty-five cents a day on that boat, including the gasoline."43 When they arrived in Sitka, "the dock stank like fish and they could see the green cupola of St. Michael's Russian Orthodox Cathedral from the harbor." They spent almost three weeks "canoeing, reading, listening to Stravinsky, snapping photographs and taking long walks" through a park of Northwest Coast Native totem poles.⁴⁴ Ricketts typed up his collecting reports and Campbell read Dostoyevsky. They talked into the night. Calvin and Ricketts worked on Between Pacific Tides, and Campbell intermittently proofread it, "chiefly correcting the grammar," which did not endear him to Calvin.45 In these ten weeks, Campbell's nascent ideas were more deeply imbued with biological dimensions. And while the hero's journey has plenty of other historical influences, in its outlines can be discerned Ed Ricketts' major preoccupation with his concept of "breaking through."

Ricketts was never terribly clear about what that meant, and in a sense, Campbell defined it for him. In Campbell's interpretation, biologically founded myths are the "masks of God" through which men everywhere have sought to relate themselves to the wonders of existence. So Campbell might have explained to me as a child that although eating the host to experience Jesus is, yes, a myth, that's its strength, not a weakness. The ritual is an entry point to transcendence, from which opening is revealed the accessibility of the supernatural through every object everywhere. "The mystery of life and consciousness pours in through the various bodies and beings round about. It must then show you yourself that you are similarly transparent to transcendence."⁴⁶

The connections between biology and spirituality are right there in the tide pool: "All those strange forms," Campbell said, "cormorants and little worms of different kinds and all. You'd hear, my gosh, this generation of life was a battle going on, life consuming life, everything learning how to eat the other one, the whole mystery, and then from there they crawl up on the land. And also in the mythic themes generally out of the ocean, or what in India is called the milky ocean out of which the whole universe comes."⁴⁷ Campbell described myth naturally issuing forth: "the full mystery of the teeming life of the earth is contained within the egg of a flea," a "production of the living psyche."⁴⁸

Regeneration

The Great Depression was a time for young men to drift and dream, and for their fathers to lose businesses. Campbell's West Coast adventure was curtailed by a telegram announcing this fate had befallen his family back East. Campbell had contributed greatly to the creative ferment of Pacific Grove. Shillinglaw calls the time he intersected with Steinbeck and Ricketts "the generative time, perhaps the *annus mirabilis*" for all of them.⁴⁹ But Campbell had also disrupted the ecosystem. Upon his departure, relationships recalibrated and proceeded apace. Campbell would work on fiction writing for years before gradually becoming the sage and seer of world mythology.

In contrast, Steinbeck was on a long roll, producing a novel a year–a partial list includes *Tortilla Flat* in 1935 and *In Dubious Battle* in 1936. In a five-month creative marathon beginning in May 1938, he birthed *The Grapes of Wrath* and collapsed at Ricketts' door basically upon completion. This novel vies with 1952's *East of Eden* as his greatest accomplishment. From the perspective of land use, climate change, and the social inequities of our great democracy, the creative insights of *The Grapes of Wrath* continue to resonate. This big novel neatly encapsulates the consequences of human dissociation from the land, leading to destruction of that land, and then to the destruction of humanity itself—a theme that is playing out, big time, today.

The Grapes of Wrath changed Steinbeck's life. He was roundly praised and roundly reviled for the work; the whole thing exhausted him. Those who loved the book called his vision of social justice revolutionary; those who hated it focused on the same theme and called it cardboard. He was accused of communism and stalked by the FBI. It was a huge best seller yet distasteful to perhaps the most influential critic then opining in the United States. Writing in the New Republic, Edmund Wilson called out Steinbeck's characterization of man in animal terms. "This animalizing tendency of Mr. Steinbeck's is, I believe, at the bottom of his relative unsuccess at representing human beings."⁵⁰ Wilson would perhaps revise his opinion today given what we know now about the realities of the Anthropocene. Homo sapiens has entered a new phase of our reality as "group man," and many people would say humans make other animals look downright civilized by comparison.

Plenty of other pressures had piled up on both Steinbeck and Ricketts, making the idea of an expedition to a beautiful place very attractive indeed. Steinbeck's wife Carol had held his hand through the intense process of writing *The Grapes of Wrath*. She typed the manuscript—no small feat—and came up with the title, but things between them were deteriorating. Ricketts' marriage, such as it was, had reached a definitive impasse and he was once again prepared to flee romantic fallout. As much as it was a voyage of discovery, the trip was also meant to heal hearts and minds. And to get out of Dodge.

Steinbeck declared he was done with fiction and that the "new thinking" was the study of science. He accumulated pages for a planned but never-finished marine guide to San Francisco Bay under the guidance of Ricketts. This ambition was replaced with the idea of a collecting expedition around the Gulf of California (also known as the Sea of Cortez). The unique and rich waters surrounding the Baja California Peninsula had not yet received major scientific attention, and the specimens Steinbeck and Ricketts collected remain important vouchers in use by scientists to this day.⁵¹ Half their specimens were new to science, not yet named or described, or were collected significantly outside their known ranges. At Steinbeck's suggestion, the trip was conceived as a literary as well as a scientific enterprise. Putting a proposition to Ricketts, he said, "We'll do a book about it that'll more than pay the expenses of the trip."⁵²

The physical voyage officially commenced on March 11, 1940, with John and Carol Steinbeck, Ricketts, and a four-man crew aboard the *Western Flyer*, a seventy-six-foot sardine purse seiner. A party atmosphere attended the launch and the *Monterey Peninsula Herald* reported on it. From Monterey they headed to San Diego, then made their way down the peninsula to Cabo San Lucas at the southern tip (arriving at Cabo on March 17). The *Western Flyer* then proceeded up the peninsula, inside the gulf, steaming as far north as Bahía de Los Ángeles before crossing to the east side of the gulf, and then south for the return to Cabo San Lucas. The expedition completed its tracery on April 18, docking once again in San Diego.

Sea of Cortez: A Leisurely Journal of Travel and Research was published in 1941. Comprising a narrative of the journey and a species list, it ran to six hundred pages. Steinbeck's editor, Pat Covici, suggested the work be attributed thusly: "By John Steinbeck. With a scientific appendix containing materials for a source-book on the marine animals of the Panamic Faunal Province, by Edward F. Ricketts."⁵³ This did not go over. Steinbeck hotly insisted that the book was wholly the product of both men, and it was copyrighted to reflect dual authorship. Steinbeck had done the actual writing of the book, based mostly on a journal kept by Ricketts; as the authors clarified for Covici, "In one case a large section was lifted verbatim from other unpublished work." What has become known as the "Easter Sunday Sermon" in *Sea of Cortez* is Ricketts' essay on non-teleological thinking, the conclusion of which states the intention of book and journey: "This little trip of ours was becoming a thing and a dual thing."⁵⁴

The Toto Picture

From the logs of Gaspar de Portolá to those of Captain James Cook and Lewis and Clark, the expedition journal has become an important category bridging history and literature. These accounts inventory the past when it was a present. They are the testimony of the eyewitness. Studded like precious gems in the narratives are corrective visions of what constitutes a place that inform how we see that place today. While Alexander von Humboldt and Charles Darwin shaped their travel narratives to literary ends, they did not venture onto their journeys for expressly artistic purposes, which Steinbeck and Ricketts in part did. In going on the trip and in writing the book, they sought to fuse existing forms into something new, a narrative that did not just document observations from A to B and back again, but provide an experience in itself, a "breaking through."

To write this book, Steinbeck declares in the introduction, "we have decided to let it form itself: its boundaries a boat and a sea; its duration a six weeks' charter time; its subject everything we could see and think and even imagine." Their avowed purpose was to locate, observe, count, and collect marine invertebrates, "and when we used this reason, we called the trip an expedition." This was only part of the truth, he admits, because the main reason they undertook the trip was that they were curious. Steinbeck's narrative mode is to repeatedly reach out for the grand, then to reveal that what he actually has in his hand is a modest thing. In this way *Sea of Cortez* is paradoxically something of an anti-expedition narrative, since its authors never take a dominating or appropriating stance toward the territory they traverse, but rather integrate observations from an essentially receptive position.

Invoking among others Linnaeus and Darwin, Steinbeck said that as they did, he would build a structure "in modeled imitation of the observed reality." The Systema Naturae and the theory of evolution by way of natural selection are rather daunting models. Steinbeck and Ricketts philosophize, opine, and reflect, and as promised, repeatedly return their attention to what Ricketts called "the good, kind sane little animals."55 As they strive after pattern recognition, the going out of thoughts and the pulling in of direct observation convey a tidal rhythm in the text. The "moon-pull" is implicitly mimicked and explicitly assigned to all manner of phenomena. Steinbeck wonders if the same tidal force that incites the gametes of polychaete worms to explode may mysteriously cause the Old Man and the Sea to rise before fishermen "in the pathways of their boats." The vision may not be a hallucination but an experience joining "past and present" through a rhythm that pulses in both the physiology of creatures and the symbols of the mind. Near the end of the text, Steinbeck concludes, "The laws of thought seemed really one with the laws of things."56

Joseph Campbell understood immediately what they were trying to do, writing to Ricketts, "I think that the book form discovered by you and John is perhaps as close to the life-form itself as [a] book could possibly be to life."⁵⁷ He told Ricketts, "During the past six months the world of the myths has been revealing to me those simple, wonderful forms that underlie and sustain the bewildering pell-mell." He promised to send some papers on the subject in a few years, "written in the jargon of another science."⁵⁸ The result almost a decade later was *The Hero with a Thousand Faces*. It would provide another structure for discerning the pattern of "observed reality." And in some ways it would more fully articulate the yearned-after sense-making of *Sea of Cortez*.

In 1951, at Pat Covici's urging, the book was reissued without the species catalog and retitled The Log from the Sea of Cortez, by John Steinbeck. Things had changed in the ten years since the book was first published. Steinbeck had moved to New York. Early in the evening of May 8, 1948, Ed Ricketts had headed out of his lab to get dinner fixings and, crossing railroad tracks in his car, was blindsided by the Del Monte Express. He died three days later. Steinbeck chronicled his grief and his friendship in "About Ed Ricketts," an essay that is presented as an appendix to the Log. Various Ed Heads who carried and still carry the Ricketts flame look upon this essay as a betrayal, finding "About Ed Ricketts" an inadequate portrait of the man and the severed Log a suspicious maneuver to give the best-selling Steinbeck full authorship and so boost sales of the book. Others admit that the story is complicated. Shillinglaw pointed out to me that the species catalog was unwieldy, after all, and that Ricketts always insisted Steinbeck had done nearly all the writing. Steinbeck "thought that with Ricketts's death, it was a different project," and had become explicitly about their friendship.

Three Cases of the Ricketts

"You are one of those Ed Ricketts nuts?" I asked Richard Brusca, who just doesn't fit the funky mold of the tribe at all. Unless you count besotted devotion to his wife, Wendy Moore, who is a professor of entomology at the University of Arizona, Brusca is very un-nut-like. "You are a drill-down evolutionary biologist in the traditional mode, Rick!" He laughed. Guilty as charged. Now executive director emeritus of the Arizona-Sonora Desert Museum, since his official retirement Brusca has been putting in more than full days at his desk. He has been turning out, among other things, peer-reviewed papers, including one on plant species moving in response to climate change; a natural history guide to the sky island region, mostly in Arizona (Moore coauthored); and most recently a third edition of his best-selling college textbook Invertebrates, which has been in print since 1990 (in four languages). I have stayed at the Brusca-Moore household and witnessed him at work-you can practically discern phyla, genera, and species thought balloons above his head.

"I grew up with marine biology," Brusca told me. "I taught with Joel Hedgpeth and we became lasting friends." Hedgpeth being the iconoclastic but also traditionally academic marine biologist who edited several editions of Ricketts' *Between Pacific Tides* as well as more Ricketts prose in *The Outer Shores*. (Hedgpeth was among those who felt Steinbeck did not give Ricketts his scientific due.) "I grew up imbued with a sense of Ricketts. I was embroiled with people who had known him and were still working-they were in their sixties. We all just referred to him as Ed." Listening to Brusca, I got the sense, as Faulkner surmised, that the past isn't even past. "Ricketts was at that interface between citizen scientist and real scientist-and by the time he died he was so respected. He codified the now universally accepted concept of intertidal zonation and was far ahead of his time."

Brusca is among those who have retraced the 1940 route of the Western Flyer. In 1972, Brusca and J. Laurens Barnard of the Smithsonian Institution visited the twenty-three field sites where Steinbeck and Ricketts collected, over a period of seven weeks (Steinbeck and Ricketts took six weeks). Eventually Brusca paid Ricketts forward, producing what Hedgpeth praised as the "monumental 1980 vade mecum, Common Intertidal Invertebrates of the Gulf of California."59 Brusca told me that Ricketts' and Steinbeck's collections were "not quantitative, empirical, or replicable in a scientific sense. Ed and friends went out when the tide was low." This means they did not geolocate areas of inquiry or develop a line of thinking along which they collected. "It was an expedition of discovery at the time, which was needed, but nothing was done in a quantitative way." Brusca has completely cataloged all their specimens from the Sea of Cortez expedition and these number about five hundred species. As a second-generation Ed Head and, yes, drill-down evolutionary biologist, Brusca brought Ricketts' work into a more organized and quantitative form.

A Serious Lark

Nailing down the who, the what, and the where is the directive of the scientific inventory but of course Steinbeck and Ricketts were up to something more. Stanford University biology professor William Gilly has long taught a course in "holistic biology," defined broadly along the lines of the "toto picture" aspired to by his gurus. "We use marine ecology as a vehicle for exploring complicated problems in the real world, like anthropogenic change, social human interactions—how all systems are coupled," Gilly told me. "It is based very much on *The Sea of Cortez*—that's our bible. It includes a lot of important philosophy about how things work, and something that is obvious but not taught very much to students: the natural world includes people."

In 2004 Gilly organized an expedition expressly to follow the example of Ricketts and Steinbeck. He teamed up with Jon Christensen, today a professor at UCLA and the editor of *Boom: A Journal of California*. Both a journalist and historian, Christensen was well equipped to amplify the trip's literary dimensions and told me it was "a serious lark."

In a kind of "everybody onto the boat" spirit, Gilly invited Katharine Rodger to join the expedition for a part of it and she brought along her mentor, Susan Shillinglaw. Falling in love on the journey, today Shillinglaw and Gilly are married, and Shillinglaw co-teaches the holistic biology class at Stanford. Gilly, Christensen, and a core of other seekers set out to methodically revisit fifteen of the original field sites, and they added fifteen others. "After studying these thirty sites by laying out transects and counting every visible organism in regularly spaced halfmeter square quadrats, I am mostly tired but still curious to decipher the changes," writes Gilly in a journal-style article after the expedition. Eventually Gilly would inventory more than six hundred quadrats with the intention of setting a baseline for future studies. "So much depends on your point of view and a commitment to keep looking." The physical changes are pretty much uniformly dispiriting and include a drastic reduction in the abundance of most species, and a huge increase in development, as in Cabo San Lucas, which Gilly calls "the adult Disneyland of Baja." He adds, "No habitat means no animals to count." The richest location in 1940, a harbor at Puerto Escondido, is today "half concrete."60

Documenting evident range changes in giant squid, far more abundant now than observed by Steinbeck and Ricketts, Gilly addresses the seeker's discovery–which is not necessarily to repeat precise observations but to see anew for oneself. "To be alone in search of squid, and to have found it all, seemingly in the real Rickettsian holistic sense, has made some of us feel so much closer to the original spirit of the 1940 trip," he writes. "At this point we are just following our own course and seeing with fresh, new eyes. This vision that comes with escape is why I wanted to undertake the whole trip in the first place and was all I ever really hoped for."⁶¹

Gilly has gone back and continues to go back. He's involved in citizen science efforts to monitor the Santa Rosalía coast of Baja, which he says is "spectacular and undeveloped—like it was in the 1940s." This is part of Mexico's biggest protected area, but unless there are baseline inventories of what lives there, it will be impossible to keep protecting them. He has also helped set up intertidal transects and surveys for monitoring the impacts of a gigantic mining operation in Santa Rosalía. Here, if you build it, invertebrates will come, and have already availed themselves of new habitat created by boulders mined from the mountains and dumped in the water. A pier under construction had so many lobsters congregating around it the locals started to sneak in to fish them. Discussions are underway to simply create another artificial reef outside the mining area so that the locals don't have to trespass to get to the lobsters.

Wish You Were Here

One sojourner along for some of the Gilly-Christensen voyage was Rafe Sagarin, a young biologist mentored by Brusca and others. Sagarin personified the third generation of Ed Head scientists along on the expedition. Not so many years later, Sagarin was hit and killed by a drunk driver while riding his bike in Tucson, Arizona, in early 2015. He was forty-three.

"We were in a café near the Burma border in Thailand, where

we were collecting insects, and Wendy was checking her email," Brusca told me. "She told me I'd better sit down, she had bad news. It took me several days to absorb it. I still haven't really absorbed it." Brusca described Sagarin to me as an effervescent, outside-the-box thinker and dreamer. "Some might call him a dilettante, but he didn't allow himself to be constrained by the way university politics work today. You have to have a big body of research in a very specific topical area so that you are a world expert in that field—but he was just too broad for that." His job at the University of Arizona's Biosphere 2 was not your traditional academic gig.

Sagarin was the author, with Aníbal Pauchard, of *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World*.⁶² "This book," the authors declare, "is dedicated to the goal of recovering a respect for excellent observations of nature." Sagarin and Pauchard discuss the contributions and benefits conferred by citizen science, and they are strongly in favor of it. As they put it: "The simplicity of going out into nature and counting, measuring, watching, and recording opens ecology to a non-elite, nonprofessional world where people who don't spend their lives as ecologists can nonetheless contribute to ecological science" and can then disseminate their ideas "into other endeavors, like politics and art."

Sagarin and Pauchard argue that the hypothesis-driven, experimental methods of most peer-reviewed science have serious limitations, especially when dealing with ecosystems, which are complex, confusing, and involve nonlinear interactions across multiple scales. Their book restlessly challenges academic science for plucking observations of nature out of context and analyzing them with technology and according to abstract models. Hypothesis-driven science in general relies on what biophysicist John R. Platt termed *strong inference*, or a yes/ no, reject/do-not-reject testing of one hypothesis against another until the most plausible one stands. Sagarin and Pauchard contend that this method "relies on testing a continually dividing tree of binary hypotheses, but many ecological phenomena occur across a continuum." To grapple with the multiple scales of time and space at play in nature requires first and foremost "a straightforward call to simply look at the data." Their book advocates for a more "toto picture" approach based on observation.

At his death, Sagarin had a paper near publication, which Brusca is a coauthor on, about "mesocosms."63 As Brusca explained it, "In the experimental world, there are three levels. The tightly controlled chamber in your lab is one. Another is the real world." Brusca's real-world example is his recent botany paper on the Santa Catalina Mountains in Arizona, in which he shows plant species moving significantly upslope in recent decades, tracked right alongside climate change data. Brusca was able to do this analysis because sixty years ago, seminal ecologist Robert Whittaker inventoried the same mountain range, and Brusca could compare what he found with what Whittaker found. Whittaker's documentation was not as precise as would be required today, but Brusca could still geolocate his observations with general accuracy and go to the same spots. Historic data sets like Whittaker's are in very short supply, and creating them to capture life as we find it today, and constantly updating them to track changes, is a main imperative of citizen science.

"But the third scale," Brusca explained, "is between the microcosm in the lab and the macrocosm in the world, and this was Rafe's idea. To create a mesocosm of the Gulf of California right here at Biosphere 2." Biosphere 2 is a domed construction outside Tucson that is now owned and used for scientific research by the University of Arizona. It was originally constructed between 1987 and 1991 as a self-enclosed system replicating earth's biomes; the experiment was basically to see if such a thing could be done. In sum, it could not, at least at the time. Based on what has been learned from the original experiment, the idea remains feasible. And some nifty research occurs on site. "Rafe's idea was to turn the ocean element mesocosm into the Sea of Cortez." This is an ambition of which no doubt Steinbeck and Ricketts would approve: the mesocosm benefits from the focus of a lab yet allows for the large-scale dynamism of nature unfolding on its own terms. Though at this point in his projected plans he hadn't articulated how he envisioned it to work, Sagarin's ambition for the Sea of Cortez mesocosm included citizen science or, in his terminology, "public participation in science."

Rafe Sagarin went more than once to the Gulf of California in the spirit of Steinbeck and Ricketts. Writing about a trip with students conducted a few years earlier, he noted, "I wanted us to go 'doubly open,"⁶⁴ as Steinbeck and Ricketts declared they were doing. Sagarin's "doubly open" entailed "a whole spectrum of observation between the coldly scientific and the deeply experiential poles that Steinbeck and Ricketts staked out." He wrote, "I've come to see science as a shifting, evolving thing," not calibrated upon "astounding discoveries" but rather occurring "holistically in system-wide modifications of simple, ancient processes... driven by observation."

The Art of Not Science

"Why are you calling Ed Ricketts a 'citizen scientist'?" is something I have been asked frequently by myriad filmmakers, writers, and other artsy types who are among Ricketts' followers today. "He was a real scientist. It was his job." Actually, "real" scientists, even when they are Ricketts fans, don't give him the title. "Not a scientist," Pete Raimondi told me about Ricketts, even while admitting he pursued his own vocation as a marine biologist partly because of Ricketts' example. "He was a collector." Even Ricketts' conceptual organization of the tide pool, credited though it is as an important ecological contribution, blurs the line between observational and quantifiable knowledge. Tide pool zonation, the sorting of different creatures into their various niches, has overlaps, exceptions, complexities.

Why is Ricketts so important to you all, then, I asked Rick Brusca, if he didn't do real science? Brusca quoted me oftrepeated Steinbeck: "It is advisable to look from the tide pool to the stars and then back to the tide pool again." Then he explained, "Sometimes scientists have the urge to connect to the universe. When you read Steinbeck and Ricketts, that's what they talked about all the time. They have become gurus in some context we unconsciously relate to and follow in some way– which is why the quote is repeated so often. It encapsulates the wanderlust most scientists have, but we get wrapped up in the minutiae and the statistics, and we forget it. Then you are sitting by a campfire and looking up at the stars and you feel it!"

Brusca told me that one of his most significant scientific contributions came about by way of a more observational approach à la Ricketts. His example also explains, if you have been scratching your head about it, how a marine biologist came to be boss of a museum in the desert. Part of the answer is that he loves both environments, and another part of the answer is that the two go together. "It dawned on me that the Sonoran Desert is the way it is because of the Sea of Cortez–all our summer monsoon rain is from the gulf, and that's what gives us our incredible diversity here. The big picture is that we get a huge transfer of heat and water from the gulf–down to the carbon made by seabirds from the gulf that leave feces and corpses here." Brusca figured this out in an intuitive way; he said it "dawned on" him.

INNOCENCE AND EXPERIENCE 329 THE EXPERIMENT © COPYRIGHT MATERIAL He coined the now commonly used term *maritime desert*. "If you are a real observer," Brusca said, "you look at more than one thing at a time and at different scales at a time. But if you want to get a paper published, you'd better translate all that into analyzed statistics."

Sagarin put it similarly, reflecting that at the end of the trip with students, "I got to thinking about the long chains of observations, and scientific knowledge, and the links that are forged" between students and teachers and between historical figures and those who read and follow the work they left behind. Again by the campfire, both real and proverbial, Sagarin said, "we... listened to the waves crashing on the rocks and watched the flickering embers rising to meet the flickering stars, and I thought how everyone's favorite moment had become my favorite moment, too. So in that moment I was finally taken to that place that existed only on paper when we started the trip, a place mapped out in prose by Ed Ricketts and John Steinbeck on one of their own leisurely journeys of travel and research." Sagarin was breaking through to Ricketts, and vice versa. And having put a distinctive marker of his own on what it means to journey to the Sea of Cortez, perhaps Sagarin can be invoked as Ricketts is when subsequent seekers follow. I think "citizen scientist" is a compliment Ricketts would gladly accept. Scientist in general refers to a man or woman alone, and *citizen* is communal-not only as one member among many in one place and time, but across those boundaries as well.

READING GROUP GUIDE

Citizen science is in many ways a form of observation, but it's also a way to include ourselves in the stories we tell about nature. "Here is I," Hannibal writes, toward the beginning of her own quest to better understand her place in nature—not only in space, but in time. The questions below offer different ways to explore how citizen science affects the way we think about and interact with the world around us, and how it encompasses much more than data collection.

CHAPTER 1: After Hannibal helps pry a sea star off her fellow citizen scientist's hand, she remarks: "Neither of us could have known it at the time, but it was possible she would never again have the opportunity to observe a giant sea star in its lair." To be a citizen scientist is to confront loss, but it's also a way to more intimately experience all the species there are left to count. Overall, do you find Hannibal's experiences with citizen science reason for hope or despair? Why?

CHAPTER 2: To what extent is *Citizen Scientist* a California story? How is it a story without borders? In what ways does geography play a role in the book?

CHAPTER 3: With trophic cascades in mind, do you think it makes the most sense to say nature works from the bottom of the food chain up, the top down, or from the middle?

Considering the example of the Amah Mutsun, do you think Western science can be integrated with traditional ecological knowledge? Who benefits, and how?

CHAPTER 4: In the spirit of citizen science's actionability, plan a citizen science expedition yourself. For example, you could count up a single species of plant or animal in a nearby park. Do you see patterns from one open space to another? Did your expedition change the way you feel about the place you chose to explore? Do you find yourself responding to citizen science in ways similar to Hannibal? In different ways? **CHAPTERS 5 AND 6**: Browsing Google Earth Outreach and ESRI Story Maps, consider how various kinds of information are being combined to tell new stories about nature. What would a map of your own story of origin look like—where your ancestors are from, and how you came to live where and in the manner you do? How would such a map help tell your family stories about what happened to each family member, where, and when?

CHAPTER 7: Natural history museums were founded mostly by amateurs such as Alice Eastwood. How does Eastwood's story affect the way you think about citizen science? In what ways do you think her legacy lives on?

CHAPTER 8: Darwin predicted that species evolve in close relationship with one another, but this wasn't proved until the 1960s. Explain how plants and pollinators depend on each other, and how their interactions are being disrupted by climate change and habitat loss.

CHAPTER 9: Do you think it's fair to call John Steinbeck, Ed Ricketts, and Joseph Campbell citizen scientists, as Hannibal does? Why or why not? Is it fair to consider storytelling, in some cases, a kind of "science"? What do you think Campbell meant when he said that myth is "nature talking"? And how would you interpret Steinbeck's advice to "to look from the tide pool to the stars and then back to the tide pool again."

CHAPTER 10: Do you think that, with the help of citizen science, we might eventually succeed in protecting "nature's half," which E. O. Wilson says is necessary for healthy ecosystem functioning? Why or why not? What do you consider the most promising aspects of citizen science? What do you fear might be problems or shortcomings?

CHAPTER 11: Through both her father's death and her experiences with citizen science, Hannibal begins to reevaluate how she understands the word *generation* and her and other species' roles in the cycle of life. Do you feel differently, after reading this book, about how you relate to other living things past, present, and future? If so, how?

A SAN FRANCISCO CHRONICLE BEST BOOK OF 2016: "Intelligent and impassioned, *Citizen Scientist* is essential reading for anyone interested in the natural world."

ward-winning writer Mary Ellen Hannibal has long reported on scientists' efforts to protect vanishing species, but it was only through citizen science that she found she could take action herself. As she wades into tide pools, spots hawks, and scours mountains, she discovers the power of the heroic volunteers who are helping scientists measure—and even slow—today's unprecedented mass extinction. Citizen science may be the future of large-scale field research—and our planet's last, best hope.

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