Ujelang Atoll, 1964. The US conducted more than eighty nuclear weapons tests on and around Bikini and Enewetak atolls between 1946 and 1958. Bikinians were relocated first to Rongerik Atoll in 1946 and later to Kwajalein, Kili ,and Jaluit. The people of Enewetak were relocatedto Ujelang in 1947. Photo Robert C. Kiste. Courtesy University of Hawaii-Manoa Library.

LORDS OF THE RING

ALISTAIR SPONSEL

Atom by atom thus the burthen grew,
Even like an infant in the womb, till Time
Deliver´d ocean of that monstrous birth,
—A coral island

—James Montgomery, "The Pelican Island" (1827)[1]

Of all the newly discovered wonders of the tropical Pacific, none seemed more far-fetched to early-modern Europeans than a peculiar form of island that barely stood above the sea. These low, ring-shaped landforms appeared to be nothing more than graceful arcs of sand wrapped around shimmering lagoons. For the French circumnavigator Louis-Antoine de Bougainville, the cluster of these low islands east of Tahiti was a landscape of contradictions. He called it *l´Archipel Dangereux*, not out of concern for the inhabitants of "these strips of land that a hurricane could bury at any moment beneath the water," but because those inconspicuous shoals posed a terrific danger to any unsuspecting ship that might be skimming across the Pacific in low light or poor weather. The ring-like form of these islands was so improbable as to demand some sort of explanation, yet they seemed so vulnerable that perhaps the appropriate story would be an elegy rather than a tale of origin. Bougainville, who returned home to convince many of his countrymen that the permissive Tahitians had escaped the fall of man on their mountainous Eden, asked rhetorically of the "almost drowned" low islands, "Is this extraordinary land rising, or is it in ruins?"[2]

Might it be that these low islands possessed a vital force that could resist the eternal swell of the Great Ocean? Johann Reinhold Forster thought so. A notoriously contrarian Scots-Prussian polymath, Forster published an English translation of Bougainville's *Voyage autour du monde* in 1772, complete with antagonistic annotations.[3] That same year, he set sail for the Pacific himself as the naturalist on Captain Cook's voyage in search of a southern continent. During Cook's great probing traverses of the Pacific, Forster saw low islands

both familiar and unknown to Bougainville and became convinced that these lagoon-encircling islands had in fact arisen providentially from the depths of the ocean.

Forster claimed that whereas high islands like Tahiti had been produced by the action of "subterraneous fire" (volcanism), these so-called low islands had been produced by the labor of living creatures. He recognized that the visible substance of the low islands was "coral rock," the fossilized remains of stony, plant-like animals that formed marvelously colorful vegetation on submerged rocks throughout the tropics. Forster's inspired suggestion was that these islands were *nothing but coral*, not just at the surface but all the way down. As insignificant as they seemed from above the water, the low islands were prodigious structures. They stood as far away from any continent as it was possible to get on earth, and even within a few hundred yards of one the ocean was inevitably so deep that the longest rope aboard ship dropped without ever reaching the bottom. Yet these animated islands could never project themselves above the top of the waves; as Forster said, they were "a production of the sea, or rather its inhabitants." And they owed their ring-like shape to nothing less than the collective will of countless tiny beings. "The animalcules forming these reefs," he explained, "want to shelter their habitation from the impetuosity of the winds, and the power and rage of the ocean. By instinct, [they] endeavour to stretch only a ledge, within which is a lagoon, which is certainly entirely screened against the power of both [the ocean and the wind]."[4]

Illustration of Pouynipéte, or Seniavine, atoll. From Charles Darwin, *The Structure and Distribution of Coral Reefs*, 1842.

Thanks to Forster, the first decades of the nineteenth century were an age of corals. The testimony of other South Sea travelers who had read of his theory inspired even greater wonder at the determination and industry of these mysterious animals. The British navigator Matthew Flinders revealed that it was corals, with their "instinctive foresight," who had built the great barrier to Australia's northeast coast, while François Péron, the naturalist who accompanied Flinders's French counterpart Nicolas Baudin, reported that great mountains of fossil coral had been elevated from the sea to form the craggy landscape of the East Indies. Poets and geologists alike began to view corals as agents of secular renewal who could compensate for the erosion that was decaying the earth's continental landmasses. (James Montgomery, quoted in the epigraph, shuddered, "Hence what Omnipotence alone could do / Worms did."[5]) But this was itself cause for thoughtful concern. Might corals flourish so successfully throughout the world's equatorial oceans, wondered the French zoologist J. V. F. Lamouroux, as eventually to form a girdle of reefs that blocked navigation between the northern and southern hemispheres altogether? Could their dogged advance ever be checked? And what was the value of charting the tropical oceans during the heyday of maritime surveying that flourished during the post-Napoleonic peace if new rings of hull-busting coral could spring up at any time?

Such questions were of real concern to the British Admiralty. In 1831, the Navy's chief officer in charge of surveying and mapmaking, Francis Beaufort, was drawing up instructions for the commander of an ambitious voyage that was to chart the intricate shorelines of southern South America before shooting across the Pacific and Indian oceans to complete a circumnavigation. The expedition would be led by a bright young aristocrat, then only twenty-six, who had received scientific training at the officers' school. Beaufort instructed Robert FitzRoy to study the origin of those "circularly formed Coral Islands in the Pacific" that had been tantalizing and terrifying European navigators since the last century. By this time, zoologists disputed Forster's claim that corals could grow up from the deepest parts of the ocean, and the widely held opinion was rather that corals could not live below a depth of about thirty feet. This only intensified the puzzle of the coral islands' annular shape and their presence in the remotest parts of the ocean. If corals needed a shallow foundation on which to grow, how had they established their strange formations in oceans that were perhaps miles deep? Beaufort was among those who believed that the circular islands

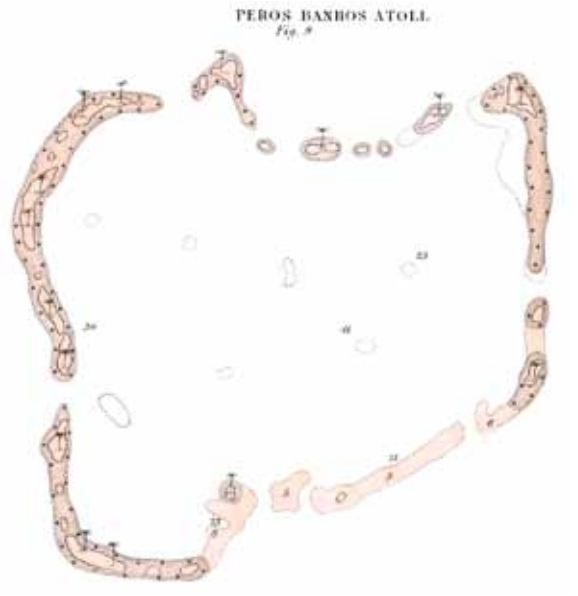

Illustration of Peros Banhos atoll. From Charles Darwin, *The Structure and Distribution of Coral Reefs*, 1842.

had been established atop submarine volcanic craters, with corals forming a mere veneer atop the crater's rim. In the instructions, he charged FitzRoy with examining this "modern and very plausible theory." By the end of the voyage, however, the theory had been dismissed as nothing more than "a monstrous hypothesis" by FitzRoy's young gentleman companion, the naturalist Charles Darwin.

In November 1835, four years into the voyage, FitzRoy brought the *Beagle* to anchor at Tahiti, a destination still full of potent associations for the descendants of Cook and Bougainville. Darwin was eager for action after the three-and-a-half-week crossing from the Galapagos, so he commissioned a few natives to guide him on the vertiginous hike inland. Having climbed to an elevation of about three thousand feet, Darwin cast his gaze west toward Tahiti's smaller neighbor, the equally precipitous island of Moorea. This mass of "lofty and broken peaks" was surrounded on all sides by a light-blue ring of shallow water, which was set off from the open ocean by a reef that encircled the entire island about a mile offshore. As he sucked in deep breaths of rarified tropical air and marveled at the "well defined line of brilliant white where the waves first encountered the wall of coral," Darwin recognized that the reef had a shape identical to that of a low island. "I was forcibly struck with this opinion," he wrote when he returned to the ship. "Remove the central group of mountains, & there remains a Lagoon."[6]

According to the view from Tahiti, the Pacific's low rings of coral were neither ruined lands nor seeds of a new continent. Each one, Darwin argued, was "a monument raised by myriads of tiny architects, to mark the spot where a former land lies buried beneath the depths of the ocean." He already had an idea of why high islands might have sunk throughout the Pacific, because he had decided earlier that year that the ocean's floor must be subsiding to compensate for the adjacent bulging of the earth that had raised the continent of South America in the recent geological past. Darwin's theory of coral reef formation, which stated that atolls (as he determined to call the low islands, appropriating the native Maldivan name for coral rings in the Indian Ocean) and barrier reefs were formed by the subsidence of reef-fringed landmasses, became his intellectual calling card when he returned to England. It earned him the admiration of the savant who became his most important patron, the geologist Charles Lyell, and inspired Darwin's first scientific treatise, the 1842 book *The Structure and Distribution of Coral Reefs*.

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You could be orbiting the moon and you wouldn't be farther from the warm, saline air of a Pacific atoll than you are in the freeze-dried, space-shuttle atmosphere of the National Archives facility in College Park, Maryland. But this is where you go to read the official files of the Atomic Energy Commission and the military agencies that coordinated nuclear weapons tests. And those files are where you can find a Navy Department press dispatch from 1947 which reads, "Drillers from the oil fields of Oklahoma began working around the clock on Bikini Island today in an operation that may settle a one hundred and ten year old argument among geologists. ... Charles Darwin, [the] famous British naturalist, advanced the theory that coral atolls are formed by coral growing upward on reefs around a slowly sinking island. Since that time arguments pro and con have been raised by geologists in all parts of the world. Up to now the question has never been settled."

Darwin himself said, in the year before he died, that the best test of his coral theory would come from drilling into a reef and examining whether it was formed by the skeletons of shallow-water corals even at great depths. If so, the foundation of the reef had most likely subsided, as Darwin's theory suggested. "I wish," he wrote suggestively to the Harvard zoologist and mining magnate Alexander Agassiz in 1881, "that some doubly rich millionaire would take it into his head to have borings made in some of the Pacific and Indian atolls, and bring home

cores for slicing from a depth of 500 or 600 feet." Agassiz and his late-nineteenth-century contemporaries did try drilling reefs, but the inconclusive results only served to intensify disagreements between advocates of Darwin's leading theory and those who believed that the foundation's subsidence played no role in the formation of atolls. None of them could have imagined the scene that found the US Navy playing the role of Darwin's millionaire halfway through the next century.

The same qualities that made atolls so intriguing to Bougainville—their remoteness, their small human populations, their calm-water lagoons—made them attractive sites to those who wished to test nuclear weapons. Thus in 1946, a hundred expendable ships were anchored in Bikini Lagoon, complete with skeleton "crews" of guinea pigs and barnyard animals, to serve as the targets for the first experiment on the effects of a nuclear device on a naval fleet. Operation Crossroads, as the test was called, was conducted on an epic scale. Its forty-two thousand personnel made it the largest US military operation that had ever been conducted during peacetime, and the services had reputedly stockpiled more than half the world's supply of cinematographic film to document two nuclear explosions, one aerial and one submarine. The phonebook-thick operation plan called for extensive pre- and post-bomb scientific surveys of the lagoon water, the atoll's flora and fauna, and the reef itself. By July, when the bombs were detonated, Bikini had already become the most carefully studied atoll on earth, and similar studies had been conducted on a smaller scale at two "control atolls" located elsewhere in the Marshall Islands archipelago.

The following summer, many of the scientists and support personnel returned to Bikini for Operation Crosscheck, an expanded version of the originally planned scientific resurvey of the atoll. Their primary task was to determine the amount and location of any radioactivity that remained from the 1946 blasts, but the resurvey also served the larger purpose of rehabilitating the image of the whole enterprise at Bikini. Already controversial diplomatically as an unnecessary show of strength so close on the heels of Hiroshima and Nagasaki, the Crossroads test had come to an abrupt end when Bikini had to be evacuated (of American personnel; the native Bikinians had long since been resettled in a compulsory migration) following the second, submarine explosion, which unexpectedly drenched the entire atoll in radioactive spray. This year's operation called for a broader research program and contained a Public Information Plan that emphasized "the necessity for presenting to the American people in an intelligent manner the story of cooperation that exists between civilian and military agencies." Publicizing the basic science research was central to this strategy, and deep core drilling was intended to be every bit as decisive a technological solution to a conflict in coral reef science as the bomb itself had been to the recent war.

The drill crew split into teams and worked around the clock as the summer wore on. The deepest of their holes took 190 hours to bore and reached 2,556 feet. Even from half a mile down, the cuttings that circulated to the surface proved to be the remains of corals and similar calcareous organisms that had lived, when they were alive, in shallow water. In the early 1950s, when the main Pacific proving ground had shifted to the adjacent atoll of Enewetak, another drilling effort achieved the geologists' ultimate goal of retrieving a sample from the reef's original foundation, which had formed in shallow water and now lay more than four thousand feet below sea level on a depressed volcanic platform. Not surprisingly, the microscopic analysis of deep samples recovered from Bikini and Enewetak told of a more erratic and complex tectonic history than Darwin had envisioned for Pacific atolls. However, they affirmed a central tenet of his theory: that what lay beneath the slight rings visible at the ocean's surface was a grand funnel of rock made from the fossil remains of millions of generations of corals who had lived, strived toward the light, and then died atop a sinking foundation.

There is something sublime in the notion of a habitable island—a tropical paradise—formed by animalcules and shaped by their responses to the ocean and wind around them. When the mushroom clouds cleared at Bikini and Enewetak, the living islands lived on. Formerly the perpetrators of violence against those who sailed too close in search of knowledge, now cratered and punctured by the modern tools of knowledge-seekers, the reefs kept growing, atom by atom.

1 James Montgomery, *The Pelican Island, and Other Poems*, 2nd ed. (London: Longman, Rees, Orme, Brown, and Green, 1828), p. 28. An excerpt of Montgomery's poem that includes the portion quoted here can be found in Richard Lansdown, ed., *Strangers in the South Seas: The Idea of the Pacific in Western Thought* (Honolulu: University of Hawai'i Press, 2006), pp. 162–170.
2 Louis-Antoine de Bougainville, *Voyage autour du monde*, [1771], critical edition, eds. Michel Bideaux and Sonia Faessel (Paris: Presses de l'Universite de Paris-Sorbonne, 2001).
3 Louis-Antoine de Bougainville, *A Voyage Round the World*, trans. Johann Reinhold Forster (London: J. Nourse and T. Davies, 1772).
4 Johann Reinhold Forster, *Observations Made During a Voyage Round the World* (London: G. Robinson, 1778).
5 James Montgomery, *The Pelican Island, and Other Poems*, op. cit., p. 27.
6 Alistair Sponsel, "Coral Reef Formation and the Sciences of Earth, Life, and Sea, c. 1770–1952" (PhD dissertation, Princeton University, 2009).

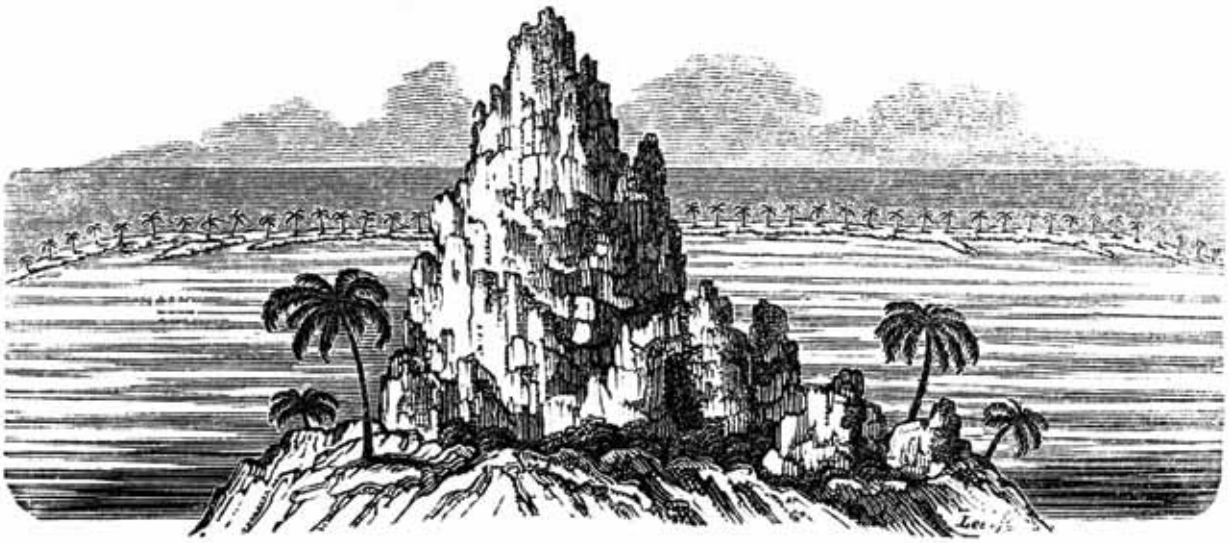

Illustration of a coral reef from Charles Darwin, *The Structure and Distribution of Coral Reefs*, 1842. Courtesy Wellcome Library, London.