# Darwin's Paradox

April 4, 1836. Over the eastern expanse of the Indian Ocean, the reliable northeast winds of monsoon season have begun to give way to the serene days of summer. On the Keeling Islands, two small atolls composed of twenty-seven coral islands six hundred miles west of Sumatra, the emerald waters are invitingly placid and warm, their hue enhanced by the brilliant white sand of disintegrated coral. On one stretch of shore usually guarded by stronger surf, the water is so calm that Charles Darwin wades out, under the vast blue sky of the tropics, to the edge of the live coral reef that rings the island.

For hours he stands and paddles among the crowded pageantry of the reef. Twenty-seven years old, seven thousand miles from London, Darwin is on the precipice, standing on an underwater peak ascending over an unfathomable sea. He is on the edge of an idea about the forces that built that peak, an idea that will prove to be the

first great scientific insight of his career. And he has just begun exploring another hunch, still hazy and unformed, that will eventually lead to the intellectual summit of the nineteenth century.

Around him, the crowds of the coral ecosystem dart and shimmer. The sheer variety dazzles: butterflyfish, damselfish, parrotfish, Napoleon fish, angelfish; golden anthias feeding on plankton above the cauliflower blooms of the coral; the spikes and tentacles of sea urchins and anemones. The tableau delights Darwin's eye, but already his mind is reaching behind the surface display to a more profound mystery. In his account of the *Beagle*'s voyage, published four years later, Darwin would write: "It is excusable to grow enthusiastic over the infinite numbers of organic beings with which the sea of the tropics, so prodigal of life, teems; yet I must confess I think those naturalists who have described, in well-known words, the submarine grottoes decked with a thousand beauties, have indulged in rather exuberant language."

What lingers in the back of Darwin's mind, in the days and weeks to come, is not the beauty of the submarine grotto but rather the "infinite numbers" of organic beings. On land, the flora and fauna of the Keeling Islands are paltry at best. Among the plants, there is little but "cocoa-nut" trees, lichen, and weeds. "The list of land animals," he writes, "is even poorer than that of the plants": a handful of lizards, almost no true land birds, and those recent immigrants from European ships, rats. "The island has no domestic quadruped excepting the pig," Darwin notes with disdain.

Yet just a few feet away from this desolate habitat, in the coral reef waters, an epic diversity, rivaled only by that of the rain forests, thrives. This is a true mystery. Why should the waters at the edge





of an atoll support so many different livelihoods? Extract ten thousand cubic feet of water from just about anywhere in the Indian Ocean and do a full inventory on the life you find there: the list would be about as "poor" as Darwin's account of the land animals of the Keelings. You might find a dozen fish if you were lucky. On the reef, you would be guaranteed a thousand. In Darwin's own words, stumbling across the ecosystem of a coral reef in the middle of an ocean was like encountering a swarming oasis in the middle of a desert. We now call this phenomenon Darwin's Paradox: so many different life forms, occupying such a vast array of ecological niches, inhabiting waters that are otherwise remarkably nutrient-poor. Coral reefs make up about one-tenth of one percent of the earth's surface, and yet roughly a quarter of the known species of marine life make their homes there. Darwin doesn't have those statistics available to him, standing in the lagoon in 1836, but he has seen enough of the world over the preceding four years on the *Beagle* to know there is something peculiar in the crowded waters of the reef.

The next day, Darwin ventures to the windward side of the atoll with the *Beagle*'s captain, Vice Admiral James FitzRoy, and there they watch massive waves crash against the coral's white barrier. An ordinary European spectator, accustomed to the calmer waters of the English Channel or the Mediterranean, would be naturally drawn to the impressive crest of the surf. (The breakers, Darwin observes, are almost "equal in force [to] those during a gale of wind in the temperate regions, and never cease to rage.") But Darwin has his eye on something else—not the violent surge of water but the force that resists it: the tiny organisms that have built the reef itself.

> The ocean throwing its waters over the broad reef appears an invincible, all-powerful enemy; yet we see it resisted, and even conquered, by means which at first seem most weak and inefficient. It is not that the ocean spares the rock of coral; the great fragments scattered over the reef, and heaped on the beach, whence the tall cocoa-nut springs, plainly bespeak the unrelenting power of the waves . . . Yet these low, insignificant coral-islets stand and are victorious: for here another power, as an antagonist, takes part in the contest. The organic forces separate the atoms of carbonate of lime, one by one, from the foaming breakers, and unite them into a symmetrical structure. Let the hurricane tear up its thousand huge fragments; yet what will that tell against the accumulated labour of myriads of architects at work night and day, month after month?

Darwin is drawn to those minuscule architects because he believes they are the key to solving the mystery that has brought the *Beagle* to the Keeling Islands. In the Admiralty's memorandum authorizing the ship's five-year journey, one of the principal scientific directives is the investigation of atoll formation. Darwin's mentor, the brilliant geologist Charles Lyell, had recently proposed that atolls are created by undersea volcanoes that have been driven upward by powerful movements in the earth's crust. In Lyell's theory, the distinctive circular shape of an atoll emerges as coral colonies construct reefs along the circumference of the volcanic crater. Darwin's mind had been profoundly shaped by Lyell's understanding of the deep time of geological transformation, but standing on the beach, watching the breakers crash against the coral, he knows that his mentor is wrong about the origin of the atolls. It is not a story





of simple geology, he realizes. It is a story about the innovative persistence of life. And as he mulls the thought, there is a hint of something else in his mind, a larger, more encompassing theory that might account for the vast scope of life's innovations. The forms of things unknown are turning, slowly, into shapes.

Days later, back on the *Beagle*, Darwin pulls out his journal and reflects on that mesmerizing clash between surf and coral. Presaging a line he would publish thirty years later in the most famous passage from *On the Origin of Species*, Darwin writes, "I can hardly explain the reason, but there is to my mind much grandeur in the view of the outer shores of these lagoon-islands." In time, the reason would come to him.

## The Superlinear City

From an early age, the Swiss scientist Max Kleiber had a knack for testing the edges of convention. As an undergraduate in Zurich in the 1910s, he roamed the streets dressed in sandals and an open collar, shocking attire for the day. During his tenure in the Swiss army, he discovered that his superiors had been trading information with the Germans, despite the official Swiss position of neutrality in World War I. Appalled, he simply failed to appear at his next call-up, and was ultimately jailed for several months. By the time he had settled on a career in agricultural science, he had had enough of the restrictions of Zurich society. And so Max Kleiber charted a path that would be followed by countless sandal-wearing, nonconformist war protesters in the decades to come. He moved to California.