On the Chatham Islands, 500 miles east of New Zealand, centuries of independence came to a brutal end for the Moriori people in December 1835. On November 19 of that year, a ship carrying 500 Maori armed with guns, clubs, and axes arrived, followed on December 5 by a shipload of 400 more Maori. Groups of Maori began to walk through Moriori settlements, announcing that the Moriori were now their slaves, and killing those who objected. An organized resistance by the Moriori could still then have defeated the Maori, who were outnumbered two to one. However, the Moriori had a tradition of resolving disputes peacefully. They decided in a council meeting not to fight back but to offer peace, friendship, and a division of resources.

Before the Moriori could deliver that offer, the Maori attacked en masse. Over the course of the next few days, they killed hundreds of Moriori, cooked and ate many of the bodies, and enslaved all the others, killing most of them too over the next few years as it suited their whim. A Moriori survivor recalled, “[The Maori] commenced to kill us like sheep. . . . [We] were terrified, fled to the bush, concealed ourselves in holes underground, and in any place to escape our enemies. It was of no avail; we were discovered and killed—men, women, and children indiscriminately.” A Maori conqueror explained, “We took possession. . . in accordance with our cus-
toms and we caught all the people. Not one escaped. Some ran away from us, these we killed, and others we killed—but what of that? It was in accordance with our custom."

The brutal outcome of this collision between the Moriori and the Maori could have been easily predicted. The Moriori were a small, isolated population of hunter-gatherers, equipped with only the simplest technology and weapons, entirely inexperienced at war, and lacking strong leadership or organization. The Maori invaders (from New Zealand's North Island) came from a dense population of farmers chronically engaged in ferocious wars, equipped with more-advanced technology and weapons, and operating under strong leadership. Of course, when the two groups finally came into contact, it was the Maori who slaughtered the Moriori, not vice versa.

The tragedy of the Moriori resembles many other such tragedies in both the modern and the ancient world, pitting numerous well-equipped people against few ill-equipped opponents. What makes the Maori-Moriori collision grimly illuminating is that both groups had diverged from a common origin less than a millennium earlier. Both were Polynesian peoples. The modern Maori are descendants of Polynesian farmers who colonized New Zealand around A.D. 1000. Soon thereafter, a group of those Maori in turn colonized the Chatham Islands and became the Moriori. In the centuries after the two groups separated, they evolved in opposite directions, the North Island Maori developing more-complex and the Moriori less-complex technology and political organization. The Moriori reverted to being hunter-gatherers, while the North Island Maori turned to more intensive farming.

Those opposite evolutionary courses sealed the outcome of their eventual collision. If we could understand the reasons for the disparate development of those two island societies, we might have a model for understanding the broader question of differing developments on the continents.

Moriori and Maori history constitutes a brief, small-scale natural experiment that tests how environments affect human societies. Before you read a whole book examining environmental effects on a very large scale—effects on human societies around the world for the last 13,000 years—you might reasonably want assurance, from smaller tests, that such effects
really are significant. If you were a laboratory scientist studying rats, you might perform such a test by taking one rat colony, distributing groups of those ancestral rats among many cages with differing environments, and coming back many rat generations later to see what had happened. Of course, such purposeful experiments cannot be carried out on human societies. Instead, scientists must look for "natural experiments," in which something similar befell humans in the past.

Such an experiment unfolded during the settlement of Polynesia. Scattered over the Pacific Ocean beyond New Guinea and Melanesia are thousands of islands differing greatly in area, isolation, elevation, climate, productivity, and geological and biological resources (Figure 2.1). For most of human history those islands lay far beyond the reach of watercraft. Around 1200 B.C. a group of farming, fishing, seafaring people from the Bismarck Archipelago north of New Guinea finally succeeded in reaching some of those islands. Over the following centuries their descendants colonized virtually every habitable scrap of land in the Pacific. The process was mostly complete by A.D. 500, with the last few islands settled around or soon after A.D. 1000.

Thus, within a modest time span, enormously diverse island environments were settled by colonists all of whom stemmed from the same founding population. The ultimate ancestors of all modern Polynesian populations shared essentially the same culture, language, technology, and set of domesticated plants and animals. Hence Polynesian history constitutes a natural experiment allowing us to study human adaptation, devoid of the usual complications of multiple waves of disparate colonists that often frustrate our attempts to understand adaptation elsewhere in the world.

Within that medium-sized test, the fate of the Moriori forms a smaller test. It is easy to trace how the differing environments of the Chatham Islands and of New Zealand molded the Moriori and the Maori differently. While those ancestral Maori who first colonized the Chathams may have been farmers, Maori tropical crops could not grow in the Chathams' cold climate, and the colonists had no alternative except to revert to being hunter-gatherers. Since as hunter-gatherers they did not produce crop surpluses available for redistribution or storage, they could not support and feed nonhunting craft specialists, armies, bureaucrats, and chiefs. Their prey were seals, shellfish, nesting seabirds, and fish that could be captured by hand or with clubs and required no more elaborate technology. In addi-
Figure 2.1. Polynesian islands. (Parentheses denote some non-Polynesian lands.)

tion, the Chathams are relatively small and remote islands, capable of supporting a total population of only about 2,000 hunter-gatherers. With no other accessible islands to colonize, the Moriori had to remain in the Chathams, and to learn how to get along with each other. They did so by renouncing war, and they reduced potential conflicts from overpopulation by castrating some male infants. The result was a small, unwarlike population with simple technology and weapons, and without strong leadership or organization.

In contrast, the northern (warmer) part of New Zealand, by far the largest island group in Polynesia, was suitable for Polynesian agriculture. Those Maori who remained in New Zealand increased in numbers until there were more than 100,000 of them. They developed locally dense populations chronically engaged in ferocious wars with neighboring populations. With the crop surpluses that they could grow and store, they fed craft specialists, chiefs, and part-time soldiers. They needed and developed varied tools for growing their crops, fighting, and making art. They erected elaborate ceremonial buildings and prodigious numbers of forts.
Thus, Moriori and Maori societies developed from the same ancestral society, but along very different lines. The resulting two societies lost awareness even of each other's existence and did not come into contact again for many centuries, perhaps for as long as 500 years. Finally, an Australian seal-hunting ship visiting the Chathams en route to New Zealand brought the news to New Zealand of islands where "there is an abundance of sea and shellfish; the lakes swarm with eels; and it is a land of the karaka berry. . . . The inhabitants are very numerous, but they do not understand how to fight, and have no weapons." That news was enough to induce 900 Maori to sail to the Chathams. The outcome clearly illustrates how environments can affect economy, technology, political organization, and fighting skills within a short time.

As I already mentioned, the Maori-Moriori collision represents a small test within a medium-sized test. What can we learn from all of Polynesia about environmental influences on human societies? What differences among societies on different Polynesian islands need to be explained?

Polynesia as a whole presented a much wider range of environmental conditions than did just New Zealand and the Chathams, although the latter define one extreme (the simple end) of Polynesian organization. In their subsistence modes, Polynesians ranged from the hunter-gatherers of the Chathams, through slash-and-burn farmers, to practitioners of intensive food production living at some of the highest population densities of any human societies. Polynesian food producers variously intensified production of pigs, dogs, and chickens. They organized work forces to construct large irrigation systems for agriculture and to enclose large ponds for fish production. The economic basis of Polynesian societies consisted of more or less self-sufficient households, but some islands also supported guilds of hereditary part-time craft specialists. In social organization, Polynesian societies ran the gamut from fairly egalitarian village societies to some of the most stratified societies in the world, with many hierarchically ranked lineages and with chief and commoner classes whose members married within their own class. In political organization, Polynesian islands ranged from landscapes divided into independent tribal or village units, up to multi-island proto-empires that devoted standing military establishments to invasions of other islands and wars of conquest.
Finally, Polynesian material culture varied from the production of no more than personal utensils to the construction of monumental stone architecture. How can all that variation be explained?

Contributing to these differences among Polynesian societies were at least six sets of environmental variables among Polynesian islands: island climate, geological type, marine resources, area, terrain fragmentation, and isolation. Let's examine the ranges of these factors, before considering their specific consequences for Polynesian societies.

The climate in Polynesia varies from warm tropical or subtropical on most islands, which lie near the equator, to temperate on most of New Zealand, and cold subantarctic on the Chathams and the southern part of New Zealand’s South Island. Hawaii’s Big Island, though lying well within the Tropic of Cancer, has mountains high enough to support alpine habitats and receive occasional snowfalls. Rainfall varies from the highest recorded on Earth (in New Zealand’s Fjordland and Hawaii’s Alakai Swamp on Kauai) to only one-tenth as much on islands so dry that they are marginal for agriculture.

Island geological types include coral atolls, raised limestone, volcanic islands, pieces of continents, and mixtures of those types. At one extreme, innumerable islets, such as those of the Tuamotu Archipelago, are flat, low atolls barely rising above sea level. Other former atolls, such as Henderson and Rennell, have been lifted far above sea level to constitute raised limestone islands. Both of those atoll types present problems to human settlers, because they consist entirely of limestone without other stones, have only very thin soil, and lack permanent fresh water. At the opposite extreme, the largest Polynesian island, New Zealand, is an old, geologically diverse, continental fragment of Gondwanaland, offering a range of mineral resources, including commercially exploitable iron, coal, gold, and jade. Most other large Polynesian islands are volcanoes that rose from the sea, have never formed parts of a continent, and may or may not include areas of raised limestone. While lacking New Zealand’s geological richness, the oceanic volcanic islands at least are an improvement over atolls (from the Polynesians’ perspective) in that they offer diverse types of volcanic stones, some of which are highly suitable for making stone tools.

The volcanic islands differ among themselves. The elevations of the higher ones generate rain in the mountains, so the islands are heavily weathered and have deep soils and permanent streams. That is true, for instance, of the Societies, Samoa, the Marquesas, and especially Hawaii,
the Polynesian archipelago with the highest mountains. Among the lower islands, Tonga and (to a lesser extent) Easter also have rich soil because of volcanic ashfalls, but they lack Hawaii's large streams.

As for marine resources, most Polynesian islands are surrounded by shallow water and reefs, and many also encompass lagoons. Those environments teem with fish and shellfish. However, the rocky coasts of Easter, Pitcairn, and the Marquesas, and the steeply dropping ocean bottom and absence of coral reefs around those islands, are much less productive of seafood.

Area is another obvious variable, ranging from the 100 acres of Anuta, the smallest permanently inhabited isolated Polynesian island, up to the 103,000 square miles of the minicontinent of New Zealand. The habitable terrain of some islands, notably the Marquesas, is fragmented into steep-walled valleys by ridges, while other islands, such as Tonga and Easter, consist of gently rolling terrain presenting no obstacles to travel and communication.

The last environmental variable to consider is isolation. Easter Island and the Chathams are small and so remote from other islands that, once they were initially colonized, the societies thus founded developed in total isolation from the rest of the world. New Zealand, Hawaii, and the Marquesas are also very remote, but at least the latter two apparently did have some further contact with other archipelagoes after the first colonization, and all three consist of many islands close enough to each other for regular contact between islands of the same archipelago. Most other Polynesian islands were in more or less regular contact with other islands. In particular, the Tongan Archipelago lies close enough to the Fijian, Samoan, and Wallis Archipelagoes to have permitted regular voyaging between archipelagoes, and eventually to permit Tongans to undertake the conquest of Fiji.

After that brief look at Polynesia's varying environments, let's now see how that variation influenced Polynesian societies. Subsistence is a convenient facet of society with which to start, since it in turn affected other facets.

Polynesian subsistence depended on varying mixes of fishing, gathering wild plants and marine shellfish and crustacea, hunting terrestrial birds and breeding seabirds, and food production. Most Polynesian islands originally supported big flightless birds that had evolved in the absence of
predators, New Zealand's moas and Hawaii's flightless geese being the best-known examples. While those birds were important food sources for the initial colonists, especially on New Zealand's South Island, most of them were soon exterminated on all islands, because they were easy to hunt down. Breeding seabirds were also quickly reduced in number but continued to be important food sources on some islands. Marine resources were significant on most islands but least so on Easter, Pitcairn, and the Marquesas, where people as a result were especially dependent on food that they themselves produced.

Ancestral Polynesians brought with them three domesticated animals (the pig, chicken, and dog) and domesticated no other animals within Polynesia. Many islands retained all three of those species, but the more isolated Polynesian islands lacked one or more of them, either because livestock brought in canoes failed to survive the colonists' long overwater journey or because livestock that died out could not be readily obtained again from the outside. For instance, isolated New Zealand ended up with only dogs; Easter and Tikopia, with only chickens. Without access to coral reefs or productive shallow waters, and with their terrestrial birds quickly exterminated, Easter Islanders turned to constructing chicken houses for intensive poultry farming.

At best, however, these three domesticated animal species provided only occasional meals. Polynesian food production depended mainly on agriculture, which was impossible at subantarctic latitudes because all Polynesian crops were tropical ones initially domesticated outside Polynesia and brought in by colonists. The settlers of the Chathams and the cold southern part of New Zealand's South Island were thus forced to abandon the farming legacy developed by their ancestors over the previous thousands of years, and to become hunter-gatherers again.

People on the remaining Polynesian islands did practice agriculture based on dryland crops (especially taro, yams, and sweet potatoes), irrigated crops (mainly taro), and tree crops (such as breadfruit, bananas, and coconuts). The productivity and relative importance of those crop types varied considerably on different islands, depending on their environments. Human population densities were lowest on Henderson, Rennell, and the atolls because of their poor soil and limited fresh water. Densities were also low on temperate New Zealand, which was too cool for some Polynesian crops. Polynesians on these and some other islands practiced a nonintensive type of shifting, slash-and-burn agriculture.
Other islands had rich soils but were not high enough to have large permanent streams and hence irrigation. Inhabitants of those islands developed intensive dryland agriculture requiring a heavy input of labor to build terraces, carry out mulching, rotate crops, reduce or eliminate fallow periods, and maintain tree plantations. Dryland agriculture became especially productive on Easter, tiny Anuta, and flat and low Tonga, where Polynesians devoted most of the land area to the growing of food.

The most productive Polynesian agriculture was taro cultivation in irrigated fields. Among the more populous tropical islands, that option was ruled out for Tonga by its low elevation and hence its lack of rivers. Irrigation agriculture reached its peak on the westernmost Hawaiian islands of Kauai, Oahu, and Molokai, which were big and wet enough to support not only large permanent streams but also large human populations available for construction projects. Hawaiian labor corvées built elaborate irrigation systems for taro fields yielding up to 24 tons per acre, the highest crop yields in all of Polynesia. Those yields in turn supported intensive pig production. Hawaii was also unique within Polynesia in using mass labor for aquaculture, by constructing large fishponds in which milkfish and mullet were grown.

As a result of all this environmentally related variation in subsistence, human population densities (measured in people per square mile of arable land) varied greatly over Polynesia. At the lower end were the hunter-gatherers of the Chathams (only 5 people per square mile) and of New Zealand’s South Island, and the farmers of the rest of New Zealand (28 people per square mile). In contrast, many islands with intensive agriculture attained population densities exceeding 120 per square mile. Tonga, Samoa, and the Societies achieved 210–250 people per square mile and Hawaii 300. The upper extreme of 1,100 people per square mile was reached on the high island of Anuta, whose population converted essentially all the land to intensive food production, thereby crammed 160 people into the island’s 100 acres, and joined the ranks of the densest self-sufficient populations in the world. Anuta’s population density exceeded that of modern Holland and even rivaled that of Bangladesh.

Population size is the product of population density (people per square mile) and area (square miles). The relevant area is not the area of an island but that of a political unit, which could be either larger or smaller than a
single island. On the one hand, islands near one another might become combined into a single political unit. On the other hand, single large rugged islands were divided into many independent political units. Hence the area of the political unit varied not only with an island's area but also with its fragmentation and isolation.

For small isolated islands without strong barriers to internal communication, the entire island constituted the political unit—as in the case of Anuta, with its 160 people. Many larger islands never did become unified politically, whether because the population consisted of dispersed bands of only a few dozen hunter-gatherers each (the Chathams and New Zealand's southern South Island), or of farmers scattered over large distances (the rest of New Zealand), or of farmers living in dense populations but in rugged terrain precluding political unification. For example, people in neighboring steep-sided valleys of the Marquesas communicated with each other mainly by sea; each valley formed an independent political entity of a few thousand inhabitants, and most individual large Marquesan islands remained divided into many such entities.

The terrains of the Tongan, Samoan, Society, and Hawaiian islands did permit political unification within islands, yielding political units of 10,000 people or more (over 30,000 on the large Hawaiian islands). The distances between islands of the Tongan archipelago, as well as the distances between Tonga and neighboring archipelagoes, were sufficiently modest that a multi-island empire encompassing 40,000 people was eventually established. Thus, Polynesian political units ranged in size from a few dozen to 40,000 people.

A political unit's population size interacted with its population density to influence Polynesian technology and economic, social, and political organization. In general, the larger the size and the higher the density, the more complex and specialized were the technology and organization, for reasons that we shall examine in detail in later chapters. Briefly, at high population densities only a portion of the people came to be farmers, but they were mobilized to devote themselves to intensive food production, thereby yielding surpluses to feed nonproducers. The nonproducers mobilizing them included chiefs, priests, bureaucrats, and warriors. The biggest political units could assemble large labor forces to construct irrigation systems and fishponds that intensified food production even further. These developments were especially apparent on Tonga, Samoa, and the Societies, all of which were fertile, densely populated, and moderately large by
Polynesian standards. The trends reached their zenith on the Hawaiian Archipelago, consisting of the largest tropical Polynesian islands, where high population densities and large land areas meant that very large labor forces were potentially available to individual chiefs.

The variations among Polynesian societies associated with different population densities and sizes were as follows. Economies remained simplest on islands with low population densities (such as the hunter-gatherers of the Chathams), low population numbers (small atolls), or both low densities and low numbers. In those societies each household made what it needed; there was little or no economic specialization. Specialization increased on larger, more densely populated islands, reaching a peak on Samoa, the Societies, and especially Tonga and Hawaii. The latter two islands supported hereditary part-time craft specialists, including canoe builders, navigators, stone masons, bird catchers, and tattooers.

Social complexity was similarly varied. Again, the Chathams and the atolls had the simplest, most egalitarian societies. While those islands retained the original Polynesian tradition of having chiefs, their chiefs wore little or no visible signs of distinction, lived in ordinary huts like those of commoners, and grew or caught their food like everyone else. Social distinctions and chiefly powers increased on high-density islands with large political units, being especially marked on Tonga and the Societies.

Social complexity again reached its peak in the Hawaiian Archipelago, where people of chiefly descent were divided into eight hierarchically ranked lineages. Members of those chiefly lineages did not intermarry with commoners but only with each other, sometimes even with siblings or half-siblings. Commoners had to prostrate themselves before high-ranking chiefs. All the members of chiefly lineages, bureaucrats, and some craft specialists were freed from the work of food production.

Political organization followed the same trends. On the Chathams and atolls, the chiefs had few resources to command, decisions were reached by general discussion, and landownership rested with the community as a whole rather than with the chiefs. Larger, more densely populated political units concentrated more authority with the chiefs. Political complexity was greatest on Tonga and Hawaii, where the powers of hereditary chiefs approximated those of kings elsewhere in the world, and where land was controlled by the chiefs, not by the commoners. Using appointed bureaucrats as agents, chiefs requisitioned food from the commoners and also
conscripted them to work on large construction projects, whose form varied from island to island: irrigation projects and fishponds on Hawaii, dance and feast centers on the Marquesas, chiefs' tombs on Tonga, and temples on Hawaii, the Societies, and Easter.

At the time of Europeans' arrival in the 18th century, the Tongan chiefdom or state had already become an inter-archipelagal empire. Because the Tongan Archipelago itself was geographically close-knit and included several large islands with unfragmented terrain, each island became unified under a single chief; then the hereditary chiefs of the largest Tongan island (Tongatapu) united the whole archipelago, and eventually they conquered islands outside the archipelago up to 500 miles distant. They engaged in regular long-distance trade with Fiji and Samoa, established Tongan settlements in Fiji, and began to raid and conquer parts of Fiji. The conquest and administration of this maritime proto-empire were achieved by navies of large canoes, each holding up to 150 men.

Like Tonga, Hawaii became a political entity encompassing several populous islands, but one confined to a single archipelago because of its extreme isolation. At the time of Hawaii's "discovery" by Europeans in 1778, political unification had already taken place within each Hawaiian island, and some political fusion between islands had begun. The four largest islands—Big Island (Hawaii in the narrow sense), Maui, Oahu, and Kauai—remained independent, controlling (or jockeying with each other for control of) the smaller islands (Lanai, Molokai, Kahoolawe, and Niihau). After the arrival of Europeans, the Big Island's King Kamehameha I rapidly proceeded with the consolidation of the largest islands by purchasing European guns and ships to invade and conquer first Maui and then Oahu. Kamehameha thereupon prepared invasions of the last independent Hawaiian island, Kauai, whose chief finally reached a negotiated settlement with him, completing the archipelago's unification.

The remaining type of variation among Polynesian societies to be considered involves tools and other aspects of material culture. The differing availability of raw materials imposed an obvious constraint on material culture. At the one extreme was Henderson Island, an old coral reef raised above sea level and devoid of stone other than limestone. Its inhabitants were reduced to fabricating adzes out of giant clamshells. At the opposite extreme, the Maori on the minicontinent of New Zealand had access to a wide range of raw materials and became especially noted for their use of jade. Between those two extremes fell Polynesia's oceanic volcanic islands,
which lacked granite, flint, and other continental rocks but did at least have volcanic rocks, which Polynesians worked into ground or polished stone adzes used to clear land for farming.

As for the types of artifacts made, the Chatham Islanders required little more than hand-held clubs and sticks to kill seals, birds, and lobsters. Most other islanders produced a diverse array of fishhooks, adzes, jewelry, and other objects. On the atolls, as on the Chathams, those artifacts were small, relatively simple, and individually produced and owned, while architecture consisted of nothing more than simple huts. Large and densely populated islands supported craft specialists who produced a wide range of prestige goods for chiefs—such as the feather capes reserved for Hawaiian chiefs and made of tens of thousands of bird feathers.

The largest products of Polynesia were the immense stone structures of a few islands—the famous giant statues of Easter Island, the tombs of Tongan chiefs, the ceremonial platforms of the Marquesas, and the temples of Hawaii and the Societies. This monumental Polynesian architecture was obviously evolving in the same direction as the pyramids of Egypt, Mesopotamia, Mexico, and Peru. Naturally, Polynesia’s structures are not on the scale of those pyramids, but that merely reflects the fact that Egyptian pharaohs could draw conscript labor from a much larger human population than could the chief of any Polynesian island. Even so, the Easter Islanders managed to erect 30-ton stone statues—no mean feat for an island with only 7,000 people, who had no power source other than their own muscles.

Thus, Polynesian island societies differed greatly in their economic specialization, social complexity, political organization, and material products, related to differences in population size and density, related in turn to differences in island area, fragmentation, and isolation and in opportunities for subsistence and for intensifying food production. All those differences among Polynesian societies developed, within a relatively short time and modest fraction of the Earth’s surface, as environmentally related variations on a single ancestral society. Those categories of cultural differences within Polynesia are essentially the same categories that emerged everywhere else in the world.

Of course, the range of variation over the rest of the globe is much greater than that within Polynesia. While modern continental peoples
included ones dependent on stone tools, as were Polynesians, South America also spawned societies expert in using precious metals, and Eurasians and Africans went on to utilize iron. Those developments were precluded in Polynesia, because no Polynesian island except New Zealand had significant metal deposits. Eurasia had full-fledged empires before Polynesia was even settled, and South America and Mesoamerica developed empires later, whereas Polynesia produced just two proto-empires, one of which (Hawaii) coalesced only after the arrival of Europeans. Eurasia and Mesoamerica developed indigenous writing, which failed to emerge in Polynesia, except perhaps on Easter Island, whose mysterious script may however have postdated the islanders’ contact with Europeans.

That is, Polynesia offers us a small slice, not the full spectrum, of the world’s human social diversity. That shouldn’t surprise us, since Polynesia provides only a small slice of the world’s geographic diversity. In addition, since Polynesia was colonized so late in human history, even the oldest Polynesian societies had only 3,200 years in which to develop, as opposed to at least 13,000 years for societies on even the last-colonized continents (the Americas). Given a few more millennia, perhaps Tonga and Hawaii would have reached the level of full-fledged empires battling each other for control of the Pacific, with indigenously developed writing to administer those empires, while New Zealand’s Maori might have added copper and iron tools to their repertoire of jade and other materials.

In short, Polynesia furnishes us with a convincing example of environmentally related diversification of human societies in operation. But we thereby learn only that it can happen, because it happened in Polynesia. Did it also happen on the continents? If so, what were the environmental differences responsible for diversification on the continents, and what were their consequences?