

Norse Greenland's Flowering

Europe's outpost ■ Greenland's climate today • Climate in the past ■
 Native plants and animals ■ Norse settlement ■ Farming ■
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My initial impression of Greenland was that its name was a cruel misnomer, because I saw only a three-colored landscape: white, black, and blue, with white overwhelmingly predominant. Some historians think that the name really was coined with deceitful intent by Erik the Red, founder of Greenland's Viking settlement, so as to induce other Vikings to join him. As my airplane from Copenhagen approached Greenland's east coast, the first thing visible after the dark blue ocean was a vast area of brilliant white stretching out of sight, the world's largest ice cap outside Antarctica. Greenland's shores rise steeply to an ice-covered high plateau covering most of the island and drained by enormous glaciers flowing into the sea. For hundreds of miles our plane flew over this white expanse, where the sole other color visible was the black of bare stone mountains rising out of that ocean of ice, and scattered over it like black islands. Only as our plane descended from the plateau towards the west coast did I spot two other colors in a thin border outlining the ice sheet, combining brown areas of bare gravel with faint green areas of moss or lichens.

But when I landed at southern Greenland's main airport of Narsarsuaq and crossed the iceberg-strewn fjord to Brattahlid, the site that Erik the Red chose for his own farm, I discovered to my surprise that the name Greenland might have been bestowed honestly, not as false PR. Exhausted by my long plane flight from Los Angeles to Copenhagen and back to Greenland, involving shifts of 13 time zones, I set out to stroll among the Norse ruins but was soon ready for a nap, too sleepy even to return the few hundred yards to the youth hostel where I had left my rucksack. Fortunately, the ruins lay amidst lush meadows of soft grass over a foot high, growing up out of thick moss and dotted with abundant yellow buttercups, yellow dandelions, blue bluebells, white asters, and pink willow-herbs. There was no

need for an air mattress or pillow here: I fell into a deep sleep in the softest and most beautiful natural bed imaginable.

As my Norwegian archaeologist friend Christian Keller expressed it, "Life in Greenland is all about finding the good patches of useful resources." While 99% of the island is indeed uninhabitable white or black, there are green areas deep inside two fjord systems on the southwest coast. There, long narrow fjords penetrate far inland, such that their heads are remote from the cold ocean currents, icebergs, salt spray, and wind that suppress growth of vegetation along Greenland's outer coast. Here and there along the mostly steep-sided fjords are patches of flatter terrain with luxuriant pastures, including the one in which I took a nap, and good for maintaining livestock (Plate 17). For nearly 500 years between A.D. 984 and sometime in the 1400s, those two fjord systems supported European civilization's most remote outpost, where Scandinavians 1,500 miles from Norway built a cathedral and churches, wrote in Latin and Old Norse, wielded iron tools, herded farm animals, followed the latest European fashions in clothing—and finally vanished.

The mystery of their disappearance is symbolized by the stone church at Hvalsey, Norse Greenland's most famous building, whose photograph will be found in any travel brochure promoting Greenland tourism. Lying in meadows at the head of the long, broad, mountain-rimmed fjord, the church commands a gorgeous view over a panorama of dozens of square miles. Its walls, west doorway, niches, and gables of stone are still intact: only the original roof of turf is missing. Around the church lie the remains of the residential halls, barns, storehouses, boathouse, and pastures that sustained the people who erected those buildings. Among all medieval European societies, Norse Greenland is the one whose ruins are best preserved, precisely because its sites were abandoned while intact, whereas almost all major medieval sites of Britain and continental Europe continued to be occupied and became submerged by post-medieval construction. Visiting Hvalsey today, one almost expects to see Vikings walking out of those buildings, but in fact all is silent: practically no one now lives within twenty miles of there (Plate 15). Whoever built that church knew enough to re-create a European community, and to maintain it for centuries—but not enough to maintain it for longer.

Compounding the mystery, the Vikings shared Greenland with another people, the Inuit (Eskimos), whereas the Iceland Norse had Iceland to themselves and faced no such additional problem to compound their own difficulties. The Vikings disappeared, but the Inuit survived, proving that

human survival in Greenland was not impossible and the Vikings' disappearance not inevitable. As one walks around modern Greenland farms, one sees again those same two populations that shared the island in the Middle Ages: Inuits and Scandinavians. In 1721, three hundred years after the medieval Vikings died out, other Scandinavians (Danes) came back to take control of Greenland, and it was not until 1979 that Native Greenlanders gained home rule. I found it disconcerting throughout my Greenland visit to look at the many blue-eyed blond-haired Scandinavians working there, and to reflect that it was people like them who built Hvalsey Church and the other ruins that I was studying, and who died out there. Why did those medieval Scandinavians ultimately fail to master Greenland's problems while the Inuits succeeded?

Like the fate of the Anasazi, the fate of the Greenland Norse has often been laid to various single-factor explanations, without agreement being reached as to which of those explanations is correct. A favorite theory has been climatic cooling, invoked in overschematic formulations approximating (in the words of archaeologist Thomas McGovern) "It got too cold, and they died." Other single-factor theories have included extermination of the Norse by the Inuit, abandonment of the Norse by mainland Europeans, environmental damage, and a hopelessly conservative outlook. In fact, the Greenland Norse extinction is a richly instructive case precisely because it involves major contributions of all five of the explanatory factors that I discussed in the introduction to this book. It is a rich case not only in reality, but also in our available information about it, because the Norse left written accounts of Greenland (whereas the Easter Islanders and Anasazi were not literate), and because we understand medieval European society much better than we understand Polynesian or Anasazi society. Nevertheless, major questions remain about even this most richly documented pre-industrial collapse.

What was the environment in which the Greenland Norse colonies arose, thrived, and fell? The Norse lived in two settlements on Greenland's west coast somewhat below the Arctic Circle, around latitudes 61 and 64 degrees north. That's south of most of Iceland, and comparable to the latitudes of Bergen and Trondheim on Norway's west coast. But Greenland is colder than either Iceland or Norway, because the latter are bathed by the warm Gulf Stream flowing up from the south, whereas Greenland's west coast is bathed by the cold West Greenland Current flowing down from the Arctic.

As a result, even at the sites of the former Norse settlements, which enjoy the most benign climate in Greenland, the weather can be summed up in four words: cold, variable, windy, and foggy.

Mean summer temperatures today at the settlements are around 42 degrees Fahrenheit (5-6 degrees Celsius) on the outer coast, 50°F (10°C) in the interiors of the fjords. While that doesn't sound so cold, remember that that's only for the warmest months of the year. In addition, strong dry winds frequently blow down from Greenland's ice cap, bringing drift ice from the north, blocking the fjords with icebergs even during the summer, and causing dense fogs. I was told that the large short-term climate fluctuations that I encountered during my summer visit to Greenland, including heavy rain, strong winds, and fog, were common and often made it impossible to travel by boat. But boats are the main means of transport in Greenland, because the coast is so deeply indented with branching fjords. (Even today, there are no roads connecting Greenland's main population centers, and the sole communities joined by road are either located on the same side of the same fjord or else on adjacent different fjords separated by just a low spine of hills.) Such a storm aborted my first attempt to reach Hvalsey Church: I arrived by boat at Qaqortoq in nice weather on July 25, to find ship traffic out of Qaqortoq on July 26 immobilized by wind, rain, fog, and icebergs. On July 27 the weather turned mild again and we reached Hvalsey, and on the following day we steamed back out of Qaqortoq Fjord to Brattahlid under blue skies.

I experienced Greenland weather at its best, at the site of the southernmost Norse settlement in peak summer. As a Southern Californian accustomed to warm sunny days, I would describe the temperatures that I encountered then as "variably cool to cold." I always needed to wear a windbreaker over my T-shirt, long-sleeved shirt, and sweatshirt, and often added as well the thick down parka that I had acquired on my first trip to the Arctic. The temperature seemed to change quickly and in wide swings, repeatedly within each hour. It sometimes felt as if my main occupation while out walking in Greenland consisted of taking my parka on and off to adjust to those frequent changes in temperature.

Complicating this picture I have just drawn of modern Greenland's average climate, the weather can change over short distances and from year to year. The changes over short distances partly account for Christian Keller's comment to me about the importance of finding the good patches of resources in Greenland. The changes from year to year affect each year's growth of pasture hay on which the Norse economy depended, and also af-

feet the quantities of sea ice that in turn affect seal hunting plus the possibility of ship travel for trade, both of which were important to the Vikings. Both the weather changes over short distances and from year to year were critical, as Greenland was at best marginally suitable for Norse hay production, so being at a slightly worse site or in a slightly colder-than-usual year could translate into not having enough hay to feed one's livestock through the winter.

As for the changes with location, an important difference is that one of the two Viking settlements lay 300 miles north of the other, but they were confusingly called Western and Eastern Settlement instead of Northern and Southern Settlement. (Those names had unfortunate consequences centuries later, when the name "Eastern Settlement" misled Europeans looking for the long-lost Greenland Norse to hunt for them in the wrong place, on Greenland's east coast, instead of on the west coast where the Norse had actually lived.) Summer temperatures are as warm at the more northerly Western Settlement as at the Eastern Settlement. However, the summer growing season is shorter at Western Settlement (just five months with average temperatures above freezing, instead of seven months as at Eastern Settlement), because there are fewer summer days of sunlight and warm temperatures as one gets further north. Another change in weather with location is that it is colder, wetter, and foggier on the seacoast at the mouths of fjords, directly exposed to the cold West Greenland Current, than in the sheltered interiors of the fjords far from the sea.

Still another change with location that I couldn't help noticing during my travels in Greenland is that some fjords have glaciers dumping into them, while others don't. Those fjords with glaciers constantly receive icebergs of local origin, while those without glaciers only receive whatever icebergs drift in from the ocean. For example, in July I found Igaliku Fjord (on which lay Viking Greenland's cathedral) free of icebergs, because no glacier flows into it; Eirik's Fjord (on which lay Brattahlid) had scattered icebergs, because one glacier enters that fjord; and the next fjord north of Brattahlid, Sermilik Fjord, has many big glaciers and was solidly clogged with ice. (Those differences, and the great variations of size and shape among the icebergs, were one of the reasons why I found Greenland such a constantly interesting landscape, despite its few colors.) While Christian Keller was studying an isolated archaeological site on Eirik's Fjord, he used to walk over the hill to visit some Swedish archaeologists excavating a site on Sermilik Fjord. The Swedes' campsite was considerably colder than Christians' campsite, and correspondingly the Viking farm that the unfortunate Swedes

had chosen to study had been poorer than the farm that Christian was studying (because the Swedes' site was colder and yielded less hay).

Weather changes from year to year are illustrated by recent experience of hay yields on sheep farms that resumed operation in Greenland beginning in the 1920s. Wetter years yield more growth of vegetation, which generally is good news to pastoralists because it means more hay to feed their sheep, and more grass to nourish the wild caribou (hence more caribou to hunt). However, if too much rain falls during the hay harvest season in August and September, hay yields decrease because the hay is hard to dry. A cold summer is bad because it decreases hay growth; a long winter is bad because it means that animals have to be kept indoors in barns for more months and require more hay; and a summer with much drift ice coming down from the north is bad because it results in dense summer fogs that are bad for hay growth. Year-to-year weather differences like those making life dicey for modern Greenland sheep farmers must have made it dicey for the medieval Norse as well.

Those are the climate changes that one can observe from year to year, or from decade to decade, in Greenland today. What about climate changes in the past? For instance, what was the weather like at the time that the Norse arrived in Greenland, and how did it change over the five centuries that they survived? How can one learn about past climate in Greenland? We have three main sources of information: written records, pollen, and ice cores.

First, because the Greenland Norse were literate and were visited by literate Icelanders and Norwegians, it would have been nice for those of us interested today in the Greenland Vikings' fate if they had bothered to leave some accounts of Greenland's weather then. Unfortunately for us, they didn't. For Iceland, though, we have many accounts of weather in different years—including mentions of cold weather, rainfall, and sea ice—from incidental comments in diaries, letters, annals, and reports. That information about the climate in Iceland is of some use for understanding the climate in Greenland, because a cold decade in Iceland tends to be cold in Greenland as well, though the agreement isn't perfect. We are on more secure ground in interpreting the significance for Greenland of comments about sea ice around Iceland, because that was the ice that made it difficult to sail to Greenland from Iceland or Norway.

Our second source of information about past Greenland climates consists of pollen samples from sediment cores drilled into Greenland lakes and

bogs by palynologists, the scientists who study pollen and whose insights into the vegetational history of Easter Island and the Maya area we already encountered (Chapters 2 and 5). Drilling down into the mud at the bottom of a lake or bog may not strike the rest of us as exciting, but it's nirvana for a palynologist, because the deeper mud layers were deposited longer ago in the past. Radiocarbon dating of organic materials in a mud sample establishes when that particular layer of mud settled out. Pollen grains from different plant species look different under the microscope, so that the pollen grains in your (you the palynologist's) mud sample tell you what plants were growing near your lake or bog and were releasing pollen that fell into it in that year. As past climates became colder in Greenland, palynologists find pollen shifting from that of warmth-demanding trees to that of cold-tolerant grasses and sedges. But that same shift in pollen may also mean that the Norse were cutting down trees, and palynologists have found other ways to distinguish those two interpretations of declining tree pollen.

Finally, by far our most detailed information about Greenland climates in the past comes from ice cores. In Greenland's cold and intermittently wet climate, trees are small, grow only locally, and their timber deteriorates quickly, so we don't have for Greenland the logs with beautifully preserved tree rings that have enabled archaeologists to reconstruct year-to-year climate changes in the dry U.S. southwestern deserts inhabited by the Anasazi. Instead of tree rings, Greenland archaeologists have the good fortune of being able to study ice rings—or, actually, ice layers. Snow that falls each year on Greenland's ice cap becomes compressed by the weight of later years of snow into ice. The oxygen in the water that constitutes snow or ice consists of three different isotopes, i.e., three different types of oxygen atoms differing just in atomic weight because of different numbers of uncharged neutrons in the oxygen nucleus. The overwhelmingly prevalent form of natural oxygen (99.8% of the total) is the isotope oxygen-16 (meaning oxygen of atomic weight 16), but there is also a small proportion (0.2%) of oxygen-18, and an even smaller amount of oxygen-17. All three of those isotopes are stable, not radioactive, but they can still be distinguished by an instrument called a mass spectrometer. The warmer the temperature at which snow forms, the higher is the proportion of oxygen-18 in the snow's oxygen. Hence each year's summer snow is higher in its proportion of oxygen-18 than the same year's winter snow. For the same reason, snow oxygen-18 in a given month of a warm year is higher than in the same month of a cold year.

Thus, as you drill down through the Greenland ice cap (something that

Greenland-ice-cap-drilling scientists have now done down to a depth of almost two miles) and measure the oxygen-18 proportion as a function of depth, you see the oxygen-18 proportion wiggling up and down as you bore through one year's summer ice into the preceding winter's ice and then into the preceding summer's ice, because of the predictable seasonal changes in temperature. You also find oxygen-18 values to differ among different summers or different winters, because of unpredictable year-to-year fluctuations in temperature. Hence the Greenland ice core yields information similar to what archaeologists studying the Anasazi deduce from tree rings: it tells us each year's summer temperature and each year's winter temperature, and as a bonus the thickness of the ice layer between consecutive summers (or between consecutive winters) tells us the amount of precipitation that fell during that year.

There is one other feature of weather about which we can learn from ice cores, but not from tree rings, and that is storminess. Storm winds pick up salt spray from the ocean around Greenland, may blow it far inland over the ice cap, and drop there some of the spray frozen as snow, including the sodium ions in seawater. Onto the ice cap, storm winds also blow atmospheric dust, which originates far away in dry dusty areas of the continents, and that dust is high in calcium ions. Snow formed from pure water lacks those two ions. When one finds high concentrations of sodium and calcium in an ice layer of the ice cap, it may mean that that was a stormy year.

In short, we can reconstruct past Greenland climates from Icelandic records, pollen, and ice cores, and the latter let us reconstruct climate on a year-to-year basis. What have we thereby learned?

As expected, we've learned that the climate warmed up after the end of the last Ice Age around 14,000 years ago; the fjords of Greenland became merely "cool," not "bitterly cold," and they developed low forests. But Greenland's climate hasn't remained boringly steady for the last 14,000 years: it has gotten colder for some periods, then reverted to being milder again. Those climate fluctuations were important to the settling of Greenland by Native American peoples before the Norse. While the Arctic has few prey species—notably reindeer, seals, whales, and fish—those few species are often abundant. But if the usual prey species die out or move away, there may be no alternative prey for hunters to fall back on, as they can at lower latitudes where species are so diverse. Hence the history of the Arctic, including that of Greenland, is a history of people arriving, occupying large areas for many centuries, and then declining or disappearing or having to

change their lifestyle over large areas when climate changes bring changes in prey abundance.

Such consequences of climate changes for native hunters have been observed firsthand in Greenland during the 20th century. A warming of sea temperatures early in that century caused seals almost to disappear from southern Greenland. Good seal hunting returned when the weather got cooler again. Then, when the weather got very cold between 1959 and 1974, populations of migratory seal species plummeted because of all the sea ice, and total sea catches by native Greenland seal hunters declined, but the Greenlanders avoided starvation by concentrating on ringed seals, a species that remained common because it makes holes in the ice through which to breathe. Similar climate fluctuations with consequent changes in prey abundance may have contributed to the first settlement by Native Americans around 2500 B.C., their decline or disappearance around 1500 B.C., their subsequent return, their decline again, and then their complete abandonment of southern Greenland some time before the Norse arrived around A.D. 980. Hence the Norse settlers initially encountered no Native Americans, though they did find ruins left by former populations. Unfortunately for the Norse, the warm climate at the time of their arrival was simultaneously allowing the Inuit people (alias Eskimos) to expand quickly eastwards from Bering Strait across the Canadian Arctic, because the ice that had permanently closed the channels between northern Canadian islands during cold centuries began to melt in the summer, permitting bowhead whales, the mainstay of Inuit subsistence, to penetrate those Canadian Arctic waterways. That climate change allowed the Inuit to enter northwestern Greenland from Canada around A.D. 1200—with big consequences for the Norse.

Between A.D. 800 and 1300, ice cores tell us that the climate in Greenland was relatively mild, similar to Greenland's weather today or even slightly warmer. Those mild centuries are termed the Medieval Warm Period. Thus, the Norse reached Greenland during a period good for growing hay and pasturing animals—good by the standards of Greenland's average climate over the last 14,000 years. Around 1300, though, the climate in the North Atlantic began to get cooler and more variable from year to year, ushering in a cold period termed the Little Ice Age that lasted into the 1800s. By around 1420, the Little Ice Age was in full swing, and the increased summer drift ice between Greenland, Iceland, and Norway ended ship communication between the Greenland Norse and the outside world. Those cold conditions were tolerable or even beneficial for the Inuit, who

could hunt ringed seals, but were bad news for the Norse, who depended on growing hay. As we shall see, the onset of the Little Ice Age was a factor behind the demise of the Greenland Norse. But the climate shift from the Medieval Warm Period to the Little Ice Age was complex, and not a simple matter that "it got steadily colder and killed off the Norse." There had been sprinklings of cold periods before 1300 that the Norse survived, and sprinklings of warm periods after A.D. 1400 that failed to save them. Above all, there remains the nagging question: why didn't the Norse learn to cope with the Little Ice Age's cold weather by watching how the Inuit were meeting the same challenges?

To complete our consideration of Greenland's environment, let's mention its native plants and animals. The best-developed vegetation is confined to areas of mild climate sheltered from salt spray in the long inner fjords of the Western and Eastern Settlements on Greenland's southwest coast. There, vegetation in areas not grazed by livestock varies by location. At higher elevations where it is cold, and in the outer fjords near the sea where plant growth is inhibited by cold, fog, and salt spray, the vegetation is dominated by sedges, which are shorter than grasses and have lower nutritional value to grazing animals. Sedges can grow in these poor locations because they are more resistant to drying out than are grasses, and they can thus establish themselves in gravel containing little water-retaining soil. Inland in areas protected from salt spray, the steep slopes and cold windy sites near glaciers are virtually bare rock without vegetation. Less hostile inland sites mostly support a heath vegetation of dwarf shrubs. The best inland sites—i.e., ones at low elevation, with good soil, protected from the wind, well watered, and with a south-facing exposure that lets them receive much sunlight—carry an open woodland of dwarf birch and willows with some junipers and alders, mostly less than 16 feet tall, in the very best sites with birches up to 30 feet tall.

In areas grazed today by sheep and horses, the vegetation presents a different picture, and would have in Norse times as well (Plate 17). Moist meadows on gentle slopes, such as those around Gardar and Brattahlid, have lush grass up to one foot high, with many flowers. Patches of dwarf willow and birch grazed down by sheep reach only a foot-and-a-half in height. Drier, more sloping and exposed fields carry grasses or dwarf willow up to only a few inches high. Only where grazing sheep and horses have been excluded, such as within the perimeter fence around Narsarsuaq Airport, did I

see dwarf willows and birches up to seven feet tall, stunted by cold wind coming off a nearby glacier.

As for Greenland's wild animals, the ones potentially most important to the Norse and Inuit were land and sea mammals and birds, fish, and marine invertebrates. Greenland's sole native large terrestrial herbivore in the former Norse areas (i.e., not considering the musk ox in the far north) is the caribou, which Lapps and other native peoples of the Eurasian continent domesticated as reindeer but which the Norse and Inuit never did. Polar bears and wolves were virtually confined in Greenland to areas north of the Norse settlements. Smaller game animals included hares, foxes, land birds (of which the largest were grouse relatives called ptarmigans), freshwater birds (the largest being swans and geese), and seabirds (especially eider ducks and auks, a.k.a. alcids). The most important marine mammals were seals of six different species, differing in significance to the Norse and Inuit, related to differences in their distribution and behavior that I shall explain below. The largest of these six species is the walrus. Various species of whales occur along the coast, and were successfully hunted by the Inuit but not by the Norse. Fish abounded in rivers, lakes, and oceans, while shrimp and mussels were the most valuable edible marine invertebrates.

According to sagas and medieval histories, around the year 980 a hot-blooded Norwegian known as Erik the Red was charged with murder and forced to leave for Iceland, where he soon killed a few more people and was chased out to another part of Iceland. Having ended up, there too, in a quarrel and killed still more people, he was this time exiled entirely from Iceland for three years beginning around 982.

Erik remembered that, many decades earlier, one Gunnbjorn Ulfsson had been blown westwards far off course while sailing for Iceland and had spotted some barren small islands, which we now know lay just off Greenland's southeast coast. Those islands had been revisited around 978 by Erik's distant relative Snaebjorn Galti, who of course got into a quarrel of his own there with his shipmates and was duly murdered. Erik sailed for those islands to try his luck, spent the next three years exploring much of the Greenland coast, and discovered good pastureland inside the deep fiords. On his return to Iceland he lost yet another fight, impelling him to lead a fleet of 25 ships to settle the newly explored land that he shrewdly named Greenland. News brought back to Iceland of the fine homesteads available for the asking in Greenland motivated three more fleets of settlers

to sail from Iceland during the next decade. As a result, by A.D. 1000 virtually all the land suitable for farms in both Western and Eastern Settlements had been occupied, yielding an eventual total Norse population estimated at around 5,000: about 1,000 people at Western Settlement, 4,000 at Eastern Settlement.

From their settlements the Norse undertook explorations and annual hunting trips northwards along the west coast, far north of the Arctic Circle. One of those trips may have gotten as far north as latitude 79° N, only 700 miles from the North Pole, where numerous Norse artifacts including pieces of chain mail armor, a carpenter's plane, and ships' rivets were discovered in an Inuit archaeological site. More certain evidence of northwards exploration is a cairn at latitude 73°N containing a runestone (a stone with writing in the Norse runic alphabet), which states that Erling Sighvatsson, Bjarni Thordarson, and Eindridi Oddson erected that cairn on the Saturday before Minor Rogation Day (April 25), probably in some year around 1300.

Greenland Norse subsistence was based on a combination of pastoralism (growing domestic livestock) and hunting wild animals for meat. After Erik the Red brought livestock with him from Iceland, the Greenland Norse proceeded to develop a dependence on additional wild food to a degree much greater than in Norway and Iceland, whose milder climate permitted people to obtain most of their food requirements from pastoralism and (in Norway) gardening alone.

Greenland's settlers started out with aspirations based on the mix of livestock maintained by prosperous Norwegian chiefs: lots of cows and pigs, fewer sheep and still fewer goats, plus some horses, ducks, and geese. As gauged by counts of animal bones identified in radiocarbon-dated Greenland garbage middens from different centuries of Norse occupation, it quickly turned out that that ideal mix was not well suited to Greenland's colder conditions. Barnyard ducks and geese dropped out immediately, perhaps even on the voyage to Greenland: there is no archaeological evidence of their ever having been kept there. Although pigs found abundant nuts to eat in Norway's forests, and although Vikings prized pork above all other meats, pigs proved terribly destructive and unprofitable in lightly wooded Greenland, where they rooted up the fragile vegetation and soil. Within a short time they were reduced to low numbers or virtually eliminated. Archaeological finds of packsaddles and sledges show that horses were kept as work animals, but there was a Christian religious ban against eating them,

so their bones rarely ended up in the garbage. Cows required far more effort than sheep or goats to rear in Greenland's climate, because they could find grass in pastures only during the three snow-free summer months. For the rest of the year they had to be kept indoors in barns and fed on hay and other fodder whose acquisition became the main summer chore of Greenland farmers. The Greenlanders might have been better off to discard their labor-intensive cows, whose numbers did become reduced through the centuries, but they were too prized as status symbols to be eliminated entirely.

Instead, the staple food-producing animals in Greenland became hardy breeds of sheep and goats much better adapted to cold climates than were the cattle. They had the additional advantage that, unlike cows, they can dig down under snow to find grass for themselves in the winter. In Greenland today, sheep can be kept outdoors for nine months per year (three times as long as cows) and have to be brought into shelter and fed for only the three months of heaviest snow cover. Numbers of sheep plus goats started off barely equal to cow numbers at early Greenland sites, and then rose with time to as many as eight sheep or goats for every cow. As between sheep and goats, Icelanders kept six or more of the former for every one of the latter, and that was also the ratio at the best Greenland farms during early years of settlement, but relative numbers shifted with time until goat numbers rivaled those of sheep. That's because goats but not sheep can digest the tough twigs, shrubs, and dwarf trees prevalent in poor Greenland pastures. Thus, while the Norse arrived in Greenland with a preference for cows over sheep over goats, the suitability of those animals under Greenland conditions was in the opposite sequence. Most farms (especially those in the more northerly and hence more marginal Western Settlement) had to content themselves eventually with more of the despised goats and few of the honored cows; only the most productive Eastern Settlement farms succeeded in indulging their cow preference and goat scorn.

The ruins of the barns in which the Greenland Norse kept their cows for nine months per year are still visible. They consisted of long narrow buildings with stone and turf walls several yards thick to keep the barn warm inside during the winter, because cows could not stand cold as could the Greenland breeds of sheep and goats. Each cow was kept in its own rectangular stall, marked off from adjacent stalls by stone dividing slabs that are still standing in many of the ruined barns. From the size of the stalls, from the height of the doors through which cows were led in and out of the barn, and of course from excavated skeletons of the cows themselves, one can calculate that Greenland cows were the smallest known in the modern world,

not more than four feet high at the shoulder. During the winter they remained all the time in their stalls, where the dung that they dropped accumulated as a rising tide around them until the spring, when the sea of dung was shoveled outside. During the winter the cows were fed on harvested hay, but if its quantities weren't sufficient, it had to be supplemented with seaweed brought inland. The cows evidently didn't like the seaweed, so that farm laborers had to live in the barn with the cows and their rising sea of dung during the winter, and perhaps to force-feed the cows, which gradually became smaller and weaker. Around May, when the snow started to melt and new grass came up, the cows could at last be brought out of doors to start grazing themselves, but by then they were so weak that they could no longer walk and had to be carried outside. In extreme winters, when hay and seaweed stores ran out before the new growth of summer grass, farmers collected the first willow and birch twigs of the spring as a starvation diet to feed their animals.

Greenland cows, sheep, and goats were used mainly for milking rather than for meat. After the animals gave birth in May or June, they yielded milk just during the few summer months. The Norse then turned the milk into cheese, butter, and the yogurt-like product called *skyr*, which they stored in huge barrels kept cold by being placed either in mountain streams or in turf houses, and they ate those dairy products throughout the winter. The goats were also kept for their hair, and the sheep for their wool, which was of exceptionally high quality because sheep in those cold climates produce fatty wool that is naturally waterproof. Meat was available from the livestock just at times of culling, especially in the autumn, when farmers calculated how many animals they would be able to feed through the winter on the hay that they had brought in that fall. They slaughtered any remaining animals for which they estimated that they would not have enough winter fodder. Because meat of barnyard animals was thus in short supply, almost all bones of slaughtered animals in Greenland were split and broken to extract the last bits of marrow, far more so than in other Viking countries. At archaeological sites of Greenland Inuit, who were skilled hunters bringing in more wild meat than the Norse, the preserved larvae of flies that feed on rotting marrow and fat are abundant, but those flies found slim pickings at Norse sites.

It took several tons of hay to maintain a cow, much less to maintain a sheep, throughout an average Greenland winter. Hence the main occupation of most Greenland Norse during the late summer had to be cutting, drying, and storing hay. The hay quantities accumulated then were critical

because they determined how many animals could be fed throughout the following winter, but that depended on the duration of that winter, which could not be predicted exactly in advance. Hence each September the Norse had to make the agonizing decision how many of their precious livestock to cull, basing that decision on the amount of fodder available and on their guess as to the length of the coming winter. If they killed too many animals in September, they would end up in May with uneaten hay and just a small herd, and they might kick themselves for not having gambled on being able to feed more animals. But if they killed too few animals in September, they might find themselves running out of hay before May and risk the whole herd starving.

Hay was produced in three types of fields. Most productive would be so-called infields near the main house, fenced to keep livestock out, manured to increase grass growth, and used just for hay production. At the cathedral farm of Gardar and a few other Norse farm ruins, one can see the remains of irrigation systems of dams and channels that spread mountain stream water over the infields to further increase productivity. The second zone of hay production was the so-called outfields, somewhat farther from the main house and outside the fenced-off area. Finally, the Greenland Norse carried over from Norway and Iceland a system called *shielings* or *saeters*, consisting of buildings in more remote upland areas suitable for producing hay and grazing animals during the summer but too cold for keeping livestock during the winter. The most complex shielings were virtually miniature farms, complete with houses where laborers lived during the summer to tend animals and make hay but returned to live on the main farm during the winter. Each year the snow melted off and the grass began to grow first at low altitude and then at increasingly higher altitudes, but new grass is especially high in nutrients and low in less-digestible fiber. Shielings were thus a sophisticated method to help Norse farmers solve the problem of Greenland's patchy and limited resources, by exploiting even temporarily useful patches in the mountains, and by moving livestock gradually uphill to take advantage of the new grass appearing at progressively higher altitudes as the summer went on.

As I mentioned earlier, Christian Keller had told me before we visited Greenland together that "life in Greenland was about finding the best patches." What Christian meant was that, even in those two fjord systems that were the sole areas of Greenland with good potential for pastures, the best areas along those fjords were few and scattered. As I cruised or walked up and down Greenland's fjords, even as a naive city-dweller I felt myself

gradually learning to recognize the criteria by which the Norse would have recognized patches good for being turned into farms. While Greenland's actual settlers from Iceland and Norway had a huge advantage over me as experienced farmers, I had the advantage of hindsight: I knew, and they couldn't know, at which patches Norse farms were actually tried or proved poor or became abandoned. It would have taken years or even generations for the Norse themselves to have weeded out deceptively good-looking patches that eventually proved unsuitable. Jared Diamond's city-dweller criteria for a good medieval Norse farm site are as follows:

1. The site should have a large area of flat or gently sloping lowlands (at elevations below 700 feet above sea level) to develop as a productive infield, because lowlands have the warmest climate and longest snow-free growing season, and because grass growth is poorer on steeper slopes. Among Greenland Norse farms, the cathedral farm of Gardar was preeminent in its expanse of flat lowlands, followed by some of the Vatnahverfi farms.

2. Complementary to this requirement for a large lowland infield is a large area of outfield at mid-elevations (up to 1,300 feet above sea level) for producing additional hay. Calculations show that the area of lowlands alone at most Norse farms would not have yielded enough hay to feed the farm's number of livestock, estimated by counting stalls or measuring areas of ruined barns. Erik the Red's farm at Brattahlid was preeminent in its large area of usable upland.

3. In the northern hemisphere, south-facing slopes receive the most sunlight. That's important so that the winter's snow will melt off earlier in the spring, the growing season for hay production will last more months, and the daily hours of sunlight will be longer. All of the best Norse Greenland farms—Gardar, Brattahlid, Hvalsey, and Sandnes—had south-facing exposures.

4. A good supply of streams is important for watering pastures by natural stream flow or by irrigation systems, to increase hay production.

5. It's a recipe for poverty to place your farm in, near, or facing a glacial valley off of which come cold strong winds that decrease grass growth and increase soil erosion on heavily grazed pastures. Glacial winds were a curse that ensured the poverty of farms at Narssaq and in Sermilik Fjord, and that eventually forced the abandonment of farms at the head of Qoroq Valley and at higher elevations in the Vatnahverfi district.

6. If possible, place your farm directly on a fjord with a good harbor for transporting supplies in and out by boat.

Dairy products alone were not enough to feed the 5,000 Norse inhabitants of Greenland. Gardening was of little use in making up that resulting deficit, because growing crops was so marginal in Greenland's cold climate and short growing season. Contemporary Norwegian documents mentioned that most Greenland Norse never saw wheat, a piece of bread, or beer (brewed from barley) during their entire lives. Today, when Greenland's climate is similar to what it was at the time that the Norse arrived, I saw at the former best Norse farm site of Gardar two small gardens in which modern Greenlanders were growing a few cold-resistant crops: cabbage, beets, rhubarb, and lettuce, which grew in medieval Norway, plus potatoes, which arrived in Europe only after the demise of the Norse Greenland colony. Presumably the Norse, too, could have grown those same crops (other than potatoes) in a few gardens, plus perhaps a little barley in especially mild years. At Gardar and two other Eastern Settlement farms I saw small fields at sites that might have served as Norse gardens, at the base of cliffs that would have retained the sun's heat, and with walls to keep sheep and winds out. But our only direct evidence for gardening by the Greenland Norse is some pollen and seeds of flax, a medieval European crop plant that was not native to Greenland, hence that must have been introduced by the Norse, and that was useful for making linen textiles and linseed oil. If the Norse did grow any other crops, they would have made only an extremely minor contribution to the diet, probably just as an occasional luxury food for a few chiefs and clergy.

Instead, the main other component of the Greenland Norse diet was meat of wild animals, especially caribou and seals, consumed to a far greater extent than in Norway or Iceland. Caribou live in large herds that spend the summer in the mountains and descend to lower elevations during the winter. Caribou teeth found in Norse garbage middens show that the animals were hunted in the fall, probably by bow and arrow in communal drives with dogs (the middens also had bones of big elkhounds). The three main seal species hunted were the common seal (alias harbor seal), which is resident all year round in Greenland and comes out on beaches in inner fjords to bear its pups in the spring, at which time it would have been easy to net from boats or to kill by clubbing; and the migratory harp seal and hooded seal, both of which breed in Newfoundland but arrive in Greenland around May in large herds along the seacoast, rather than in the inner fjords where most Norse farms were located. To hunt those migratory seals, the Norse established seasonal bases on the outer fjords, dozens of miles from any farm.

The May arrival of harp and hooded seals was critical to Norse survival, because at that time of year the stocks of stored dairy products from the previous summer and of caribou meat hunted in the previous fall would be running out, but the snow had not yet disappeared from the Norse farms so that livestock could not yet be put out to pasture, and consequently the livestock had not yet given birth and were not yet producing milk. As we shall see, that made the Norse vulnerable to starvation from a failure of the seal migration, or from any obstacle (such as ice in the fjords and along the coast, or else hostile Inuit) that impeded their access to the migratory seals. Such ice conditions may have been especially likely in cold years when the Norse were already vulnerable because of cold summers and hence low hay production.

By means of measurements of bone composition (so-called carbon isotope analyses), one can calculate the ratio of seafood to land-grown food that the human or animal owner of those bones had consumed over the course of a lifetime. As applied to Norse skeletons recovered from Greenland cemeteries, this method shows that the percentage of seafood (mostly seals) consumed in Eastern Settlement at the time of its founding was only 20% but rose to 80% during the later years of Norse survival: presumably because their ability to produce hay to feed wintering livestock had declined, and also because the increased human population needed more food than their livestock could provide. At any given time, seafood consumption was higher in Western Settlement than in Eastern Settlement, because hay production was lower at Western Settlement's more northerly location. Seal consumption by the Norse population may have been even higher than these measurements indicate, since archaeologists would understandably rather excavate big rich farms than small poor farms, but available bone studies show that people at small poor farms with just a single cow ate more seal meat than did rich farmers. At one poor Western Settlement farm, an astonishing 70% of all animal bones in garbage middens were of seals.

Apart from that heavy reliance on seals and caribou, the Norse obtained minor amounts of wild meat from small mammals (especially hares), seabirds, ptarmigans, swans, eider ducks, beds of mussels, and whales. The latter probably just consisted of the occasional stranded animal; Norse sites contain no harpoons or other whale-hunting equipment. All meat not consumed immediately, whether from livestock or wild animals, would have been dried in storage buildings called *skemmur*, built of uncemented stones for the wind to whistle through and dry out the meat, and located on windy sites like tops of ridges.

Conspicuously nearly absent from Norse archaeological sites are fish, even though the Greenland Norse were descended from Norwegians and Icelanders who spent much time fishing and happily ate fish. Fish bones account for much less than 0.1% of animal bones recovered at Greenland Norse archaeological sites, compared to between 50 and 95% at most contemporary Iceland, northern Norway, and Shetland sites. For instance, the archaeologist Thomas McGovern found the grand total of three fish bones in Norse garbage from Vatnahverfi farms next to lakes teeming with fish, while Georg Nygaard recovered only two fish bones from a total of 35,000 animal bones in the garbage of the Norse farm 034. Even at the GUS site, which yielded the largest number of fish bones—166, representing a mere 0.7% of all animal bones recovered from the site—26 of those bones come from the tail of a single cod, and bones of all fish species are still outnumbered 3 to 1 by bones of one bird species (the ptarmigan) and outnumbered 144 to 1 by mammal bones.

This paucity of fish bones is incredible when one considers how abundant fish are in Greenland, and how saltwater fish (especially haddock and cod) are by far the largest export of modern Greenland. Trout and salmon-like char are so numerous in Greenland's rivers and lakes that, on my first night in the youth hostel at Brattahlid, I shared the kitchen with a Danish tourist cooking two large char, each weighing two pounds and about 20 inches long, that she had caught with her bare hands in a small pool where they had become trapped. The Norse were surely as adept with their hands as that tourist, and they could also have caught fish in fjords with nets while they were netting seals. Even if the Norse didn't want to eat those easily caught fish themselves, they could at least have fed them to their dogs, thereby reducing the amount of seal and other meat that their dogs required, and sparing more meat for themselves.

Every archaeologist who comes to excavate in Greenland refuses initially to believe the incredible claim that the Greenland Norse didn't eat fish, and starts out with his or her own idea about where all those missing fish bones might be hiding. Could the Norse have strictly confined their munching on fish to within a few feet of the shoreline, at sites now underwater because of land subsidence? Could they have faithfully saved all their fish bones for fertilizer, fuel, or feeding to cows? Could their dogs have run off with those fish carcasses, dropped the fish bones in fields chosen with foresight to be ones where future archaeologists would rarely bother to dig, and carefully avoided carrying the carcasses back to the house or midden lest archaeologists subsequently find them? Might the Norse have had so much meat that

they didn't need to eat fish?—but why, then, did they break bones to get out the last bit of marrow? Might all of those little fish bones have rotted away in the ground?—but preservation conditions in Greenland middens are good enough to preserve even sheep lice and sheep fecal pellets. The trouble with all those excuses for the lack of fish bones at Greenland Norse sites is that they would apply equally well to Greenland Inuit and Icelandic and Norwegian Norse sites, where fish bones prove instead to be abundant. Nor do these excuses explain why Greenland Norse sites contain almost no fish-hooks, fish line sinkers, or net sinkers, which are common in Norse sites elsewhere.

I prefer instead to take the facts at face value: even though Greenland's Norse originated from a fish-eating society, they may have developed a taboo against eating fish. Every society has its own arbitrary food taboos, as one of the many ways to distinguish itself from other societies: we virtuous clean people don't eat those disgusting things that those other gross weirdos seem to savor. By far the highest proportion of those taboos involves meat and fish. For instance, the French eat snails and frogs and horses, New Guineans eat rats and spiders and beetle larvae, Mexicans eat goat, and Polynesians eat marine annelid worms, all of which are nutritious and (if you let yourself taste them) delicious, but most Americans would recoil at the thought of eating any of those things.

As for the ultimate reasons why meat and fish so often get tabooed, they are much more likely than plant foods to develop bacteria or protozoa that give us food poisoning or parasites if we eat them. That's especially likely to happen in Iceland and Scandinavia, whose people employ many fermentation methods for long-term preservation of smelly (non-Scandinavians would say "rotting") fish, including methods using deadly botulism-causing bacteria. The most painful illness of my life, worse even than malaria, arose when I contracted food poisoning from eating shrimp that I had bought in a market in Cambridge, England, and that were evidently not fresh. I was confined to bed for several days with awful retching, intense muscle pain, headaches, and diarrhea. That suggests to me a scenario for the Greenland Norse: perhaps Erik the Red, in the first years of the Greenland settlement, got an equally awful case of food poisoning from eating fish. On his recovery, he would have told everybody who would listen to him how bad fish is for you, and how we Greenlanders are a clean, proud people who would never stoop to the unhealthy habits of those desperate grubby ichthyophagous Icelanders and Norwegians.

Greenland's marginality for raising livestock meant that the Greenland Norse had to develop a complex, integrated economy in order to make ends meet. That integration involved both time and space: different activities were scheduled at different seasons, and different farms specialized in producing different things to share with other farms.

To understand the seasonal schedule, let's begin in the spring. In late May and early June came the brief but crucial season of seal hunting, when the migratory harp and hooded seals moved in herds along the outer fjords, and the resident common seals came out on beaches to give birth and were easiest to catch. The summer months of June through August were an especially busy season, when the livestock were brought out to pastures to graze, livestock were yielding milk to turn into storable dairy products, some men set out in boats for Labrador to cut timber, other boats headed north to hunt walruses, and cargo boats arrived from Iceland or Europe for trading. August and early September were hectic weeks of cutting, drying, and storing hay, just before the weeks in September when the cows were led back to barns from pastures and the sheep and goats were brought nearer to shelter. September and October were the season of the caribou hunt, while the winter months from November to April were a time to tend the animals in barns and shelters, to weave, to build and repair with wood, to process the tusks of walrus killed during the summer—and to pray that the stores of dairy products and dried meat for human food, the hay for animal fodder, and the fuel for heating and cooking didn't run out before the winter's end.

Besides that economic integration over time, integration over space was also necessary, because not even the richest Greenland farm was self-sufficient in everything required to survive through the year. That integration involved transfers between outer and inner fjords, between upland and lowland farms, between Western and Eastern Settlement, and between rich and poor farms. For instance, while the best pastures were in the lowlands at the heads of the inner fjords, the caribou hunt took place at upland farms suboptimal for pasturing because of cooler temperatures and a shorter growing season, while the seal hunt was concentrated in outer fjords where salt spray, fog, and cold weather meant poor farming. Those outer fjord hunting sites were beyond reach of inner-fjord farms whenever the fjords froze or filled up with icebergs. The Norse solved these spatial problems by transporting seal and seabird carcasses from outer to inner fjords, and caribou joints downhill from upland to lowland farms. For instance, seal bones remain abundant in the garbage of the highest-elevation inland farms, to which the carcasses must have been carried dozens of miles from the fjord

mouths. At Vatnahverfi farms far inland, seal bones are as common in the garbage as are the bones of sheep and goats. Conversely, caribou bones are even commoner at big rich lowland farms than at the poorer uphill farms where the animals must have been killed.

Because Western Settlement lies 300 miles north of Eastern Settlement, its hay production per acre of pasture was barely one-third that of Eastern Settlement. However, Western Settlement was closer to the hunting grounds for walrus and polar bears that were Greenland's chief export to Europe, as I shall explain. Yet walrus ivory has been found at most Eastern Settlement archaeological sites, where it was evidently being processed during the winter, and ship trade (including ivory export) with Europe took place mainly at Gardar and other big Eastern Settlement farms. Thus, Western Settlement, although much smaller than Eastern Settlement, was crucial to the Norse economy.

Integration of poorer with richer farms was necessary because hay production and grass growth depend especially on a combination of two factors: temperature, and hours of sunlight. Warmer temperatures, and more hours or days of sunlight during the summer growing season, meant that a farm could produce more grass or hay and hence feed more livestock, both because the livestock could graze the grass for themselves during the summer and had more hay to eat during the winter. Hence in a good year the best farms at low elevation, on the inner fjords, or with south-facing exposures produced big surpluses of hay and livestock over and above the amounts required for the farm's human inhabitants to survive, while small poor farms at higher elevations, near the outer fjords, or without south-facing exposures produced smaller surpluses. In a bad year (colder and/or foggier), when hay production was depressed everywhere, the best farms might still have been left with some surplus, albeit a small one. But poorer farms might have found themselves with not even enough hay to feed all their animals through the winter. Hence they would have had to cull some animals in the fall and might at worst have had no animals left alive in the spring. At best, they might have had to divert their herd's entire milk production to rearing calves, lambs, and kids, and the farmers themselves would have had to depend on seal or caribou meat rather than dairy products for their own food.

One can recognize that pecking order of farm quality by the pecking order of space for cows in the ruins of Norse barns. By far the best farm, as reflected in the space for the most cows, was Gardar, unique in having two huge barns capable of holding the grand total of about 160 cows. The barns

at several second-rank farms, such as Brattahlid and Sandnes, could have held 30 to 50 cows each. But poor farms had room for only a few cows, perhaps just a single one. The result was that the best farms subsidized poor farms in bad years by lending them livestock in the spring so that the poor farms could rebuild their herds.

Thus, Greenland society was characterized by much interdependence and sharing, with seals and seabirds being transported inland, caribou downhill, walrus tusks south, and livestock from richer to poorer farms. But in Greenland, as elsewhere in the world where rich and poor people are interdependent, rich and poor people didn't all end up with the same average wealth. Instead, different people ended up with different proportions of high-status and low-status foods in their diets, as reflected in counts of bones of different animal species in their garbage. The ratio of high-status cow to lower-status sheep bones, and of sheep to bottom-status goat bones, tends to be higher on good than on poorer farms, and higher on Eastern than on Western Settlement farms. Caribou bones, and especially seal bones, are more frequent at Western than at Eastern Settlement sites because Western Settlement was more marginal for raising livestock and was also near larger areas of caribou habitat. Among those two wild foods, caribou is better represented at the richest farms (especially Gardar), while people at poor farms ate much more seal. Having forced myself out of curiosity to taste seal while I was in Greenland, and not gotten beyond the second bite, I can understand why people from a European dietary background might prefer venison over seal if given the choice.

As an illustration of these trends with some actual numbers, the garbage of the poor Western Settlement farm known as W48 or Niaquusat tells us that the meat consumed by its unfortunate inhabitants came to the horrifying extent of 85% from seals, with 6% from goats, only 5% from caribou, 3% from sheep, and 1% (O rare blessed day!) from beef. At the same time, the gentry at Sandnes, the richest Western Settlement farm, was enjoying a diet of 32% caribou venison, 17% beef, 6% sheep, and 6% goat, leaving only 39% to be made up by seal. Happiest of all was the Eastern Settlement elite at Erik the Red's farm of Brattahlid, who succeeded in elevating beef consumption above either caribou or sheep, and suppressing goat to insignificant levels.

Two poignant anecdotes further illustrate how high-status people got to eat preferred foods much less available to low-status people even on the same farm. First, when archaeologists excavated the ruins of the Cathedral of St. Nicholas at Gardar, they found under the stone floor the skeleton of a

man holding a bishop's staff and ring, probably John Arnason Smyrill, who served as Greenland's bishop from 1189 to 1209. Carbon isotope analysis of his bones shows that his diet had consisted 75% of land-based foods (probably mostly beef and cheese) and only 25% of marine foods (mostly seal). A contemporary man and woman whose skeletons were buried immediately beneath the bishop's, and who thus were presumably also of high status, had consumed a diet somewhat higher (45%) in marine food, but that percentage ranged up to 78% for other skeletons from Eastern Settlement, and 81% from Western Settlement. Second, at Sandnes, the richest farm in Western Settlement, the animal bones in the garbage outside the manor house proved that its occupants were eating plenty of caribou and livestock and not much seal. Only fifty yards away was a barn in which animals would have been kept for the winter, and in which farm workers would have lived then along with the animals and the manure. The garbage dump outside that barn showed that those workers had to content themselves with seal and had little caribou, beef, or mutton to enjoy.

The complexly integrated economy that I have described, based on raising livestock, hunting on land, and hunting in the fiords, enabled the Greenland Norse to survive in an environment where no one of those components alone was sufficient for survival. But that economy also hints at a possible reason for the Greenlanders' eventual demise, because it was vulnerable to failure of any of those components. Many possible climatic events could raise the specter of starvation: a short, cool, foggy summer, or a wet August, that decreased hay production; a long snowy winter that was hard on both the livestock and the caribou, and that increased the winter hay requirements of the livestock; ice pile-up in the fjords, impeding access to the outer fiords during the May-June sealing season; a change in ocean temperatures, affecting fish populations and hence the populations of fish-eating seals; or a climate change far away in Newfoundland, affecting harp and hooded seals on their breeding grounds. Several of these events have been documented in modern Greenland: for instance, the cold winter and heavy snows of 1966-1967 killed 22,000 sheep, while migratory harp seals during the cold years of 1959-1974 fell to a mere 2% of their former numbers. Even in the best years, Western Settlement was closer to the margin for hay production than was Eastern Settlement, and a drop in summer temperature by a mere 1°C would suffice to cause failure of the hay crop at the former location.

The Norse could cope with livestock losses from one bad summer or bad winter, provided that it was followed by a series of good years enabling

them to rebuild their herds, and provided that they could hunt enough seal and caribou to eat during those years. More dangerous was a decade with several bad years, or a summer of low hay production followed by a long snowy winter necessitating much hay for feeding livestock indoors, in combination with a crash in seal numbers or else anything impeding spring access to the outer fjords. As we shall see, that was what actually happened eventually at Western Settlement.

Five adjectives, mutually somewhat contradictory, characterize Greenland Norse society: communal, violent, hierarchical, conservative, and Eurocentric. All of those features were carried over from the ancestral Icelandic and Norwegian societies, but became expressed to an extreme degree in Greenland.

To begin with, Greenland's Norse population of about 5,000 lived on 250 farms, with an average of 20 people per farm, organized in turn into communities centered on 14 main churches, with an average of about 20 farms per church. Norse Greenland was a strongly communal society, in which one person could not go off, make a living by himself or herself, and hope to survive. On the one hand, cooperation among people of the same farm or community was essential for the spring seal hunt, summer Nordrseta hunt (described below), late-summer hay harvest, and autumn caribou hunt and for building, each of which activities required many people working together and would have been inefficient or impossible for a single person alone. (Imagine trying to round up a herd of wild caribou or seals, or lifting a 4-ton stone of a cathedral into place, by yourself.) On the other hand, cooperation was also necessary for economic integration between farms and especially between communities, because different Greenland locations produced different things, such that people at different locations depended on each other for the things that they did not produce. I already mentioned the transfers of seals hunted at the outer fjords to the inner fjords, of caribou meat hunted at upland sites to lowland sites, and of livestock from rich to poor farms when the latter lost their animals in a harsh winter. The 160 cattle for which the Gardar barns contained stalls far exceeded any conceivable local needs at Gardar. As we shall see below, walrus tusks, Greenland's most valuable export, were acquired by a few Western Settlement hunters in the Nordrseta hunting grounds but were then distributed widely among Western and Eastern Settlement farms for the laborious task of processing before export.

Belonging to a farm was essential both to survival and to social identity. Every piece of the few useful patches of land in the Western and Eastern Settlements was owned either by some individual farm or else communally by a group of farms, which thereby held the rights to all of that land's resources, including not only its pastures and hay but also its caribou, turf, berries, and even its driftwood. Hence a Greenlander wanting to go it alone couldn't just go off hunting and foraging for himself. In Iceland, if you lost your farm or got ostracized, you could try living somewhere else—on an island, an abandoned farm, or the interior highlands. You didn't have that option in Greenland, where there wasn't any "somewhere else" to which to go.

The result was a tightly controlled society, in which the few chiefs of the richest farms could prevent anyone else from doing something that seemed to threaten their interests—including anyone experimenting with innovations that did not promise to help the chiefs. At the top, Western Settlement was controlled by Sandnes, its richest farm and its sole one with access to the outer fjords, while Eastern Settlement was controlled by Gardar, its richest farm and the seat of its bishop. We shall see that this consideration may help us understand the eventual fate of Greenland Norse society.

Also carried to Greenland from Iceland and Norway along with this communality was a strong violent streak. Some of our evidence is written: when Norway's King Sigurd Jorsalfar proposed in 1124 to a priest named Arnald that Arnald go to Greenland as its first resident bishop, Arnald's excuses for not wanting to accept included that the Greenlanders were such cantankerous people. To which the shrewd king replied, "The greater the trials that you suffer at the hands of men, the greater will be your own merits and rewards." Arnald accepted on condition that a highly respected Greenland chief's son named Einar Sökkason swear to defend him and the Greenland church properties, and to smite his enemies. As related in Einar Sökkason's saga (see synopsis following), Arnald did get involved in the usual violent quarrels when he reached Greenland, but he handled them so skillfully that all the main litigants (including even Einar Sökkason) ended up killing each other while Arnald retained his life and authority.

The other evidence for violence in Greenland is more concrete. The church cemetery at Brattahlid includes, in addition to many individual graves with neatly placed whole skeletons, a mass grave dating from the earliest phase of the Greenland colony, and containing the disarticulated bones of 13 adult men and one nine-year-old child, probably a clan party that lost a feud. Five of those skeletons bear skull wounds inflicted by a sharp instrument, presumably an axe or sword. While two of the skull wounds show

A Typical Week in the Life of a Greenland Bishop: The Saga of Einar Sökkason

While off hunting with 14 friends, Sigurd Njalsson found a beached ship full of valuable cargo. In a nearby hut were the stinking corpses of the ship's crew and its captain Arnbjorn, who had died of starvation. Sigurd brought the bones of the crew back to Gardar Cathedral for burial, and donated the ship itself to Bishop Arnald for the benefit of the corpses of the souls. As for the cargo, he asserted finders/keepers rights and divided it among his friends and himself.

When Arnbjorn's nephew Ozur heard the news, he came to Gardar, together with the relatives of others of the dead crew. They told the Bishop that they felt entitled to inherit the cargo. But the Bishop answered that Greenland law specified finders/keepers, that the cargo and ship should now belong to the church to pay for masses for the souls of the dead men who had owned the cargo, and that it was shabby of Ozur and his friends to claim the cargo now. So Ozur filed a suit in the Greenland Assembly, attended by Ozur and all his men and also by Bishop Arnald and his friend Einar Sökkason and many of their men. The court ruled against Ozur, who didn't like the ruling at all and felt humiliated, so he ruined Sigurd's ship (now belonging to Bishop Arnald) by cutting out planks along the full length of each side. That made the Bishop so angry that he declared Ozur's life forfeit.

While the Bishop was saying holiday mass in church, Ozur was in the congregation and complained to the Bishop's servant about how badly the Bishop had treated him. Einar seized an axe from the hand of another worshipper and struck Ozur a death-blow. The Bishop asked Einar, "Einar, did you cause Ozur's death?" "Very true," said Einar, "I have." The Bishop's response was: "Such acts of murder are not right. But this particular one is not without justification." The Bishop didn't want to give Ozur a church burial, but Einar warned that big trouble was on its way.

In fact, Ozur's relative Simon, a big strong man, said that this was not the time for merely big talk. He gathered his friends Kolbein Thorljotsson, Keitel Kalfsson, and many men from Western Settle-

Dating from later years of the Greenland colony, at a time when axes and swords had become vanishingly rare because of scarcity of iron, are skulls of four adult women and one eight-year-old child, each with one or two sharp-edged holes between half an inch and one inch in diameter and evidently made by a crossbow bolt or arrow. Domestic violence is suggested by the skeleton of a 50-year-old woman at Gardar Cathedral with a fractured throat bone called the hyoid; forensic pathologists have learned to interpret a fractured hyoid as evidence that the victim was strangled by a hand choke hold.

Along with that violent streak coexisting uneasily with an emphasis on communal cooperation, the Greenland Norse also carried over from Iceland and Norway a sharply stratified, hierarchically organized social organization, such that a small number of chiefs dominated owners of small farms, tenants who didn't even own their own farms, and (initially) slaves. Again like Iceland, Greenland politically was not organized as a state but as a loose federation of chiefdoms operating under feudal conditions, with neither money nor a market economy. Within the first century or two of the Greenland colony, slavery disappeared, and the slaves became freedmen. However, the number of independent farmers probably decreased with time as they were forced into becoming tenants of the chiefs, a process that is well documented in Iceland. We don't have corresponding records for the process in Greenland, but it seems likely there too, because the forces promoting it were even more marked in Greenland than in Iceland. Those forces consisted of climate fluctuations driving poorer farmers in bad years into debt to richer farmers who lent them hay and livestock, and who could eventually foreclose on them. Evidence of those farm hierarchies is still visible today among Greenland farm ruins: compared to poor farms, the best-located farms had a larger area of good pasture, larger cow and sheep barns with stalls for more animals, bigger hay barns, larger houses, larger churches, and smithies. The hierarchies are also visible today as the higher ratios of cow and caribou bones to sheep and seal bones in garbage middens at rich farms compared to those at poor farms.

Still like Iceland, Viking Greenland was a conservative society resistant to change and sticking to old ways, compared to the society of the Vikings who remained behind in Norway. Over the centuries, there was little change in styles of tools and of carvings. Fishing was abandoned in the earliest years of the colony, and Greenlanders did not reconsider that decision during the four-and-a-half centuries of their society's existence. They did not learn from the Inuit how to hunt ringed seals or whales, even though that

meant not eating locally common foods, and starving as a result. The ultimate reason behind that conservative outlook of the Greenlanders may have been the same as the reason to which my Icelandic friends attribute their own society's conservatism. That is, even more than the Icelanders, the Greenlanders found themselves in a very difficult environment. While they succeeded in developing an economy that let them survive there for many generations, they found that variations on that economy were much more likely to prove disastrous than advantageous. That was good reason to be conservative.

The remaining adjective that characterizes Greenland Norse society is "Eurocentric." From Europe, the Greenlanders received material trade goods, but even more important were non-material imports: identities as Christians, and as Europeans. Let us consider first the material trade. What trade items were imported into Greenland, and with what exports did the Greenlanders pay for those imports?

For medieval sailing ships, the voyage to Greenland from Norway took a week or more and was dangerous; annals often mention shipwrecks, or ships that sailed and were never heard from again. Hence the Greenlanders were visited by at most a couple of European ships a year, and sometimes only one every few years. In addition, the capacities of European cargo ships in those days were small. Estimates of the frequency of ship visits, ship capacities, and Greenland's population let one calculate that imports worked out to about seven pounds of cargo per person per year—on the average. Most Greenlanders received much less than that average, because much of that arriving cargo capacity was devoted to materials for churches and luxuries for the elite. Hence imports could only be valuable items occupying little space. In particular, Greenland had to be self-sufficient in food and could not depend on bulk imports of cereals and other food staples.

Our two sources of information about Greenland's imports are lists in Norwegian records, and items of European origin found in Greenland archaeological sites. They included especially three necessities: iron that the Greenlanders were hard-pressed to produce for themselves; good lumber for buildings and furniture, of which they were equally short; and tar as a lubricant and wood preservative. As for non-economic imports, many were for the church, including church bells, stained glass windows, bronze candlesticks, communion wine, linen, silk, silver, and churchmen's robes and jewelry. Among secular luxuries found in archaeological sites at farm-

houses were pewter, pottery, and glass beads and buttons. Small-volume luxury food imports probably included honey to ferment into mead, plus salt as a preservative.

In exchange for those imports, the same consideration of limited ship cargo capacity would have prevented Greenlanders from exporting bulk fish, as did medieval Iceland and as does modern Greenland, even if Greenlanders had been willing to fish. Instead, Greenland's exports, too, had to be things of low volume and high value. They included skins of goats, cattle, and seals, which Europeans could also obtain from other countries but of which medieval Europe required large quantities to make leather clothes, shoes, and belts. Like Iceland, Greenland exported wool cloth that was valued for being water-repellent. But Greenland's most prized exports mentioned in Norwegian records were five products derived from Arctic animals rare or absent in most of Europe: walrus ivory from walrus tusks, walrus hide (valued because it yielded the strongest rope for ships), live polar bears or their hides as a spectacular status symbol, tusks of the narwhal (a small whale) known then in Europe as unicorn horns, and live gyrfalcons (the world's largest falcon). Walrus tusks became the only ivory available in medieval Europe for carving after Moslems gained control of the Mediterranean, thereby cutting off supplies of elephant ivory to Christian Europe. As an example of the value placed on Greenland gyrfalcons, 12 of those birds sufficed in 1396 to ransom the Duke of Burgundy's son after he was captured by the Saracens.

Walruses and polar bears were virtually confined to latitudes far to the north of the two Norse settlements, in an area called the Nordrseta (the northern hunting ground), which began several hundred miles beyond Western Settlement and stretched farther north along Greenland's west coast. Hence each summer the Greenlanders sent out hunting parties in small, open, six-oared rowboats with sails, which could cover about 20 miles per day and could hold up to a ton-and-a-half of cargo. Hunters set off in June after the peak of the harp seal hunt, taking two weeks to reach the Nordrseta from Western Settlement or four weeks from Eastern Settlement, and returning again at the end of August. In such small boats they obviously could not carry the carcasses of hundreds of walruses and polar bears, each of which weighs about a ton or half-a-ton respectively. Instead, the animals were butchered on the spot, and only the walrus jaws with the tusks, and the bear skins with the paws (plus the occasional live captive bear), were brought home, for the tusks to be extracted and the skin to be cleaned at leisure back in the settlements during the long winter. Also

brought home was the baculum of male walrus, a bone like a straight rod about one foot long that forms the core of the walrus penis, because it proved to be of just the right size and shape (and, one suspects, conversation value) to make into an axe handle or a hook.

The Nordrseta hunt was dangerous and expensive in many ways. To begin with, hunting walrus and polar bears without a gun must have been very dangerous. Please imagine yourself, equipped with just a lance, spear, bow and arrow, or club (take your choice) trying to kill a huge enraged walrus or bear before it could kill you. Please also imagine yourself spending several weeks in a small rowboat shared with a live, trussed-up polar bear or its cubs. Even without a live bear as companion, the boat journey itself along the cold stormy coast of West Greenland exposed hunters to risk of death from shipwreck or exposure for several weeks. Apart from those dangers, the trip constituted expensive use of boats, manpower, and summer time for people short of all three. Because of Greenland's scarcity of lumber, few Greenlanders owned boats, and using those precious boats to hunt walrus came at the expense of other possible uses of the boats, such as going to Labrador to acquire more lumber. The hunt took place in the summer, when men were needed to harvest the hay required to feed livestock through the winter. Much of what the Greenlanders obtained materially by trade with Europe in return for those walrus tusks and bearskins was just luxury goods for churches and chiefs. From our perspective today, we can't help thinking of seemingly more important uses that the Greenlanders could have made of those boats and man-time. From the Greenlanders' perspective, though, the hunt must have brought great prestige to the individual hunters, and it maintained for the whole society the psychologically vital contact with Europe.

Greenland's trade with Europe was mainly through the Norwegian ports of Bergen and Trondheim. While at first some cargo was carried in ocean-going ships belonging to Icelanders and to the Greenlanders themselves, those ships as they aged could not be replaced due to the islands' lack of timber, leaving the trade to Norwegian ships. By the mid 1200s, there were often periods of several years in which no ship at all visited Greenland. In 1257 Norway's King Haakon Haakonsson, as part of his effort to assert his authority over all of the Norse Atlantic island societies, sent three commissioners to Greenland to persuade the hitherto-independent Greenlanders to acknowledge his sovereignty and pay tribute. Although the details of the resulting agreement have not been preserved, some documents suggest that Greenland's acceptance of Norwegian sovereignty in 1261 was in return for

the king's promise to dispatch two ships each year, similar to his simultaneous agreement with Iceland which we know stipulated six ships each year. Thereafter, Greenland's trade became a Norwegian royal monopoly. But Greenland's association with Norway remained loose, and Norwegian authority difficult to enforce because of Greenland's distance. We know for sure only that a royal agent resided in Greenland at various times during the 1300s.

At least as important as Europe's material exports to Greenland were its psychological exports of Christian identity and European identity. Those two identities may explain why the Greenlanders acted in ways that—we today would say with the value of hindsight—were maladaptive and ultimately cost them their lives, but that for many centuries enabled them to maintain a functioning society under the most difficult conditions faced by any medieval Europeans.

Greenland converted to Christianity around A.D. 1000, at the same time as the conversions of Iceland and the other Viking Atlantic colonies, and of Norway itself. For more than a century the Greenland churches remained small structures built of turf on some farmer's land, mainly on the largest farms. Most likely, as in Iceland, they were so-called proprietary churches, built and owned by the landowning farmer, who received part of the tithes paid to that church by its local members.

But Greenland still had no resident bishop, whose presence was required for performing confirmations and for a church to be considered consecrated. Hence around 1118 that very same Einar Sokkason whom we have already encountered as a saga hero killed by an axe blow from behind was sent by the Greenlanders to Norway in order to persuade its king to provide Greenland with a bishop. As inducements, Einar took along to give the king a large supply of ivory, walrus hides, and—best of all—a live polar bear. That did the trick. The king, in turn, persuaded that Arnald whom we already met in Einar Sokkason's saga to become Greenland's first resident bishop, to be followed by about nine others over the succeeding centuries. Without exception, all were born and educated in Europe and came to Greenland only upon their appointment as bishop. Not surprisingly, they looked to Europe for their models, preferred beef over seal meat, and directed resources of Greenland society to the Nordrseta hunt that enabled them to buy wine and vestments for themselves, and stained glass windows for their churches.

A big construction program of churches modeled on European churches followed Arnald's appointment, and continued to around 1300, when the lovely church at Hvalsey was erected as one of the last. Greenland's ecclesiastical establishment came to consist of one cathedral, about 13 large parish churches, many smaller churches, and even a monastery and a nunnery. While most of the churches were built with stone lower walls and turf upper walls, Hvalsey Church and at least three others had walls entirely of stone. These big churches were all out of proportion to the size of the tiny society that erected and supported them.

For instance, St. Nicholas's Cathedral at Gardar, measuring 105 feet long by 53 feet wide, was as large as either of the two cathedrals of Iceland, whose population was ten times that of Greenland. I estimated the largest of the stone blocks of its lower walls, carefully carved to fit each other and transported from sandstone quarries at least a mile distant, to weigh about three tons. Even larger was a flagstone of about 10 tons in front of the bishop's house. Adjacent structures included a bell tower 80 feet high, and a ceremonial hall with a floor area of 1,400 square feet, the largest hall in Greenland and nearly three-quarters the size of the hall of the archbishop of Trondheim in Norway. On an equally lavish scale were the cathedrals' two cow barns, one of them 208 feet long (the largest barn in Greenland) and fitted with a stone lintel weighing about four tons. As a splendid welcome to visitors, the cathedral's grounds were decorated with about 25 complete walrus skulls and five narwhal skulls, which may be the only ones preserved at any Greenland Norse site: otherwise, archaeologists have found only chips of ivory, because it was so valuable and was almost all exported to Europe.

Gardar Cathedral and the other Greenland churches must have consumed horrifyingly large amounts of scarce timber to support their walls and roofs. Imported church paraphernalia, such as bronze bells and communion wine, were also expensive to Greenlanders because they were ultimately bought with the sweat and blood of Nordrseta hunters and competed against essential iron for the limited cargo space on arriving ships. Recurrent expenses that their churches cost the Greenlanders were an annual tithe paid to Rome, and additional Crusade tithes levied on all Christians. These tithes were paid with Greenland exports shipped to Bergen and converted to silver there. A surviving receipt for one such shipment, the six-year Crusade Tithe of 1274-1280, shows that it consisted of 1,470 pounds of ivory from the tusks of 191 walruses, which Norway's archbishop managed to sell for 26 pounds of pure silver. That the Church was able to extract such tithes

and complete such building programs testifies to the authority it commanded in Greenland.

Church-associated land ultimately came to comprise much of the best land in Greenland, including about one-third of the land of Eastern Settlement. Greenland's church tithes, and possibly its other exports to Europe, went through Gardar, where one can still see the ruins of a large storage shed standing immediately next to the cathedral's southeast corner. With Gardar thus boasting Greenland's largest storage building, as well as by far its largest cattle herd and richest land, whoever controlled Gardar controlled Greenland. What remains unclear is whether Gardar and the other church farms in Greenland were owned by the Church itself or else by the farmers on whose land the churches stood. But whether authority and ownership rested with the bishop or with the chiefs doesn't alter the main conclusion: Greenland was a hierarchical society, with great differences of wealth justified by the Church, and with disproportionate investment in churches. Again, we moderns have to wonder if the Greenlanders wouldn't have been better off had they imported fewer bronze bells, and more iron with which to make tools, weapons to defend themselves against the Inuit, or goods to trade with the Inuit for meat in times of stress. But we ask our question with the gift of hindsight, and without regard to the cultural heritage that led the Greenlanders to make their choices.

Besides that specific identity as Christians, Greenlanders maintained their European identity in many other ways, including their importation of European bronze candlesticks, glass buttons, and gold rings. Over the centuries of their colony's existence, the Greenlanders followed and adopted changing European customs in detail. One well-documented set of examples involves burial customs, as revealed by excavations of bodies in Scandinavian and Greenland churchyards. Medieval Norwegians buried infants and stillborns around a church's east gable; so did the Greenlanders. Early medieval Norwegians buried bodies in coffins, with women on the south side of churchyards and men on the north side; later Norwegians dispensed with coffins, just wrapped bodies in clothing or a shroud, and mingled the sexes in the churchyard. Greenlanders made those same shifts with time. In continental European cemeteries throughout the Middle Ages, bodies were laid out on their backs with the head towards the west and the feet towards the east (so that the deceased could "face" east), but the position of the arms changed with time: until 1250 the arms were arranged to extend parallel to the sides, then around 1250 they were bent slightly over the pelvis, later bent

further to rest over the stomach, and finally in the late Middle Ages folded tightly over the chest. Even those shifts in arm positions are observed in Greenland cemeteries.

Greenland church construction similarly followed Norwegian European models and their changes with time. Any tourist accustomed to European cathedrals, with their long nave, west-facing main entrance, chancel, and north and south transepts, will immediately recognize all those features in the stone ruins of Gardar Cathedral today. Hvalsey Church so closely resembles Eidfjord Church in Norway that we can conclude that Greenlanders must either have brought over the same architect or else copied the blueprints. Between 1200 and 1225, Norwegian builders abandoned their previous unit of linear measurement (the so-called international Roman foot) and adopted the shorter Greek foot; Greenland builders followed suit.

Imitation of European models extended to homely details like combs and clothes. Norwegian combs were single-sided, with the tines on just one side of the shaft, until around 1200, when those combs went out of fashion and were replaced by two-sided models with sets of tines projecting in opposite directions; Greenlanders followed that switch in comb styles. (That calls to mind Henry Thoreau's comment, in his book *Walden*, about people who slavishly adopt the latest style of fashion designers in a distant land: "The head monkey at Paris puts on a traveler's cap, and all the monkeys in America do the same.") The excellent preservation of garments wrapped around the corpses buried in the permafrost at Herjolfsnes Churchyard from the final decades of the Greenland colony's existence shows us that Greenland clothes followed smart European fashions, even though they seem far less appropriate to Greenland's cold climate than the Inuit one-piece tailored parka with fitted sleeves and attached hood. Those clothes of the last Greenland Norse included: for women, a long, low-necked gown with a narrow waist; for men, a sporty coat called a *houpelande*, which was a long loose outer garment held in by a belt at the waist and with loose sleeves up which the wind could whistle; jackets buttoned up the front; and tall cylindrical caps.

All these adoptions of European styles make it obvious that the Greenlanders paid very close attention to European fashions and followed them in detail. The adoptions carry the unconscious message, "We are Europeans, we are Christians, God forbid that anyone could confuse us with the Inuit." Just as Australia, when I began visiting it in the 1960s, was more British than Britain itself, Europe's most remote outpost of Greenland remained emotionally tied to Europe. That would have been innocent if the ties had ex-

pressed themselves only in two-sided combs and in the position in which the arms were folded over a corpse. But the insistence on "We are Europeans" becomes more serious when it leads to stubbornly maintaining cows in Greenland's climate, diverting manpower from the summer hay harvest to the Nordrseta hunt, refusing to adopt useful features of Inuit technology, and starving to death as a result. To us in our secular modern society, the predicament in which the Greenlanders found themselves is difficult to fathom. To them, however, concerned with their social survival as much as with their biological survival, it was out of the question to invest less in churches, to imitate or intermarry with the Inuit, and thereby to face an eternity in Hell just in order to survive another winter on Earth. The Greenlanders' clinging to their European Christian image may have been a factor in their conservatism that I mentioned above: more European than Europeans themselves, and thereby culturally hampered in making the drastic lifestyle changes that could have helped them survive.