Death in Norse Greenland

By combining data from ice cores, archaeological digs, and fossil flies, researchers have shown how increasing cold and an inflexible culture could have doomed this medieval Norse outpost

In the 10th century A.D., the inhospitable coast of Greenland was transformed into Europe's westernmost outpost. Settlers from Scandinavia founded two major settlements on the narrow fringe of land between the ice sheet and the sea, and raised dairy cattle and sheep in the face of glacial cold and fierce winter gales. The Norse, an estimated 5000 to 6500 strong at the colony's height, built stone churches and apparently traded walrus ivory and a live polar bear in order to get their own bishop. Then, in one of the great mysteries of medieval history, the colony foundered. By 1361, a seafaring Norwegian priest, Ivar Bárdarson, and his companions reported Greenland's Western Settlement eerily empty. "They found nobody, either Christians or heathens, only some wild cattle and sheep," noted an anonymous author who recorded Bárdarson's journey in a mid–14th century text. By 1500, archaeological and historical evidence shows, the Norse settlers had utterly vanished.

Just what happened continues to be the subject of debate. Some researchers, influenced by rare medieval accounts of hostilities, pin the blame on warring Thule hunters—ancestors of the modern Inuit who migrated from Ellesmere Island in about A.D. 1100. No archaeological evidence has ever surfaced to support this idea, however, and others have favored changes in climate. The North Atlantic region was unusually mild when the Norse first settled Greenland, then plunged into a 500-year cold spell known as the Little Ice Age starting about 1300. Now, researchers are bringing many different types of data together to paint the clearest picture yet of the Norse colony's last days and the forces that led to its demise.

The data sources for these international, interdisciplinary studies range from fossil flies to a model of the settlers' economy to the latest records of seasonal climate change, teased out of core samples of Greenland ice. The results show that worsening climate was at least partly to blame, as reported last year by Paul Buckland, a paleoecologist at the University of Sheffield in the United Kingdom, and colleagues. But researchers have now also found that the colony's economy was fragile from the start. Spurning fishing and Inuit hunting methods in favor of traditional Norse dairy farming, the colony had teetered dangerously close to extinction throughout its history. In the end, a 20-year series of cool summers was apparently enough to trigger abandonment of one of the two major settlements, says Tom McGovern, a zooarchaeologist at the City University of New York (CUNY). The real mystery, adds Buckland, is not why the Norse died out, but why they clung to such a poorly adapted economy for 5 centuries. "They lived on the edge from the beginning to the end," he says. "It didn't take much to push them over."

Many of the new studies were done under the auspices of a 5-year-old research cooperative called the North Atlantic Biocultural Organization (NABO)* headquartered at CUNY, which focuses on the North Atlantic region since the Iron Age. And the collaboration between these archaeologists and the physical scientists of the ice-core program—the Greenland Ice Sheet Project Two (GISP2)—draws kudos from the research community. The fate of the Norse "was one of those mysteries that no one has ever known completely," says Noel Broadbent, program director for the Arctic Social Sciences program at the National Science Foundation, which has just awarded NABO $208,000 for workshops, publications, and fieldwork on subjects ranging from Norse settlement to hunting and gathering cultures in Labrador. "What [the NABO team has] done is bring all these scholars together from a number of different disciplines and put them on the issue [of Norse extinction]. And it creates a much greater dynamic. There's not enough of this kind of science done." This new approach has yielded new insight, agrees William Fitzhugh, an Arctic archaeologist at the National Museum of Natural History in Washington. "There's no doubt there has been a climatic impact," he says. "And it can be significant in a place like the North Atlantic where agricultural societies cherished the European way of life and [were] not adapting to the environment."

A farther shore. The Norse settled Greenland's west coast, but couldn't sustain their way of life.

The Norse way of life

Much of the new research draws on data gleaned from the most northerly of the Norse outposts, the Western Settlement near modern-day Nuuk (see map), where four separate archaeological teams have conducted extensive digs since the mid-1970s. To understand the Norse economy, McGovern spent nearly 2 decades studying animal bones from these digs and from previously excavated Eastern Settlement sites. He and colleagues identified tens of thousands of bones by species and analyzed the contributions of livestock and wild game to the Norse diet. Combining these results with details from the Icelandic sagas and other data, such as the habits of wild game, McGovern sketched the medieval settlers' seasonal rounds.

He found that they journeyed north in summer to hunt walrus for ivory to trade with Europe and spent winters tending sheep, goats, and cattle confined in byres. The Norse also hunted caribou as well as migratory harp and common seals in pupping areas. But they apparently did little fishing: McGovern's 2 decades of study turned up very little fish bone, and excavations in both settlements have turned up almost no fishing gear. Buckland's recent findings, in press in a Columbia University monograph, confirm this: After screening nearly 1 metric ton of house floor and midden sediments through 300-micrometer mesh, he and his associates gleaned only one skate tooth and three fish vertebrae. "So this is a nonmaritime culture on the edge of the sea," says Buckland. "It's very strange."

To examine the effects of climate on this economy, McGovern and colleagues at CUNY devised a series of computer simulations, using archaeological data on such variables as the sizes of pastures and the number of cattle

* For more on NABO, see its Web site at http://maxweber.hunter.cuny.edu/anthro.

stalls—and therefore cattle—in each byre. Tax records from medieval Norse Iceland added further data on the standard numbers of livestock and farming laws. The CUNY team estimated the amount of fodder grown and consumed and the production of dairy foods and meats, and put it all into a still-evolving computer model that has received NABO funding. Then, they ran their model to see how the Norse economy would fare in three hypothetical climatic scenarios, from optimal to catastrophically cold.

Their results, also in press in the monograph, reveal the difficulty Norse families had in amassing fodder and food surpluses to tide them over hard times. While the settlers could weather one bad year, a series of poor to moderate years would have pushed the entire community to the edge. Although the harshest weather was in winter, the model shows that the fate of the Norse hung on the summers, when the community stocked up on fodder for the winter. In particular, says McGovern, "a series of closely spaced poor summers" would have been devastating, "drawing down all the resources of not just an individual farm but the whole community." Those shortages would have become most acute in late winter—"a period of maximum vulnerability," says McGovern.

To arctic archaeologists such as Susan Kaplan, director of the Peary-MacMillan Arctic Museum at Bowdoin College in Brunswick, Maine, this research offers much new clarification. "What he's presenting here is for some people not as romantic or mysterious a view of the Norse demise as some would like, but it's one that is probably realistic," she says.

McGovern and others can now compare their model with actual data on the climate the Norse faced, extracted from the GISP2 ice core. The top part of the core yields a seasonal record of dust, trapped gas, and chemical changes in past atmospheres and is considered a particularly faithful record of Greenland itself. Researchers have already analyzed changes in the proportions of oxygen isotopes in the ice, thought to indicate past temperature, to trace climate over thousands of years. But as part of her dissertation research, University of Colorado paleoclimatologist Lisa Barlow took a closer look at Greenland climate, measuring another paleoclimate indicator—hydrogen isotopes—season by season in samples taken from a 200-meter section of the core. She charted summer and winter signals from medieval times to the mid-1980s.

In the 14th century, Barlow discovered four major isotopic excursions suggesting clusters of chilly periods from 1308 to 1318, 1324 to 1329, 1343 to 1362, and 1380 to 1384. The longest cold spell, beginning in 1343, correlated almost exactly with the abandonment of the Western Settlement, as suggested by Bárdarson's account and confirmed by such evidence as radiocarbon dating of mammal bones strewn over the top layers of Western Settlement sites. And "if you pull out the wintertime and summertime signals [in that period], it looks like the excursions are happening more in the summertime," says Barlow, whose work is in press at *Holocene*.

Barlow's picture is persuasive, says Paul Mayewski, a paleoclimatologist at the University of New Hampshire and a leader of the GISP2 team. In this time period, he says, "because it's so close to the present, the calibration with temperature is probably quite good." And he's pleased that the ice-core data are at last being applied to human history. "When I started GISP, one of the goals we had was to match climate records with archaeological records. ... There is an immense story that can be pulled out of the paleoclimate data."

THOMAS H. MCGOVERN

The remains of their days. Archaeological digs suggest a crisis on some Norse farms.

The final days

With both the climate record and the model of the Norse economy suggesting that a series of cool summers led to starvation in the Western Settlement, McGovern set out to trace the details of its last months and days. By reanalyzing animal bones gathered from the uppermost floor layers in farmhouses, he pieced together a bitter tale of desperation and disaster. For example, although canine bones were rare in the older layers of the house floors, four different teams unearthed remains of large elkhound-like dogs, likely used in hunting caribou, in the top strata in four farms. Some bones revealed human cut marks, suggesting that the Norse butchered these valuable dogs for food.

And before the inhabitants of a farm called Nipaatsoq ate their dogs, says McGovern, they consumed all their dairy cattle—in violation of traditional Norse law, which prohibits the slaughter of cows. Excavators at Nipaatsoq found the hooves of five cows—the total number of cattle sheltered in the farm's byre—scattered among other food remains across a lower layer of one room. Apparently, fodder for the cattle had run out, and people had even tried to eat the hooves. "The hooves are usually a waste piece," says Tom Amorosi, a zooarchaeologist at CUNY. "If you're finding that in the food remains, it means they're really searching for calories. They've scaled down to a point where there's no food left." Adds McGovern: "And of course, once you've eaten your cows, you're out of the dairy-farming business."

Other, tinier fauna echoed this tale of decline and fall. In as-yet-unpublished research, entomologist and NABO member Peter Skidmore of the University of Sheffield discovered an intriguing succession of fossil flies preserved in bedroom sediments at Nipaatsoq. In lower layers, the dominant fly was *Teleomarina flavipes*, a species of housefly that required warm quarters and was accidentally introduced by the Norse to Greenland. In the penultimate layer, however, *T. flavipes* disappeared—perhaps as room fires died—only to be succeeded by two cold-tolerant indoor carrion species. The nature of the carrion—animal or human—is unknown. In the top layer, which likely accumulated during a 2-year period encompassing the abandonment of the farm, an outdoor fauna of flies predominated, as if the farmhouse roof had caved in. To McGovern, all the evidence to date adds up to a final crisis—"a late-winter disaster, in which they eat the cows and they eat the dogs and then the flies get them." Whether a similar crisis took place at the other settlement is unknown, but McGovern and colleagues are eager to compare this record with data from an upcoming excavation at the Eastern Settlement.

But not everyone is convinced that such a catastrophe unfolded. Jette Arneborg, a curator at the Danish National Museum in Copenhagen and a principal investigator at one of the digs in the Western Settlement, has found scant evidence of such harrowing events. "To me, it doesn't really seem that there was a disaster," she says, noting that the buildings were abandoned in a very orderly fashion. The settlers seem to have taken all their precious items, including church bells, away with them, leaving only ordinary bulky items behind. "I think they simply decided to give up the area," says Arneborg, perhaps leaving for the Eastern Settlement. Instead of starvation, she suggests that the settlement was abandoned in part because of declining trade with Europe, which left settlers isolated from their homeland.

Whatever the reason the settlers left, it's clear that they wanted to keep close ties with Norway. Indeed, says McGovern, one of the most intriguing findings to date is the key role that culture played in the colony's extinction.

Archaeological evidence shows that Greenland's other inhabitants, the Thule, flourished throughout the 14th century, thanks to their prowess in hunting ringed seals below the sea ice in late winter, when few other sources of meat and fat were available. But the Norse failed to adopt ringed-seal hunting methods and other technology from their highly successful neighbors, says McGovern.

In fact, the cultural flow seemed to go in only one direction. Teams excavating Thule campsites have uncovered scavenged or stolen Norse artifacts, including chess pieces, iron nails, and fragments of cloth, but Arneborg and others working in the Norse farmsteads have found scarcely any Thule goods. "If you looked at the distribution of artifacts on the Norse side, you would say that there's been no contact," says McGovern. It may be, he adds, that the fervently Christian Norse spurned contact with the shamanistic Thule.

The styles of clothing in Greenland further underline the isolation of the two cultures. Naturally mummified Thule women exhumed at the Qilakitsoq site in 1978 were swaddled in warm sealskin parkas and trousers, while women buried in a Norse churchyard were dressed in low-cut, narrow-waisted woolen gowns like those then fashionable in Europe.

To McGovern, all the evidence to date suggests that for the Norse, ethnic purity triumphed at the expense of biological survival. While the starving settlers slaughtered their cattle and dogs, "there were seals in the fjord, right under the ice." But without harpoons and the skill to find the seals' breathing holes in the ice, the Norse couldn't reach them. It seems, says McGovern, that the Norse in Greenland remained true to the laws and customs of their warmer homeland—and paid the final price for it.

–Heather Pringle

Heather Pringle, a Vancouver-based science writer, is the author of In Search of Ancient North America.

AUTOIMMUNITY

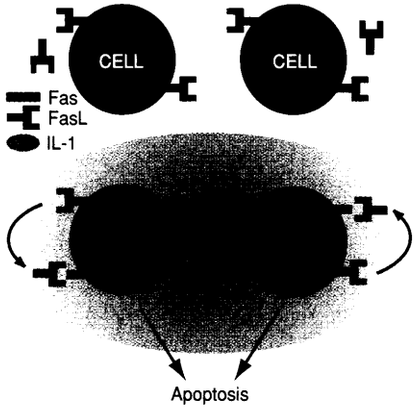
Thyroid Disease: A Case of Cell Suicide?

The name tells the story: Autoimmune diseases, such as diabetes and rheumatoid arthritis, result when the immune system goes awry and turns on the body's own tissues. But how it does so is far from clear. Researchers do not know which of the immune system's several types of killer T cells carries out the attack. And even more puzzling, killer cells are scarce at the site of tissue destruction in many autoimmune diseases. New results published in this issue (p. 960), however, could resolve those puzzles. In at least one disease, they suggest, the immune system itself may not carry out the final act: Instead, the target cells commit suicide through a process called apoptosis.

"These are intriguing results and present an appealing mechanism," says autoimmune disease researcher Ricardo Pujol-Borrell of the University Hospital "Germans Trias i Pujol," in Barcelona, Spain. "What's interesting is that apoptosis is a natural process, and I've always believed autoimmune diseases result from an exaggeration of natural processes," adds immunologist Noel Rose of Johns Hopkins University. So far, the results apply only to Hashimoto's thyroiditis (HT), a disease marked by a gradual destruction of thyroid tissue that is among the commonest autoimmune diseases. But they suggest that in this and possibly other autoimmune diseases, the immune system may have a less direct role than currently thought.

The new work, done in four laboratories in Italy, builds on rapid progress in the past few years in understanding apoptosis, a normal process for eliminating unwanted cells in tissues and organs during development and for reining in immune responses. One key to triggering this process of cell suicide is a molecule called Fas, found on the surface of many different types of cells. When another molecule, the Fas ligand (FasL), binds to it, Fas initiates a series of events inside the cell that leads to its death.

Although many cell types can express Fas on their surfaces, FasL at first seemed to occur mainly on the immune system's activated T lymphocytes. Expression of the ligand allows these T cells not only to kill unwanted cells by prompting them to undergo apoptosis, but also to moderate their own activity by triggering apoptosis in other T cells, which express both Fas and FasL. Researchers soon found that a small number of other cell types expressed FasL, such as cells in the eye chamber, parts of the nervous system, and the testis. These sensitive sites use FasL to protect themselves from immune attack by prompting apoptosis in attacking T cells.



Kiss of death. IL-1 prompts FasL-bearing thyroid cells to express Fas, and hence to die.

Now, the Italian researchers have identified a role for Fas in the converse phenomenon—autoimmune disease. The team was studying cells from patients with HT, a chronic disease, most common in middle-aged women, that leads to loss of thyroid hormone–producing cells. The team's first clue that apoptosis was involved came when they found Fas on the surface of cells taken from the thyroid glands of several patients, while it did not appear on thyroid cells from control glands. They then showed that interleukin-1 (IL-1), an immune messenger molecule found in the diseased thyroid glands, induced control thyroid cells to express Fas.

But what came next really surprised the team. They found that both normal thyroid cells and cells from patients with HT expressed high levels of FasL. "That was totally unexpected," says immunologist Roberto Testi of the University of Rome "Tor Vergata," who is one of the team members. This result suggested that the abnormal Fas expression leads the cells to trigger apoptosis in each other or in themselves.

To bolster this picture, the team took IL-1, which they had shown in lab studies induces Fas expression, and added it to normal thyroid cells in culture. They found that large numbers of cells died with the characteristic features of apoptosis. "This puts a different slant on the role of FasL and suggests a completely unexpected pathological role for the molecule," says Doug Green at the La Jolla Institute for Allergy and Immunology in California.

There are some problems with the apoptosis theory, however: The rapid cell death demonstrated in the laboratory does not square with the normally slow progression of the disease, which can last for years. The team believes that tight control of Fas expression within the body may explain this slow pace. "We need to know the sequence of events," says Testi. Another key unknown is the source of the IL-1 that sets the process in motion. IL-1 is normally produced by activated cells of the immune system to stimulate other cells within the system. "People have not thought of IL-1 as a destructive cytokine, but they now may want to look again," says Green. But if these loose ends in the theory can be tied up, researchers can begin looking for ways to block cell death to prevent thyroid destruction.

The Italian team's results may also hold out hope for a better understanding of other autoimmune diseases—and why T lymphocytes are puzzlingly scarce in so many of them. Says Green: "The new work is a fascinating hint at an entirely new disease mechanism. I think we are going to see more of this."

–Nigel Williams