Two

BANKS ISLAND
Ovibos moschatus

IT IS THE MIDDLE OF JUNE, so it is apparent, as it would never be on a dark and frozen day in December, that the Thomsen River is actually a river. It rises among unnamed creeks in east-central Banks Island and flows black and sparkling under the summer light, north to Castel Bay on M'Clure Strait. It is a highway of nutrients, and northwest Banks Island is an arctic oasis because of it, a kind of refuge for plants and animals.

The verdant, fertile valley of the Thomsen River is striking country in part because so much of the rest of the island is a desert of gravel, of bare soils and single, far-flung plants—a patch of yellow cinquefoil blooms, say, or a bright green cushion of moss

campion. On the west bank of the Thomsen, where I am camped between Able and Baker creeks, the landscape is stark: gully erosion has cut deeply into a high-rising plateau to the west. But even here is a suggestion of the refugelike character of the Thomsen River Valley, for these desert-colored shores were never touched by Pleistocene glaciers. Like most of western and interior Alaska, much of Banks Island went unscathed during the glacial epoch. These, in fact, might have been the shores of an ice-free Arctic Ocean 20,000 years ago.

I have come here to watch muskoxen. The muskox, along with the American bison, is one of the few large animals to have survived the ice ages in North America. Most all of its companions—the mammoth, the dire wolf, the North American camel, the short-faced bear—are extinct. The muskox abides, conspicuously alone and entirely at ease on the tundra, completely adapted to a polar existence.

I am sitting at the edge of a precipitous bluff, several hundred feet above the Thomsen, with a pair of high-powered binoculars. At this point the river curves across a broad plain of seepage meadows and tundra in a sweeping oxbow to my left; on my right Baker Creek has cut a steep-banked gash into the badlands to the west. Far to the south, in front of me, are clusters of black dots; at a distance of more than two miles they arrest even the naked eye with a strange, faint reflection. The mind knows by that slow drift of dark points over a field of tan grasses on an open hillside that there is life out there. But an older, deeper mind is also alerted by the flash of light from those distant, long-haired flanks. The predatory eye is riveted.

The broad valley in which the muskoxen graze has the color and line of a valley in Tibet. I raise my field glasses to draw it nearer. Beyond the resolution of the ground glass the animals look darker, the tans of the hills more deeply pigmented, and the sky at the end of the distant valley is a denser blue. The light shimmers on them. I recall the observation of a Canadian muskox biologist: "They are so crisp in the landscape. They stand out like no other

animal, against the whites of winter or the colors of the summer tundra."

I put the glasses back in my lap. A timeless afternoon. Off to my left, in that vast bowl of stillness that contains the meandering river, tens of square miles of tundra browns and sedge meadow greens seem to snap before me, as immediate as the pages of my notebook, because of unscattered light in the dustless air. The land seems guileless. Creatures down there take a few steps, then pause and gaze about. Two sandhill cranes stand still by the river. Three Peary caribou, slightly built and the silver color of the moon, browse a cutbank in that restive way of deer. Tundra melt ponds, their bright dark blue waters oblique to the sun, stand out boldly in the plain. In the center of the large ponds, beneath the surface of the water, gleam cores of aquamarine ice, like the constricted heart of winter.

On the far side of the Thomsen other herds of muskoxen graze below a range of hills in clusters of three or four. In groups of ten and twelve. I sketch the arrangements in my notebook. Most remarkable to me, and clear even at a distance of two or three miles because of the contrast between their spirited, bucking gambols and the placid ambling of the others, is the number of calves. Among forty-nine animals, I count twelve calves. The mind doesn't easily register the sustenance of the sedge meadows, not against the broad testimony of the barren hills and eroded plateaus. It balks at the evidence of fecundity, and romping calves. The muskoxen on the far side of the river graze, nevertheless, on sweet coltsfoot, on mountain sorrel, lousewort, and pendant grass, on water sedge. The sun gleams on them. On the melt ponds. The indifferent sky towers. There is something of the original creation here.

I bring my glasses up to study again the muskoxen in the far valley to the south. Among fifty or sixty animals are ten or fifteen calves. I regard them for a while, until I hear the clattering alarm call of a sandhill crane. To the southwest an arctic hare rises up immediately, smartly alert. To the southeast a snowy owl

sitting on a tussock, as conspicuous in its whiteness as the hare, pivots its head far around, right then left. The hare, as intent as if someone had whistled, has found me and fixed me with his stare. In that moment I feel the earth bent like a bow and sense the volume of space between us, as though the hare, the owl, and I stood on a dry lakebed. The moment lasts until the hare drops, becomes absorbed again in the leaves of a willow. The owl returns its gaze to the river valley below.

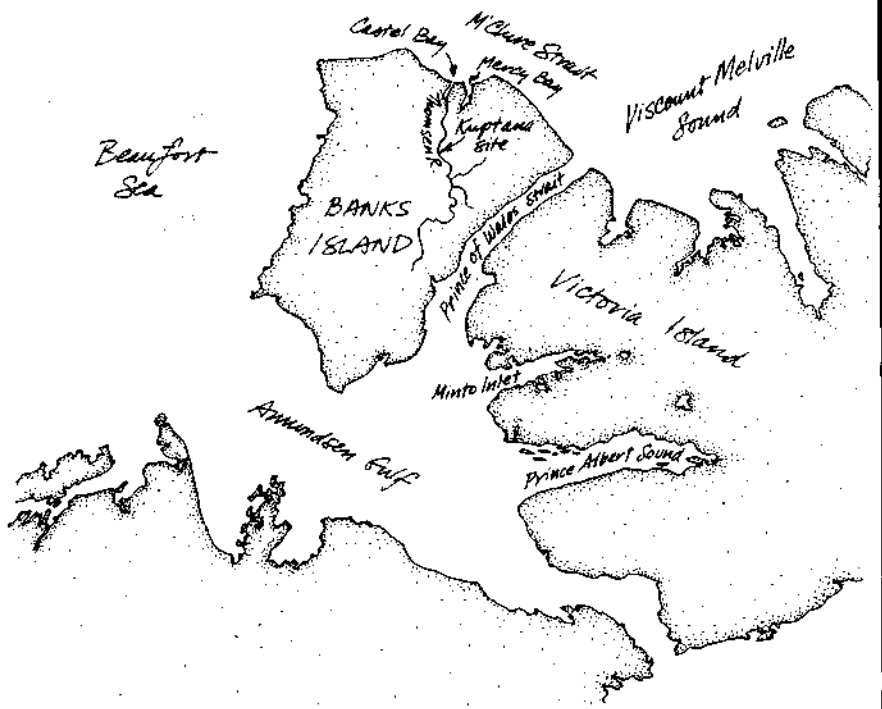
The indictment of the sandhill cranes continues; I shift my perch so they cannot see me, and their calls cease.

Behind me to the north my four companions, dressed in patterns of color unmistakably human, are at work on a hillside: archaeologists, meticulously mapping the placement of debris at a nineteenth-century Copper Eskimo campsite called PjRa-18, or, informally, the Kuptana site. Like others in the region, this campsite sits near the top of a windswept hill and looks down on well-developed sedge meadows, exceptional muskox pasturage. Scattered over 20,000 square yards at the campsite are more than 27,000 pieces of bone, representing the skeletal debris of about 250 muskoxen. The archaeologists call it a "death assemblage." There are also rings of river stones there, which once anchored caribou-skin tents against wind and rain; and the remnants of meat caches built of shale and ironstone slabs, and of charcoal fires of willow twigs and arctic white heather. The lower jaw of an arctic char, eaten a hundred years ago, still glistens with fish oil. A sense of timelessness is encouraged by this primordial evidence of human hunger.

The muskoxen grazing so placidly in the hills to the south and in the sedge meadows to the east, so resplendent with life, are perhaps descendants of these, whose white, dark-horned skulls now lie awry on the land.

The story of this camp begins in the previous century.

In September 1851, Captain Robert M'Clure was guiding HMS *Investigator* along the north coast of Banks Island, desperate for relief from the press of heavy ice in the strait later named for him. Toward the island's eastern cape M'Clure found a shallow,



protected embayment, which he called the Bay of God's Mercy. He and his men overwintered there. The following summer the ice did not go out of the bay, and they were forced to overwinter again in the same spot. In the spring of 1853 a rescue party reached them from HMS *Resolute*, a sister ship in winter quarters at Melville Island. (Both ships were part of a British search force looking for the lost Franklin Expedition.) M'Clure, reluctantly accepting the fact that *Investigator* was inextricably trapped, abandoned the 450-ton, copper-sheathed vessel and followed the rescue party back to Melville Island.

Copper Eskimos living more than 200 miles away on Victoria Island somehow learned of the abandoned ship. (These Kanghiryuakmiut and Kanghiryuachiakmiut people, from around Minto

Inlet and Prince Albert Sound, had never seen white people. They would not be contacted by whites until American whalers visited them in 1906. Shortly thereafter they would be named Copper Eskimos, identifying them with the tools they made from local copper deposits.) When the Victoria Island people first crossed over the spring ice of Prince of Wales Strait to Banks Island is not known, but they left a clear trail up the Thomsen River Valley to Mercy Bay.

It was ironic that such wealth should fall into the hands of the Victoria Island people. Until that moment they had found themselves at the far end of not one but two arctic trade routes. The first came from the west, from Siberia across the north coast of Alaska; the other came from the south, up the Mackenzie River from the interior of Canada. Now they could reverse the flow of trade goods.* Rarely had they seen the likes of the materials they found at Mercy Bay, and never in such abundance. The shore cache and the ship itself were as marvelous to them as the discovery of a well-provisioned vehicle from space.

The Eskimos likely traveled lightly on their annual excursions to Mercy Bay, saving space on their small sleds and inside dog panniers for salvaged materials. Most prized were strips of iron and sheets of canvas, and softwood boards, which were easier to carve than caribou antler. Also copper sheathing, woven cloth, hemp lines, wool yarn, and leather boots (for the leather alone—they were completely unsuitable as arctic footwear, a point the British were slow to learn).

On their journeys north, except for small amounts of seal meat and blubber carried with them from Victoria Island, the Eskimos ate what they killed en route—an occasional caribou,

* The reversal in the flow of trade goods initially confused anthropologists trying to figure out the development of trading patterns in the Far North. Others, unaware of the effect the *Investigator* had had on the lives of Victoria Island Eskimos, mistakenly assumed for years that these tribal groups were part of a pristine aboriginal culture.

molting geese (which, flightless, could not escape), fish, and a great many muskoxen. They drove the muskoxen out of the sedge meadows along the river and up onto hilltops where, predictably, they turned to make a stand and Eskimo dogs held them at bay. The hunters shot them with copper- and iron-tipped arrows, the shafts carefully assembled from willow twigs bound together with bits of sinew. (Today, shoulder blade after shoulder blade bears the small, round arrow hole, at an angle that would have carried the arrow straight to the heart. Their knowledge of the animal's anatomy was precise.)

The muskoxen were butchered where they fell, and a camp was set up. From such camps, presumably, small parties traveled back and forth to the *Investigator* and its cache all summer. In early fall, when the first snows provided a traveling surface for the sleds, the people returned south to country where seal hunting would hold them in good stead through the coming winter. The same camps were used year after year, apparently, and the skeletons of hundreds of muskoxen piled up at some of them, like PjRa-18. By 1981, scientists had found 150 such campsites, large and small, along the Thomsen River, along with the dismembered skeletons of about 3000 muskoxen.

The muskox population, some think, collapsed under this heavy hunting pressure before the ship and its cache were fully exploited. (Remnants of the cache remain. The ship either sank in the bay or floated away—it has never been found.) After about 1890, no people from Victoria Island traveled the route anymore.

Between 1914 and 1918 the explorer Vilhjalmur Stefansson crossed Banks Island several times, but he never once saw muskoxen. None, in fact, was seen thereafter anywhere on the island until the summer of 1952, when a Canadian biologist spotted a lone bull in the Thomsen River drainage. The bull could have been part of a small, remnant population, previously undetected, or from a group that crossed over from Victoria Island and followed the same route the Eskimo had taken to the north. During the 1950s and 1960s muskoxen were seen sporadically on northern

Banks Island, and surveys conducted in the early 1970s confirmed the presence of between 1200 and 1800 animals. A 1975 survey indicated further increases, and surveys in the early 1980s revealed the population had reached an astonishing size—16,000 to 18,000 animals.

The phenomenal recovery of muskoxen on Banks Island is something biologists cannot adequately explain. They do not have enough information about muskox reproductive biology and nutrition or about the play of other factors, such as prolonged periods of favorable weather or the absence of caribou competing for some of the same food. Informally, however, there is agreement that the lush sedge meadows and grasslands of the Thomsen River Valley have played a critical role in the recovery at the northern end of the island, and in the extension of the animals' range toward the south.

A modern visitor to the Thomsen River district feels the resilience of the country right away, in the rich and diverse bird life, the numbers of arctic fox, the many lemming burrows, and in the aggregations of arctic hare and caribou grazing on the hillsides. And in seeing how many calves there are in the muskoxen herds. The valley is robust and serene with its life.

To leave the story here, with the herds recovered and the hunting excesses of the Copper Eskimo a part of the past, would serve a sense of restitution. We could imagine that the muskoxen had been killed out by rough and thoughtless people, preoccupied with retrieving the wealth at Mercy Bay. An isolated incident. But a parallel with incidents at Pond's Bay suggests itself; and something else about man and nature and extinction, much older, flows here.

Fatal human involvement with wild animals is biologically and economically complicated. In the 1940s and 1950s, Banks Island Eskimos all but wiped out the wolf population at the southern end of the island in an effort to protect their arctic fox trap lines from scavenging. In 1981 and 1982, they brought heavy hunting pressure to bear against muskoxen in the southern portion of the island, to

protect the caribou herds upon which they are dependent for food, which, in their view, compete poorly with muskoxen for the same forage. (The northeastern end of the island, the Thomsen River country, the Eskimos regard as an oasis, an endlessly productive landscape from which animals pour forth to satisfy the many needs of mankind for flesh and hides, bones, sinews, and furs. They neither hunt nor trap there.)

Hunting wild animals to the point of extinction is a very old story. Aleut hunters, for example, apparently wiped out populations of sea otter in the vicinity of Amchitka Island in the Aleutians 2500 years ago. New Zealand's moas were killed off by Maori hunters about 800 years ago. And zoogeographers working in the Hawaiian Islands discovered recently that more than half of the indigenous bird life there was killed off by native residents before the arrival of the first Europeans in 1778. (The motivations of the hunters involved are unknown to us. Nor do we know whether they understood the consequences of their acts. Nor, if they did, whether they would have behaved differently. Some anthropologists caution, too, that the apparent incidents of slaughter of bison at buffalo jumps in North America and of caribou at river crossings in historic and prehistoric times were ethical in context and consistent with a native understanding of natural history and principles of conservation.)

Man's ability to destroy whole wildlife populations goes back even farther than this, however. Arthur Jelinek, a vertebrate paleontologist, has referred to early man in North America in very harsh terms, calling him a predator "against whom no [naturally] evolved defense systems were available" and "a source of profound changes" in the ecosystems of North America at the beginning of the Holocene. This was "an extremely efficient and rapidly expanding predator group," Jelinek writes, with "a formidable potential for disruption."

The specific events on which Jelinek bases these judgments are the catastrophic die-offs of large mammals that began about

18,000 years ago in North America and in which he believes man played the crucial role. Collectively the events are known as the Pleistocene extinction.

We are used to thinking of the North American plains as a place that teemed with life before the arrival of Europeans—60 million buffalo and millions of pronghorn antelope, elk, and deer, and grizzly bears and wolves. Oddly, however, this was only the remnant of an aggregation of animals the likes and numbers of which were truly staggering. By comparison with the late Pleistocene, eighteenth-century North America was an impoverished world, one "from which all the hugest, the fiercest, and strangest forms had recently disapepared." Giant armadillo, ground sloths that stood as tall on their hind legs as modern giraffes, the North American cheetah, saber-toothed cats, mammoths, fleet horses and camels, and close relatives of the muskox as well—all were gone, both species and populations. And the land itself had changed radically. Where the eighteenth-century traveler saw deserts there had once been lush grasslands, and great herds of browsers and grazers and their attendant predators and scavengers.

There are sharply differing explanations of why all these animals died out at or near the end of the Pleistocene, but there is some general agreement that it was for one of two reasons. Either the climate changed swiftly and radically and the animals couldn't adapt, or they were hunted to extinction by man. Some scientists are quick to discount human hunting as a factor. They find the idea that this "intelligent" predator was a waster of meat untenable (though evidence to the contrary is overwhelming in early as well as modern times). And they are skeptical about the killing efficiency of the weapons and hunting techniques involved. They also believe there were too few human beings by far to account for the sheer numbers of animals killed. A climatic explanation alone, they suggest, might suffice. The land, according to this argument, dried up, and the composition and distribution of plant life changed radically. The large herbivorous mammals most

dependent on these plants died out, along with their predators and scavengers. In this model the predatory efficiency of man is sometimes regarded as the final blow to the ecosystem at a time of extreme environmental stress.

Intricate, cogent, and forceful arguments have been made in support of both explanations. That man played a significant, if not decisive, role, however, seems inescapable. His capacity to do so is clear and, to judge from the fate of the plains buffalo, the passenger pigeon, the great auk, and the bowhead whale, he can be lethally and extensively efficient. The pattern, some would argue, is still with us, and the extinctions are about to increase again, because of the exponential destruction of natural habitat attendant upon the expansion of human numbers.

We lament the passing of the Eskimo curlew, the sea mink, the Labrador duck, Pallas' cormorant, and Steller's sea cow. Their lives are now beyond our inquiry. Our reluctance to accept direct responsibility for these losses, however, is sound if somewhat complicated biological thinking, rooted in a belief that there is nothing innately wrong with us as a species and in our belief that we are not solely responsible for every extinction. (The California condor, for example, is perhaps doomed on its own ecological account.) Our recent biological heritage has been exactly this, to sharply reduce the populations of other species or eliminate them entirely and occupy their niches in the food web whenever we had need or desire. It is not denigrating, not even criticizing from a certain point of view, to so understand ourselves. The cold view to take of our future is that we are therefore headed for extinction in a universe of impersonal chemical, physical, and biological laws. A more productive, certainly more engaging view, is that we have the intelligence to grasp what is happening, the composure not to be intimidated by its complexity, and the courage to take steps that may bear no fruit in our lifetimes.

Squatting over the detritus at the Kuptana site on a June evening, picking at the earth between two willow runners with a

muskox rib, one cannot blame the Copper Eskimo who killed the muskoxen here. Perhaps they even understood, at some level in the human makeup now irretrievable to us, that the muskoxen would come back, even if it seemed they had killed them all. Nor can one blame the modern Eskimo hunters on the island for wanting to get rid of wolves to protect the cash income from their trap lines, or to get rid of muskoxen to ensure a good supply of caribou meat. They are trying to adapt to an unorthodox, for them, economics. But we could help each other. Their traditional philosophy is insistent on the issue of ethical behavior toward animals. Within the spirit of this tradition and within the European concept of compassionate regard may lie the threads of a modern realignment with animals. We need an attitude of enlightened respect which will make both races feel more ethically at ease with animals, more certain of following a dignified course in the years ahead, when the animals will still be without a defense against us.

Here in the dirt, pushing past the desiccated winter pellets of muskoxen with my rib bone, past the fresher pellets of arctic hare, past windblown tufts of shed caribou hair, and a layer of dry, curled leaves from willows and saxifrage, I find a damp and precious mud. A foundation. Whatever their moral predilections may have been, the Kanghiryuakmiut and Kanghiryuachiakmiut ate the flesh of the muskoxen who browsed these willows. They made ladles from their horns, tools from their bones, and slept through the first, freezing storms of autumn on the thick insulation of their hides. And they survived. In the long history of man, before and after the coming of the glaciers, this counts for more than one can properly say.

When I stand up and look out over the valley I can feel the tremendous depth of time: myself at this 100-year-old campsite, before a valley the scientists say was never touched by glacial ice, and which the modern Eskimo say is and has been a sacred precinct. The muskoxen graze out there as though I were of no more importance than a stone. The skulls of their ancestors lie in the

sun at my feet, and cool winds come down the Kuptana slope and ride up over my bare head.

THE first muskoxen I ever saw were on a research farm outside Fairbanks, Alaska. It was summer, a pleasant day when the light air, the cleared fields beyond, and the surrounding hills seemed innocent. A lone animal emerged from tall, dry grasses at the foot of a slope below me. The grasses rolled in his wake, until he stood stolid on open ground, his long flank hair falling still with the stilling grass. In that moment I was struck by qualities of the animal that have stayed with me the longest: the movement was Oriental, and the pose one of meditation. The animal seemed to quiver with attention before he lowered his massive head and moved on, with the most deliberate step I have ever seen a large animal take. The shaft of a dark horn came into view, forward of the high shoulders and the full collar of his distinctive mane. The muskox settled then in my mind as a Buddhist monk, a samurai warrior. In the months after, these characterizations proved impetuous; but like many unbidden insights they served, and I retain them.

I entered that six-acre enclosure with the animals' caretaker, a Danish student at the University of Alaska named Poul Henrichsen. The animals had moved into a patch of spruce trees, and Henrichsen warned me to be alert, to stay near the fence and be ready to climb it. We came upon them from below the crest of a hill, with only their backs visible, and I was struck by how easily in this view the animal, with its shoulder hump and the tawny saddle behind its withers, could be confused with a grizzly bear. We came closer. I was surprised by how small they were. And, as we drew nearer still, by how adroitly they moved in the trees, and, as they moved, how close to each other they remained, hip to flank, flank to flank, even in that confining picket of spruce trees.

We did not press them further, but retreated toward the fence and watched in silence. Occasionally I would ask a question in low tones, and Henrichsen would reply. The animals regarded

us warily, testing the cool air in the trees with the flared nostrils of their broad black noses, rolling their large, golden-brown eyes as though we were two figures caught in a light they could not quite fathom.

Later, walking across a pasture in which caribou grazed (in comparison with the muskoxen they seemed high-strung and confused in their movements), I told Henrichsen of my Oriental impression of the muskox.

"But you know where they come from?"

"Yes," I said, smiling, "but I had forgotten."

They came from the high plains of northern China, where their evolutionary ancestors adapted in sheeplike and cattlelike ways to alpine and tundra life. Richard Harington, a Canadian vertebrate paleontologist, believes the genus *Ovibos* itself emerged about 2 million years ago on the steppes of central Siberia, finding its expression in several species. One, *Ovibos pallantis*, a Eurasian muskox hunted by Cro-Magnon people, may have survived into modern times on the Taimyr Peninsula in Russia. *Ovibos moschatus*, the modern North American animal, migrated across the Bering land bridge about 125,000 years ago, at the end of the Illinoian ice advance, or perhaps earlier. It was probably preceded by its own ancestors and relatives, including *Symbos cavifrons*, a taller, more slender animal and the dominant muskox in North America during the Pleistocene; *Praeovibus*, also larger, longer-legged, and more slender; *Bootherium*, a small woodland muskox; and *Euceratherium*, an alpine-adapted muskox. All these animals died out at the end of the Pleistocene, along with several species of *Ovibos* itself—*O. yukonensis* and *O. proximus*. Remains of the only one of this group to survive, *O. moschatus*, the modern animal, have been found as far south as New Jersey and Nebraska, where they lived during the height of the last, or Wisconsin, ice age.

When the Wisconsin ice began to retreat about 18,000 years ago, a current theory goes, muskoxen living in what is now the central and eastern United States began moving north. Their very

distant offspring—the animals found today south of Queen Maud Gulf, north of Great Bear Lake, and along the Thelon River—are called barren ground or mainland Canadian muskoxen. A second group of muskoxen, which moved south from high arctic refugia after the retreat of the ice, down the east coast of Greenland and onto Ellesmere, Devon, and Melville islands, are called high arctic or Greenland muskoxen.*

The muskox has a single living relative, the takin of northern Tibet, a calflike animal of ponderous build with a bulging snout like a saiga antelope's, short, stout legs, and small, swept-back horns, showing the same montane sheep/goat ancestry in its conformation and movements as the modern muskox. (The thick golden fleece Jason sailed in quest of was that of the takin.)

Early observers were confused about the muskox's heredity. Because of its heavy head and shoulders, Ernest Thompson Seton thought it was related to the buffalo. Stefansson thought it was related to the highland cattle of Europe, and Otto Sverdrup, a Norwegian explorer, called the animals "polar oxen." Distant relatives all. The muskox's nearest relatives after the takin include the Japanese serow, the chamois, the Rocky Mountain goat, and the Barbary sheep.

In the end its scientific name, *O. moschatus*, the "sheeplike cow with a musky smell," as well as its popular name, is ill-fitting. The animal has no musk glands. During their rut muskoxen bulls secrete a substance in their urine that is evident on their breath and even in the flesh of a carefully butchered animal. The late John Teal, an American muskox researcher, characterized the smell as "pungent and faintly sweetish." Another biologist has called it "a muskily sweet scent, resembling that of a gorilla." Because the odor, in Teal's judgment, is less rank than that of other ruminants, it is odd that the name "muskox" stuck. One explanation is that in the seventeenth century, when the animals were first seen by Europeans on the western shores of Hudson Bay, their exotic appearance and the smells of bulls in rut led entrepreneurs to believe an association with musk deer of the Orient might exist. The wishful confusion of the riches of the Orient with those of North America was common at the time, and the illusion of a trade base was not discouraged by seventeenth-century traders.

* The successful transplants of muskoxen to several ranges in Alaska, where the muskox was wiped out in the nineteenth century, have been made with animals from this population.

The long, glossy skirt of its guard hair is, initially, the muskox's most striking feature, particularly if the animal is moving. (The Eskimo word for the animal, *oomingmaq*, means "the animal with skin like a beard.") It is not so wild an affair as Nicolas Jérémie maintained in *Relation de détroit de la baye de Hudson* (1720), when he wrote that one could not tell "at a short distance which end the head was on." The pelage is an orderly arrangement of several sorts of hair, which appeared in disarray to Jérémie and others because they saw the animals only in the summer, when they are shedding. An extremely dense underfur of fine, woolly hairs, about two inches long, lies close to the skin and covers all of the animal but its hooves and horns and a patch of skin between its nostrils and lips. Its rump, belly, flanks, and throat are covered as well by a dense layer of long, coarse guard hair that hangs down skirtlike and that melds across the shoulders with a layer of thick but less coarse hairs which come up over the shoulders from low on the neck to form a mane. Behind the withers these hairs fade into an area of woolly underfur without guard hairs called the saddle.

The longest guard hairs—25 inches or more—grow down from the throat. The hairs of the skirt, which are replaced continuously, become more prominent with age and are most lustrous in rutting bulls. The underfur is shed in patches and streamers from late May to mid-July, though this strong, extremely light fleece continues to work its way out through the guard hairs until August, giving the animal a primordial appearance. This inelastic underfur, eight times warmer than sheep's wool by weight,

is as soft as the pashm of Kashmir goats or the wool of the vicuña. A single muskox might carry ten pounds of it, enough, in the estimation of one diligent observer, to make a single forty-strand thread 150 miles long.

Calves are born with a short coat of natal underfur and a fine layer of cinnamon-colored overfur. These are replaced toward the end of the first summer by thicker underfur and longer overfur. Coarse guard hairs don't begin to appear until the second year.

The underfur in the saddle area is white to tawny yellow, and elsewhere light brown, with shadings of cinnamon. The overlying guard hairs are black on the rump and flanks, shading to blackish browns with auburn highlights on the forequarters. The legs below the "knee" (the heel, actually) are white. Among certain populations (and with some individuals) white hairs are prominent on the face, muzzle, and back of the head, behind the horn boss, and between the horns of females. An unusual strain of muskoxen with cream-colored guard hairs is known to Eskimos living in the Queen Maud Gulf region and has recently been described for the first time by scientists. (British sailors reported seeing an albino muskox cow with a dark calf near Cape Smyth, Melville Island, in June 1853.)

The great thickness of their hair—short, roundly pointed ears are almost hidden in the ruff of hair forward of the neck, as is a short tail at the other end—makes muskoxen seem larger than they are. Their weights vary widely, depending on sex, the season, and their diets. An "average" mature male might weigh 650 pounds, a female 400 pounds. An adult male might stand 55 inches at the shoulder and measure 90 inches from nose to rump, with a female measuring 48 inches and 75 inches, respectively.

Both sexes grow slowly. Males reach maturity in size in their sixth or seventh year and females at five or six. According to Canadian zoologist Ben Hubert, muskoxen weights vary so much because, in the case of males, the animals are in a "positive nutritional state" (i.e., gaining weight) for only two months out of the year, July and August. He found them to be in a "neutral

balance" for four months, and to be slowly losing weight the other six months, during rut in the fall and for much of the winter. Females gain weight during about five months of the year, and lose it in winter and during calving and lactation (the calves are nursed for about fifteen months).

The muskox's unique, characteristic horns suggest a cape buffalo's, but they curve down close to the cheeks before hooking out and up in a recurved point. The female's horns are shorter and more slender. They also taper more sharply than the male's and do not grow together, helmetlike, in a boss over the skull. The horns, which turn a darker brown with light tips in older animals, continue to grow slowly throughout an animal's life. The female's attain the finished line of the adult shape in about four years, the male's in six. The horns are primarily defensive weapons, wielded against predators, but they also serve to uproot vegetation and in an important and complex way for social display and in fighting during the males' rut.

The large eyes, which protrude from the skull to clear the thick pelt and permit a wider field of lateral vision, are superbly well adapted. A double retina serves to intensify images in the darkness and the low light of winter, and the pupil, a horizontal slit, can close completely to prevent snowblindness. (Traditional Eskimo snow goggles imitate this design.) The pupil is also heavily lined with corpora nigra, which shield the retina against glare from the sky above and from snow and ice on the ground.

For its size, the muskox is surprisingly nimble and surefooted. In part this is due to the shape and structure of its hooves, which are broadly round and sharp-edged with concave bottoms. A broad heel pad gives the animal excellent traction on rock and hard ground and on various snow surfaces. The front hooves, which are larger, are used in winter to break and paw through wind-slabbed snow and groundfast ice. The muskox also uses its chin for this purpose.

Muskoxen appear to have only two gaits, a walk and a gallop. The gallop is swift and energetic, in contrast to the slow,

almost drifting walk. The animals can gallop for several miles without breaking stride, stop short in perfect balance, and run up steep talus slopes with remarkable speed, revelations of their mountain-climbing heritage. They have a curious habit of occasionally pausing to sit on their haunches when rising from a resting position, an action that gives them an air of being preoccupied with thought. Adults also roll over on their backs and loll, with their legs suspended in the air.

Adults maintain a generally stolid demeanor, even when calves cavort wildly among them or when arctic foxes scamper and feint back and forth through a herd. In summer, however, adults are just as apt to romp in creeks and rivers, which they seem to delight in splashing and whirling through. (An American archaeologist working on Banks Island told me about a herd of seventeen or eighteen he watched slide down a gravel hill into a creek on their rumps and then go bucking off like horses in various directions.) Moving water is a short-lived summer phenomenon, and Anne Gunn, a Scottish biologist, remembers watching newborn calves encountering it for the first time. "The calves were spell-bound. There were seven or eight of them, about two months old. They jostled each other at the edge, shocked to get their feet wet, then ran off into the herd, stomping and bucking to get away from it." Young calves chase each other regularly through a grazing herd and play "king of the mountain," perching their oddly tapirlike bodies on tussocks, their small feet pressed together like a mountain goat's.

Muskoxen are unique among ruminants in the amount of body contact they make. Even when they are fleeing, they gallop away shoulder to shoulder, flank to flank. One of the most dazzling displays of this I ever witnessed occurred on Seward Peninsula when a herd of muskoxen spun around on a hill in confusion at the approach of a low-flying aircraft. They moved as a single animal, rising in a tight turn to change direction. The wild, synchronous sweep of their long skirts was like a dark wave of water climbing a sea cliff before falling back on itself. Long-term

muskoxen researchers frequently comment on these synchronous aspects of their behavior, noting, for example, that a herd feeds and rests on a rough cycle of 150-minute periods, winter and summer.

At the approach of a threatening animal, including men and their dogs, muskoxen begin to draw near to each other, sometimes quickly, and occasionally in response to the sudden bellow of a herd bull. (The herd bull is more often distinguished, however, by being the last to respond, and the first to relax, in these situations.) The animals may initially press together in a line abreast, with the herd bull toward the center and slightly forward, and younger bulls at the flanks. If the approaching animal changes direction, or if more than one animal is approaching, the muskoxen may back around into a rosette, rump to rump, with calves and yearlings wedged between adults.

This defensive formation is not always symmetrical, nor do muskoxen always take this position when challenged—sometimes they just run off. But in evolutionary terms it has been exceedingly effective against their major predator, the wolf. Bulls and cows rush out from this formation to make short, hooking charges with lowered heads. Wolves are only successful if they can get behind a charging animal and cut it off from the herd, or if they dash into a momentary opening and snatch a calf. Wolves are patient and opportunistic in these situations, or they wouldn't still be around either.

This close-contact, defensive formation is found in no other species, and it is interesting to speculate about its origin. Some researchers have suggested that muskoxen prefer hilly country to open plains, noting that they often run to a hilltop before assuming their defensive formation. When caught out alone by wolves, a muskoxen will try to back itself into a snowbank or a landform of some sort, even backing slowly into a fast-moving river, to protect its hindquarters. In the defensive rosette, of course, each animal creates a back and a side wall for the others. This suggests that somewhere in their evolutionary history muskoxen lived a long while in open country, where they discovered a way to

create, cooperatively, the spatial relief necessary to protect themselves.

Muskoxen herds change size and composition over the year. Summer groups tend to be small, from two to ten animals, while winter herds may consist of sixty or more animals. In summer, too, one is especially likely to see lone animals, almost always bulls, and single-sex herds—bulls or cows accompanied by younger animals and calves. As bulls come into rut the presence of a mature breeding bull within a herd may become apparent, though it is taking a step in the wrong direction to call such aggregations "bulls with their harems." (Bulls are selecting themselves out as suitable male parents in their violent rutting encounters; what females are doing at this time is more obscure, but chances are they are not as passive in this drama as they appear.)*

The makeup of a particular herd, to take the extreme examples, can change frequently or remain stable for months on end. A large herd grazing in a sedge meadow may, after longer scrutiny, be seen actually to consist of multiple, discrete herds. Two herds may merge to become one; a day later three herds may emerge. Herds are neither disorganized nor rigidly organized. They are cohesive social arrangements existing in time. Biologists posit that they give some animals advantages in their feeding, breeding, and survival strategies, but they are not certain what these are.

Changes in the composition of muskox herds suggest that both individual animals and the aggregations themselves have "personalities." Mixed herds do not always consist of retiring females and younger animals being led by domineering males. Cows as

* In trying to generalize about herd behavior, one is always confronted with knowledge of variation and inconsistency; for example, the ratio of one age class in a herd to another, as well as its sexual makeup, may result in two herds behaving differently under apparently similar circumstances. It is a simple truth of field biology that it is easy to miss and hard to figure out what, exactly, an animal is doing. And what animals do may be more complex than the descriptions we apply or the measurements we devise.

well as bulls influence herd movement and behavior, though the activity of herd bulls is frequently more evident. Herd leaders emerge not only at the approach of predators but whenever obstacles present themselves—a formidable river, a steep escarpment, or a crumbling cutbank. A knowledge of the other animals' personalities, some actual experience with each other, may come into play in these situations and may be especially apparent in the creation of a defensive formation. Perhaps animals somewhat unknown to each other are the ones that panic, running off to leave calves and their mothers behind; while other groups, better known to each other, are the ones that move with efficient precision, the older animals butting and kicking momentarily confused or obstinate calves to the protective interior of the formation.

We are sometimes at a loss in trying to describe such events because we unthinkingly imagine the animals as instinctual. We are suspicious of motive and invention among them. The lesson of evolution with the muskox, an animal that has changed little in 2 million years, is that whether it is witty or dull in its deliberation, a significant number have consistently chosen correctly.

The muscular, restless behavior of rutting bulls is so charged with energy that humans experience nervous amusement as well as exhilaration in watching it. The same interactions—head-butting, horn display, charging—go on all year, but they increase in frequency and intensity during the rut. The bulls' otherwise placid and presumably subtle relationships with each other take on a raw edge of intolerance.

David Gray, a Canadian muskox biologist who observed bulls' behavior closely for a number of years in the Polar Bear Pass region of Bathurst Island, was the first to fully describe these male encounters, using the categories that follow (from least to most intense).

First is the (usually) passive displacement of one bull by another at a feeding spot. As one bull approaches, the other simply moves on, often to displace another animal. A bull might raise its head to regard another bull, ordinarily a sign of attentiveness or

alarm as well as a mild threat display (or, to be perfectly candid, a sign he is only urinating). A more serious threat display, one unique to muskoxen, is lowering the head to rub one or the other of two pear-shaped glands below the eye on the inside of a foreleg. This is often done with great vigor, suggesting a "whetting of the horns." More agitation still is expressed by an animal raking the ground with the tips of his horns, or escalating his irritation to head tilting. In head tilting, bulls move toward each other with averted eyes, leading with a shoulder and a prominent display of the horn boss. In doing so alone, one bull appears to be circling sideways around the other animal; when two bulls are head tilting simultaneously, they are said to be "parallel walking."

The most serious confrontations are actual head butts and charges, which vary in their intensity. Two bulls may place their horn bosses together and push mild-manneredly at each other for a few moments—or push off their forequarters with driving strength and quick, ferocious thrusts of the head. A loss of advantage here opens an animal to sideways, jabbing hooks with the horns, or goring. When two bulls engage each other like this —head tilting, parallel walking, butting and charging—their movements become stylized. They select flat terrain for these meetings, heightening the aura of ritual. The usual deliberate walking gait becomes stiff-legged, slow, and exaggerated. A charge is preceded by side-to-side head swinging and a backing away from each other, as though the air between them had suddenly expanded. They charge from 20 to 30 feet apart, furious head-to-head crashes that can knock one animal back on its haunches or carry both animals up on their hind legs. The sound of their meeting is like the fracturing of sea ice.

Bulls may charge each other repeatedly. When they back away, bristling with energy, the image is primordial. The mane is erect. The neck is swollen, exaggerating the size of the forequarters. Their eyes, their long guard hairs, glisten with light. Should a wind be blowing and tatters of underfur be whipping

about their flanks in streamers, their appearance is apocalyptic, savage with intent. The encounters are sometimes fatal.

Mating is a less violent affair. The males, again in the human view, seem fulsome in their attentions to receptive females. They approach them repeatedly, overwrought and obsequious, sniffing the vaginal opening, drawing close along the female's flanks and resting a chin on her buttocks, nosing her neck, sometimes scraping her flanks with a foreleg. Bulls also engage in a mating display of sorts by twisting their heads over to look up at a female. And they bellow. David Gray describes the sound as "similar to the roar of a caged African lion."

Mating occurs when a female, repeatedly tested in these ways, remains stationary. The bull, rising on his hind legs, mounts her. The act lasts but a moment.

Mating takes place from mid-August to mid-September. Calves are born 240 to 250 days later, in mid-April to mid-May. Like most prey species, muskox calves are born precocious, able to stand up almost immediately and very soon able to run. Mid-April is still winter, but as long as they do not get wet, calves seem to survive very well. They are well insulated and born with ample adipose (brown) fat reserves from which they can draw heat. They spend much of their first few days resting and nursing. Their mothers call after them softly. In cool weather they take advantage of their mother's body as a shield, curling between her legs to sleep while she turns her back to the wind.

Herds are stationary during calving, which might go on for a month; but they rarely travel far at any time. Their summer ranges, where succulent sedges and other forbs emerge in June, and their winter ranges, where sun-cured grasses are exposed by winds, are often within only a few miles of each other. The infrequency of large-scale movement underscores a salient aspect of muskox ecology: only a relatively few, widely scattered feeding areas in this severe arctic environment will support muskoxen.

Researchers speculate that migration to a new area may occur

as a result of the rut, when a single male forces other mature males to leave the area and these bulls depart with a few cows to establish a herd of their own. One theory about how whole herds locate new range to move to is that solitary bulls, wandering great distances in summer, find areas of suitable, year-round forage, then return to a herd in the vicinity of the one they left. Come fall, they lead the herd across sparsely vegetated range (including sea ice) to the new pasture. Pheromones (biochemical substances an animal produces and which its olfactory system can later detect) might make such movements possible. Bulls scent-mark by dribbling their urine on grasses and other elevated spots, especially during the rut. They also mark tussocks with secretions from their preorbital glands. These scent posts very likely play a role in mating but may also be important in regulating the spatial arrangement of muskoxen in a given landscape. Over time, such scent-making might well prevent over-grazing in those areas where muskoxen thrive, by "forcing" animals to spread out.

How muskoxen navigate over their native landscapes in darkness and snow, how they conceive of the space around them, is unknown.

Muskoxen maintain a constant body temperature of about 101°F, no matter what the air temperature. Because they routinely endure extremes of −40°F for prolonged periods of time, conditions that would drive polar bears and perhaps even arctic fox to shelter, the ability to maintain a constant temperature is striking. The heat they depend upon is generated by normal cell metabolism and the burning of stored fats and by other complex biochemical processes connected with nutrition. Their thick coats provide such excellent insulation that little of this heat escapes, the reason why snow that accumulates on their backs in a storm doesn't melt.

Ecologists are reasonably certain that arctic animals do not increase their basal rate of metabolism until the temperature reaches a certain critical level, different for each animal but around −50°F. (Birds are an exception.) The climate, in other words, does not force arctic animals to eat more. Heat retention, not increased heat production, is an animal's principal defense against cold. In 1847 Karl Bergmann suggested that since heat production is a three-dimensional process (heat radiates in all directions) and heat loss is a two-dimensional phenomenon (it occurs only at the surface of the skin), it would stand to reason that animals living in cold environments would evolve larger body sizes, with a greater ratio of mass (heat production) to surface (heat loss).

Bergmann's Rule, as it is called, is a somewhat archaic concept, as is a companion, Allen's Rule, set out in 1877. Allen believed that in cold environments there is a tendency toward the evolution of shorter extremities—ears, limbs, tails, and snouts. Both rules have a firm empirical basis in spite of many exceptions. What makes them archaic is that other adaptations for heat retention are comparatively more effective. The insulation provided by hair and underfur, exceptional in the case of the arctic fox and the muskox, is one source of warmth in severe cold. Polar bears are heavily insulated with fat, and den up in the worst weather. Other animals, particularly birds, warm cold venous blood from exposed extremities by running it through a coil of warm arterial blood before it reaches the body core. Animals also use differential heating (arctic fox, for example, can reduce the temperature of their footpads to near 32°F), and changes in the electrical conductivity of their nervous systems to stay warm. No single one of these adaptations, however, is effective by itself; and physiological and biochemical research continues to reveal a more complicated picture of how arctic animals function in severe cold (e.g., how they control the loss of water from their bodies, or replenish what they do lose).

Muskoxen and other animals also conserve heat in winter by a conspicuous economy of action. In very cold weather, when any movement at all requires the burning of limited fat reserves, animals will just stand still for long periods of time, so long that someone has suggested the term "standing hibernation." When muskoxen do travel in cold weather, they move in single file through any appreciable accumulation of snow, stepping carefully

in the track cleared by the animal ahead of them. During blizzards they might even bed down for several days. (An explorer in Greenland once terrified himself by seeking refuge from a storm in the lee of what he first took to be mounds of snow-covered earth. They were muskoxen, and they began to stand up as he walked over them.) Alwin Pederson believed that in the severest storms muskoxen choose an open area where the wind blows in a single direction and form a wedge into it, the herd bull at the apex, calves and yearlings to the rear. David Gray, for one, doubts that this occurs. He once observed a herd of muskoxen in a storm with 24-knot winds, blowing snow, and a temperature of −27°F (wind chill about −90°F). The animals "continued to feed in the usual manner or remained lying down" with their backs and sides to the wind.*

Kent Jingfors, a Swedish muskox biologist, once camped out in the drainage of the Sadlerochit River in Alaska in winter, in an effort to learn how muskoxen survived there. He recalls "days" of brutal cold and darkness when it took nearly all his will to carry out the simple tasks he set for himself. The animals moved slowly through the willows, wary of him. He followed behind with a flashlight, peering closely to see which plants they were browsing. He came to look on them with awe. Anyone who has tried to work effectively in −40°F weather, to contend with darkness in winter for long periods of time or the knife slash of windblown snow at these temperatures, wonders that any creature can endure like this for weeks on end, let alone seem to be at peace.

* * *

* Annual snowfall over most of the Arctic is light, often no more than four to six inches, and actual snowstorms are rare. Ground blizzards frequently occur in coastal areas, however, where most settlements are located. High winds and a furious swirling of dry snow already on the ground might persist for days, the condition commonly referred to in the Far North as a "blizzard."

WHAT muskoxen eat in their "marginal existence" in the Arctic, as well as when and how often, vitally affects their survival, but precisely how it does remains a mystery. Their year-long metabolic rhythms are as complex as their uptake of nutrients. There are some clues. They synthesize B-complex vitamins in their rumens. In winter they might draw vitamin A from storage in the liver. In the months without sunshine they may also draw on stores of vitamin D (needed for the uptake of calcium and phosphorus). They consume about 10 pounds of browse and fodder a day, more in July and August, when they are laying on adipose fat reserves for the winter. If biologists could determine what an optimal muskox diet is (how much of what when), and how animals use the plants available to them in breeding and nonbreeding years, and what their preference for such things as lousewort and oxytrope means—if they knew this, they would be close to answering one of the most perplexing questions about muskoxen: in response to what variables do these animals breed and bear young? And a corollary: how can we recognize excellent muskox habitat in areas where the animals no longer live?

The phenomenal recovery of the Banks Island muskox population is not an isolated event. In 1973–74, when an early winter rainstorm created a layer of groundfast ice that kept muskoxen from feeding in many places in the high Arctic, 48 percent of the herds on eastern Melville Island perished, including most of the animals in an area called Dundas Peninsula. When, several years later, D. C. Thomas of the Canadian Wildlife Service found the Dundas Peninsula population thriving again, he suggested that the area had been repopulated from a nearby muskox refuge, an arctic oasis on Melville Island called Bailey Point.

Bailey Point represents perhaps the best muskox habitat in the high Arctic. Total precipitation (snow accumulation) is low. Ground ice rarely forms. It is protected from winter storms. And its lowlands and stream valleys are fertile and productive. There are at least three other such areas in the high Arctic: at Mokka

Fiord on the east coast of Axel Heiberg Island; on Fosheim Peninsula, northern Ellesmere Island; and at Truelove and adjacent lowlands on the northeast coast of Devon Island. Thomsen River is likely a fifth place. Peary Land on the north coast of Greenland and Hochstetter Peninsula on its east coast are very likely other refuges.

Research does not yet exist to compare the nutrition available to muskoxen in each of these areas (or to compare what is in these areas with what is in other areas where muskoxen are occasionally found), but Martha Robus, an American botanist, believes nutrition plays a critical role in how quickly muskoxen repopulate an area. Her studies were focused on a remarkable area of the Sadlerochit River in northeastern Alaska, where Kent Jingfors also pursued his graduate studies. (The muskoxen living along the Sadlerochit arrived there around June 1969, after fifty-one of them were transplanted by the U.S. Fish and Wildlife Service to Barter Island, 40 miles away on the Alaska coast. Others of these animals have since taken up life in adjacent drainages of the Jago River and, from a 1970 transplant, the Canning River.)

The conventional wisdom about sexual maturity in muskoxen, before Jingfors began his study of the Sadlerochit herd, was that females bred only every other year beginning in their fourth year and rarely twinned. Although Jingfors saw no twins on the Sadlerochit, he noticed cows were calving in their second year, and some cows were even calving in successive years. The population was expanding at a tremendous rate.

The Sadlerochit drainage is obviously lush, but it takes a tutored eye to make the connection between the kinds and abundance of plants here and large numbers of muskoxen. Start on a ridge west of the river. The soil is mostly barren, a rubble of talus, scree, and frost boils with very few plants—mountain avens, veiny-leafed willow, woodrush, and oxytrope. During spring melt in May and June, when the river valley floods, muskoxen climb up to this ridge and begin to feed here and in the dry tundra

beyond, a tussock meadow of tea-leaf willow, dwarf birch, and cottongrass.

At the foot of the ridge a snowbank waters a meadow of sedges and tundra grass. Beyond, toward the river, is a plain of heathlike tundra with dwarf birch, mountain cranberry, diamond-leaf willow, and cottongrass. Near a small creek is yet another sort of willow muskoxen favor, Richardson willow. Muskoxen feed heavily here in the summer.

Beyond this plain lies the Sadlerochit River itself, with riparian thickets of blue, feltleaf, and barren-ground willows, fields of grasses, and leguminous forbs rich in nitrogen, including sweet-broom, blue-spike lupine, alpine milkvetch, and dwarf fireweed.

If you were a muskox, you would look on the abundance and variety of edible plants here as boon and bounty. It is on the willows that the Sadlerochit muskoxen browse most heavily, and Robus believes the high nutritional value of these plants puts Sadlerochit muskoxen in a favorable energy balance for longer periods of time than might be the case in more marginal areas. This makes it possible for the herd to sustain its high rate of productivity.

In other parts of their arctic range, where willows are not as plentiful, muskoxen depend more on sedges and grasses. For a long time it was thought that the muskox diet was simple. Now it is known that they consume a great variety of flowering plants, grasses, sedges, mosses, and forbs—bluegrass and willow herb, bladder campion and foxtail, cowberry, mountain sorrel, and Labrador tea. Their diet varies with the season, according to where they are, and according to their idiosyncratic needs and tastes. They favor some of the same forage that attracts caribou, but can subsist on a coarser diet than perhaps any other ruminant.

We do not often think of animals in relation to the other animals in their communities much beyond the way they serve each other as food. Observers who have followed muskoxen on foot over the

tundra, however, and who have had memorable if not always pleasant encounters with them, often remark on the muskox's relationships with birds. Snow buntings and Lapland longspurs line their tundra nests with muskox wool. These and other ground-nesters such as plovers and jaegers are seen flying up in displays of indignant irritation when the big animals threaten to step on their nests. In their winter pawing, muskoxen expose food for arctic hares and willow buds for ptarmigan. Arctic fox derive some unknown delight in their company. And in their wandering they stir up insects, which the birds feed upon.

At death their carcasses feed the scavengers, and the insects that break down their flesh under the short summer sun are, again, the food of the snow bunting.

An old muskox is one approaching twenty, though some live longer. They die of their environment, as victims of predation, and by drowning in rivers, especially during breakup in the spring. They die of starvation and exposure, or from broken necks in falling from ridges. They are fatally gored in the rut, or die of infections from their broken horns. They are remarkably free of external parasites, which is why one so rarely sees them grooming. They are occasionally bothered by mosquitoes and flies about their eyes and ears.

They are tranquil animals, but their equipoise should not be confused with docility. John Teal once observed a rutting bull leap clear of the ground in an apparent attempt to snag the pontoons of a low-flying aircraft. Martha Robus watched a muskox rout a grizzly bear that had stumbled into its willow patch. And Anne Gunn once found herself confronting an irritated bull on Prince of Wales Island, an animal that had been bested in a bout with another bull. Though she was armed, she permitted the bull to force her into a river at her back, gun, notebook, and camera held high over her head. She recalls whimpering with pain in the cold water, waiting for the animal to back off.

Gunn's forebearance, and the patience and unobtrusive attitude of muskox researchers in general, make up in some way for

inanities of the past. One arctic traveler, curious about the resilience of a bull's horn boss, shot a muskox in the head with a 9.3-mm armor-piercing bullet to see what would happen. Another curious fellow bound a month-old calf up in a sled dog harness (after shooting its mother) to study "the instinctive mode of defense against a wolf hanging to the flanks." He then tied a dead wolf to the calf to record the methods by which it attempted to free itself. Such witless amusement once passed for science, and, with a strong enough statistical basis, might still pass in some quarters.

THE two most disastrous periods in history for muskoxen came in the nineteenth century, when they were exterminated in the eastern subarctic by Indians and Eskimos to feed American whalers and to be used in trade to the Hudson's Bay Company; and in the early twentieth century, when entire herds were shot to provide a calf or two for zoos, or to provision fur trappers and their dogs in Greenland. While the former story, like the exploitation of beaver in eastern North America or the havoc wreaked on American bison, is familiar, the latter events are relatively obscure.

At the turn of the century, muskoxen lived in fairly large numbers (perhaps as many as 2000) along the northeast coast of Greenland, at places like Hold With Hope and Hochstetter peninsulas, Clavering Island, and in Jameson Land on Scoresby Sound. Whalers and sealers working along these coasts were wont to put ashore to hunt muskoxen for fresh meat. They easily put the animals to bay with dogs and shot them to the last animal. "After an invasion like ours," noted one ship's naturalist, "when every animal obtainable is slain for food, it must take some years to restock the ground."

After the turn of the century, Norwegian fur trappers living in these same areas shot muskoxen for trap bait and to feed both their sled dogs and the wild animals they were collecting for zoos. They shot hundreds of muskoxen; in a short time their depradations seriously threatened the animal's future in northeast Greenland. Under sharp criticism for these practices the Norwegians

were testy enough to charge that, actually, the Danish trappers, of which there were a few, were more to blame because they were not as "racially adept" as the Norwegians on cross-country skis and therefore traveled more slowly and had to kill more animals along the way to survive until they got back to their trapping camps.

Worse in its effect on the animals was what happened when zoos became interested in muskoxen. Entrepreneurs found the only practical way to secure a calf was to kill all the adults in a defensive formation. The hooking charges of the last animal among its dead companions must have been one of the most pathetic sights ever engineered by civilized people. Ejnar Mikkelsen, a Danish historian working with an American, Elisabeth Hone, estimated in 1932 that five adults were killed for every calf secured. Hone arrived at a figure of some 2000 animals killed this way between 1899 and 1926. Zoos finally signed an agreement that put an end to the business. And the fur trappers, who had done most of this work, finally moved out as Denmark began to exercise a protective hegemony over the east coast of Greenland.

Today the muskox survives in Alaska, where, at this writing, there are about 1000 animals, the progeny of successful transplants; in Canada, where as many as 40,000 live along the northern rim of the continent and in the Canadian Archipelago; and in North and East Greenland, where P. C. Lent estimates there are 1500. In the face of an ice storm, or with human disruption of their refugia, none of which is fully protected, these numbers could change radically tomorrow.

In the eroded hills south of the Copper Eskimo site called PjRa-18, I wrote a note to myself. It was not the sort of thought I would forget, but I am too much a creature of such habits, or, perhaps, was too encouraged by the earnest note-taking of my scientific companions, to be able to let it go. On pages crowded with crude field drawings of the snow bunting and the pattern of a bone scatter along Baker Creek, I wrote: "the innocence."

The words came at the end of a long afternoon in which I had wandered with and sat at the perimeter of a small herd of seven adults, a yearling, and four calves. It was a reaction to something I could not have located on a muskox farm: they were so intensely good at being precisely what they were. The longer you watched, the more intricately they seemed a part of where they were living, of what they were doing. Their color, their proportions against the contours of the land, were exquisite.

They were, in evolution's terms, innocent of us and of our plans.

On the long trek back to PjRa-18, and as the five of us crossed the tundra from there to our tent camp on the river, I thought of their vulnerability. At PjRa-18 the idea of innocence founders in the evidence of an encounter between two non-Socratic societies, the cunning hunters and these most obvious and least retiring of arctic mammals.

Over our meal, Cliff Hickey, the senior anthropologist in the group, said of the Copper Eskimo, "You ignore at your peril the variety in human culture."

After dinner I went down by the water to wash my hair and to sit. Two silver-gray caribou were grazing on the far side of the river. It was so warm I was barefoot. In the hills beyond were the black dots of muskoxen and the white dots of browsing arctic hare. The sound of the river was in my head, and its cold drops ran down my chest. A Chipewyan guide named Saltatha once asked a French priest what lay beyond the present life. "You have told me heaven is very beautiful," he said. "Now tell me one more thing. Is it more beautiful than the country of the muskoxen in the summer, when sometimes the mist blows over the lakes, and sometimes the water is blue, and the loons cry very often? That is beautiful. If heaven is still more beautiful, I will be glad. I will be content to rest there until I am very old."

In the reprieve at the end of a day, in the stillness of a summer evening, the world sheds its categories, the insistence of its future, and is suspended solely in the lilt of its desire.