

Winner of Two Pulitzer Prizes

Biophilia

EDWARD O. WILSON



The human bond with other species

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Prologue

ON MARCH 12, 1961, I stood in the Arawak village of Bernhardsdorp and looked south across the white-sand coastal forest of Surinam. For reasons that were to take me twenty years to understand, that moment was fixed with uncommon urgency in my memory. The emotions I felt were to grow more poignant at each remembrance, and in the end they changed into rational conjectures about matters that had only a distant bearing on the original event.

The object of the reflection can be summarized by a single word, *biophilia*, which I will be so bold as to define as the innate tendency to focus on life and lifelike processes. Let me explain it very briefly here and then develop the larger theme as I go along.

From infancy we concentrate happily on ourselves and other organisms. We learn to distinguish life from the inanimate and move toward it like moths to a porch light. Novelty and diversity are particularly esteemed; the mere mention of the word *extraterrestrial* evokes reveries about still unexplored life, displacing the old and once potent *exotic* that drew earlier generations to remote islands and jungled interiors. That much is immediately clear, but a great deal more needs to be added. I will make the case that to explore and affiliate with life is a deep and complicated process in mental development. To an extent still undervalued in philosophy and religion, our existence depends on this propensity, our spirit is woven from it, hope rises on its currents.

There is more. Modern biology has produced a genuinely new way of looking at the world that is incidentally congenial to the inner direction of biophilia. In other words, instinct is in this rare instance aligned with reason. The conclusion I draw is optimistic: to the degree that we come to understand other organisms, we will place a greater value on them, and on ourselves.

Bernhardsdorp

AT BERNHARDSDORP on an otherwise ordinary tropical morning, the sunlight bore down harshly, the air was still and humid, and life appeared withdrawn and waiting. A single thunderhead lay on the horizon, its immense anvil shape diminished by distance, an intimation of the rainy season still two or three weeks away. A footpath tunneled through the trees and lianas, pointing toward the Saramacca River and far beyond, to the Orinoco and Amazon basins. The woodland around the village struggled up from the crystalline sands of the Zanderij formation. It was a miniature archipelago of glades and creekside forest enclosed by savanna — grassland with scattered trees and high bushes. To the south it expanded to become a continuous lacework fragmenting the savanna and transforming it in turn into an archipelago. Then, as if conjured upward by some unseen force, the woodland rose by stages into the triple-canopied rain forest, the principal habitat of South America's awesome ecological heartland.

In the village a woman walked slowly around an iron cooking pot, stirring the fire beneath with a soot-blackened machete. Plump and barefoot, about thirty years old, she wore two long pigtails and a new cotton dress in a rose floral print. From politeness, or perhaps just shyness, she gave no outward sign of recognition. I was an apparition, out of place and irrelevant, about to pass on down the footpath and out of her circle of required attention. At her feet a small child traced meanders in the dirt with a stick. The village around

them was a cluster of no more than ten one-room dwellings. The walls were made of palm leaves woven into a herring-bone pattern in which dark bolts zigzagged upward and to the onlooker's right across flesh-colored squares. The design was the sole indigenous artifact on display. Bernhardsdorp was too close to Paramaribo, Surinam's capital, with its flood of cheap manufactured products to keep the look of a real Arawak village. In culture as in name, it had yielded to the colonial Dutch.

A tame peccary watched me with beady concentration from beneath the shadowed eaves of a house. With my own, taxonomist's eye I registered the defining traits of the collared species, *Dicotyles tajacu*: head too large for the piglike body, fur coarse and brindled, neck circled by a pale thin stripe, snout tapered, ears erect, tail reduced to a nub. Poised on stiff little dancer's legs, the young male seemed perpetually fierce and ready to charge yet frozen in place, like the metal boar on an ancient Gallic standard.

A note: Pigs, and presumably their close relatives the peccaries, are among the most intelligent of animals. Some biologists believe them to be brighter than dogs, roughly the rivals of elephants and porpoises. They form herds of ten to twenty members, restlessly patrolling territories of about a square mile. In certain ways they behave more like wolves and dogs than social ungulates. They recognize one another as individuals, sleep with their fur touching, and bark back and forth when on the move. The adults are organized into dominance orders in which the females are ascendant over males, the reverse of the usual mammalian arrangement. They attack in groups if cornered, their scapular fur bristling outward like porcupine quills, and can slash to the bone with sharp canine teeth. Yet individuals are easily tamed if captured as infants and their repertory stunted by the impoverishing constraints of human care.

So I felt uneasy — perhaps the word is embarrassed — in the presence of a captive individual. This young adult was a perfect anatomical specimen with only the rudiments of so-

cial behavior. But he was much more: a powerful presence, programed at birth to respond through learning steps in exactly the collared-peccary way and no other to the immemorial environment from which he had been stolen, now a mute speaker trapped inside the unnatural clearing, like a messenger to me from an unexplored world.

I stayed in the village only a few minutes. I had come to study ants and other social insects living in Surinam. No trivial task: over a hundred species of ants and termites are found within a square mile of average South American tropical forest. When all the animals in a randomly selected patch of woodland are collected together and weighed, from tapirs and parrots down to the smallest insects and roundworms, one third of the weight is found to consist of ants and termites. If you close your eyes and lay your hand on a tree trunk almost anywhere in the tropics until you feel something touch it, more times than not the crawler will be an ant. Kick open a rotting log and termites pour out. Drop a crumb of bread on the ground and within minutes ants of one kind or another drag it down a nest hole. Foraging ants are the chief predators of insects and other small animals in the tropical forest, and termites are the key animal decomposers of wood. Between them they form the conduit for a large part of the energy flowing through the forest. Sunlight to leaf to caterpillar to ant to anteater to jaguar to maggot to humus to termite to dissipated heat: such are the links that compose the great energy network around Surinam's villages.

I carried the standard equipment of a field biologist: camera; canvas satchel containing forceps, trowel, ax, mosquito repellent, jars, vials of alcohol, and notebook; a twenty-power hand lens swinging with a reassuring tug around the neck; partly fogged eyeglasses sliding down the nose and khaki shirt plastered to the back with sweat. My attention was on the forest; it has been there all my life. I can work up some appreciation for the travel stories of Paul Theroux and other urbanophile authors who treat human settlements as virtually the whole world and the intervening

natural habitats as troublesome barriers. But everywhere I have gone — South America, Australia, New Guinea, Asia — I have thought exactly the opposite. Jungles and grasslands are the logical destinations, and towns and farmland the labyrinths that people have imposed between them sometime in the past. I cherish the green enclaves accidentally left behind.

Once on a tour of Old Jerusalem, standing near the elevated site of Solomon's Throne, I looked down across the Jericho Road to the dark olive trees of Gethsemane and wondered which native Palestinian plants and animals might still be found in the shade underneath. Thinking of "Go to the ant, thou sluggard; consider her ways," I knelt on the cobblestones to watch harvester ants carry seeds down holes to their subterranean granaries, the same food-gathering activity that had impressed the Old Testament writer, and possibly the same species at the very same place. As I walked with my host back past the Temple Mount toward the Muslim Quarter, I made inner calculations of the number of ant species found within the city walls. There was a perfect logic to such eccentricity: the million-year history of Jerusalem is at least as compelling as its past three thousand years.

AT BERNHARDSDORP I imagined richness and order as an intensity of light. The woman, child, and peccary turned into incandescent points. Around them the village became a black disk, relatively devoid of life, its artifacts adding next to nothing. The woodland beyond was a luminous bank, sparked here and there by the moving lights of birds, mammals, and larger insects.

I walked into the forest, struck as always by the coolness of the shade beneath tropical vegetation, and continued until I came to a small glade that opened onto the sandy path. I narrowed the world down to the span of a few meters. Again I tried to compose the mental set — call it the naturalist's trance, the hunter's trance — by which biologists locate more

elusive organisms. I imagined that this place and all its treasures were mine alone and might be so forever in memory — if the bulldozer came.

In a twist my mind came free and I was aware of the hard workings of the natural world beyond the periphery of ordinary attention, where passions lose their meaning and history is in another dimension, without people, and great events pass without record or judgment. I was a transient of no consequence in this familiar yet deeply alien world that I had come to love. The uncounted products of evolution were gathered there for purposes having nothing to do with me; their long Cenozoic history was enciphered into a genetic code I could not understand. The effect was strangely calming. Breathing and heartbeat diminished, concentration intensified. It seemed to me that something extraordinary in the forest was very close to where I stood, moving to the surface and discovery.

I focused on a few centimeters of ground and vegetation. I willed animals to materialize, and they came erratically into view. Metallic-blue mosquitoes floated down from the canopy in search of a bare patch of skin, cockroaches with variegated wings perched butterfly-like on sunlit leaves, black carpenter ants sheathed in recumbent golden hairs filed in haste through moss on a rotting log. I turned my head slightly and all of them vanished. Together they composed only an infinitesimal fraction of the life actually present. The woods were a biological maelstrom of which only the surface could be scanned by the naked eye. Within my circle of vision, millions of unseen organisms died each second. Their destruction was swift and silent; no bodies thrashed about, no blood leaked into the ground. The microscopic bodies were broken apart in clean biochemical chops by predators and scavengers, then assimilated to create millions of new organisms, each second.

Ecologists speak of “chaotic regimes” that rise from orderly processes and give rise to others in turn during the passage of life from lower to higher levels of organization.

The forest was a tangled bank tumbling down to the grassland's border. Inside it was a living sea through which I moved like a diver groping across a littered floor. But I knew that all around me bits and pieces, the individual organisms and their populations, were working with extreme precision. A few of the species were locked together in forms of symbiosis so intricate that to pull out one would bring others spiraling to extinction. Such is the consequence of adaptation by coevolution, the reciprocal genetic change of species that interact with each other through many life cycles. Eliminate just one kind of tree out of hundreds in such a forest, and some of its pollinators, leafeaters, and woodborers will disappear with it, then various of their parasites and key predators, and perhaps a species of bat or bird that depends on its fruit—and when will the reverberations end? Perhaps not until a large part of the diversity of the forest collapses like an arch crumbling as the keystone is pulled away. More likely the effects will remain local, ending with a minor shift in the overall pattern of abundance among the numerous surviving species. In either case the effects are beyond the power of present-day ecologists to predict. It is enough to work on the assumption that all of the details matter in the end, in some unknown but vital way.

After the sun's energy is captured by the green plants, it flows through chains of organisms dendritically, like blood spreading from the arteries into networks of microscopic capillaries. It is in such capillaries, in the life cycles of thousands of individual species, that life's important work is done. Thus nothing in the whole system makes sense until the natural history of the constituent species becomes known. The study of every kind of organism matters, everywhere in the world. That conviction leads the field biologist to places like Surinam and the outer limits of evolution, of which this case is exemplary:

The three-toed sloth feeds on leaves high in the canopy of the lowland forests through large portions of South and

Central America. Within its fur live tiny moths, the species *Cryptoses choloepi*, found nowhere else on Earth. When a sloth descends to the forest floor to defecate (once a week), female moths leave the fur briefly to deposit their eggs on the fresh dung. The emerging caterpillars build nests of silk and start to feed. Three weeks later they complete their development by turning into adult moths, and then fly up into the canopy in search of sloths. By living directly on the bodies of the sloths, the adult *Cryptoses* assure their offspring first crack at the nutrient-rich excrement and a competitive advantage over the myriad of other coprophages.

At Bernhardsdorp the sun passed behind a small cloud and the woodland darkened. For a moment all that marvelous environment was leveled and subdued. The sun came out again and shattered the vegetative surfaces into light-based niches. They included intensely lighted leaf tops and the tops of miniature canyons cutting vertically through tree bark to create shadowed depths two or three centimeters below. The light filtered down from above as it does in the sea, giving out permanently in the lowermost recesses of buttressed tree trunks and penitralia of the soil and rotting leaves. As the light's intensity rose and fell with the transit of the sun, silverfish, beetles, spiders, bark lice, and other creatures were summoned from their sanctuaries and retreated back in alternation. They responded according to receptor thresholds built into their eyes and brains, filtering devices that differ from one kind of animal to another. By such inborn controls the species imposed a kind of prudent self-discipline. They unconsciously halted their population growth before squeezing out competitors, and others did the same. No altruism was needed to achieve this balance, only specialization. Coexistence was an incidental by-product of the Darwinian advantage that accrued from the avoidance of competition. During the long span of evolution the species divided the environment among themselves, so that now each ten-

uously preempted certain of the capillaries of energy flow. Through repeated genetic changes they sidestepped competitors and built elaborate defenses against the host of predator species that relentlessly tracked them through matching genetic countermoves. The result was a splendid array of specialists, including moths that live in the fur of three-toed sloths.

NOW TO THE very heart of wonder. Because species diversity was created prior to humanity, and because we evolved within it, we have never fathomed its limits. As a consequence, the living world is the natural domain of the most restless and paradoxical part of the human spirit. Our sense of wonder grows exponentially: the greater the knowledge, the deeper the mystery and the more we seek knowledge to create new mystery. This catalytic reaction, seemingly an inborn human trait, draws us perpetually forward in a search for new places and new life. Nature is to be mastered, but (we hope) never completely. A quiet passion burns, not for total control but for the sensation of constant advance.

At Bernhardsdorp I tried to convert this notion into a form that would satisfy a private need. My mind maneuvered through an unending world suited to the naturalist. I looked in reverie down the path through the savanna woodland and imagined walking to the Saramacca River and beyond, over the horizon, into a timeless reconnaissance through virgin forests to the land of magical names, Yékwana, Jívaro, Sirionó, Tapirapé, Siona-Secoya, Yumana, back and forth, never to run out of fresh jungle paths and glades.

The same archetypal image has been shared in variations by others, and most vividly during the colonization of the New World. It comes through clearly as the receding valleys and frontier trails of nineteenth-century landscape art in the paintings of Albert Bierstadt, Frederick Edwin Church, Thomas Cole, and their contemporaries during the crossing of the American West and the innermost reaches of South America.

In Bierstadt's *Sunset in Yosemite Valley* (1868), you look down a slope that eases onto the level valley floor, where a river flows quietly away through waist-high grass, thickets, and scattered trees. The sun is near the horizon. Its dying light, washing the surface in reddish gold, has begun to yield to blackish green shadows along the near side of the valley. A cloud bank has lowered to just beneath the tops of the sheer rock walls. More protective than threatening, it has transformed the valley into a tunnel opening out through the far end into a sweep of land. The world beyond is obscured by the blaze of the setting sun into which we are forced to gaze in order to see that far. The valley, empty of people, is safe: no fences, no paths, no owners. In a few minutes we could walk to the river, make camp, and afterward explore away from the banks at leisure. The ground in sight is human-sized, measured literally by foot strides and strange new plants and animals large enough to be studied at twenty paces. The dreamlike quality of the painting rolls time forward: what might the morning bring? History is still young, and human imagination has not yet been chained by precise geographic knowledge. Whenever we wish, we can strike out through the valley to the unknown terrain beyond, to a borderland of still conceivable prodigies—bottomless vales and boundless floods, in Edgar Allan Poe's excited imagery, "and chasms, and caves and Titan woods with forms that no man can discover." The American frontier called up the old emotions that had pulled human populations like a living sheet over the world during the ice ages. The still unfallen western world, as Melville wrote of the symbolizing White Steed in *Moby Dick*, "revived the glories of those primeval times when Adam walked majestic as a god."

Then a tragedy: this image is almost gone. Although perhaps as old as man, it has faded during our own lifetime. The wildernesses of the world have shriveled into timber leases and threatened nature reserves. Their parlous state presents us with a dilemma, which the historian Leo Marx has called the machine in the garden. The natural world is the refuge of the spirit, remote, static, richer even than human

imagination. But we cannot exist in this paradise without the machine that tears it apart. We are killing the thing we love, our Eden, progenitrix, and sibyl. Human beings are not captive peccaries, natural creatures torn from a sylvan niche and imprisoned within a world of artifacts. The noble savage, a biological impossibility, never existed. The human relation to nature is vastly more subtle and ambivalent, probably for this reason. Over thousands of generations the mind evolved within a ripening culture, creating itself out of symbols and tools, and genetic advantage accrued from planned modifications of the environment. The unique operations of the brain are the result of natural selection operating through the filter of culture. They have suspended us between the two antipodal ideals of nature and machine, forest and city, the natural and the artifactual, relentlessly seeking, in the words of the geographer Yi-Fu Tuan, an equilibrium not of this world.

So at Bernhardsdorp my own thoughts were inconstant. They skipped south to the Saramacca and on deep into the Amazon basin, the least spoiled garden on Earth, and then swiftly back north to Paramaribo and New York, greatest of machines. The machine had taken me there, and if I ever seriously thought of confronting nature without the conveniences of civilization, reality soon regained my whole attention. The living sea is full of miniature horrors designed to reduce visiting biologists to their constituent amino acids in quick time. Arboviruses visit the careless intruder with a dismaying variety of chills and diarrhea. Breakbone fever swells the joints to agonizing tightness. Skin ulcers spread remorselessly outward from thorn scratches on the ankle. *Triatoma* assassin bugs suck blood from the sleeper's face during the night and leave behind the fatal microorganisms of Chagas' disease — surely history's most unfair exchange. Leishmaniasis, schistosomiasis, malignant tertian malaria, filariasis, echinococcosis, onchocerciasis, yellow fever, amoebic dysentery, bleeding bot-fly cysts . . . evolution has devised a hundred ways to macerate livers and turn blood into a para-