CHAPTER 1

In Praise of Slowness

What Does It Mean to Be a Sloth?

One more defect and they could not have existed.

~ George Louis Leclerc, Comte de Buffon

We conceive of the individual animal as a small world, existing for its own sake, by its own means. Every creature is its own reason to be. All its parts have a direct effect on one another, a relationship to one another, thereby constantly renewing the circle of life; thus we are justified in considering every animal physiologically perfect.

~ Johann Wolfgang von Goethe

The first sloths I encountered were in zoos. They were definitely not animals that attracted many visitors. But I had heard and read some about them, so I was interested in seeing them. I was with my family, and we stood for a while and watched a ball of fur hanging from a limb. It didn't move. My children soon became impatient—why were we spending time with this animal?—and so I moved on with them, while my wife stayed a bit longer. Soon we heard her voice, "It's moving!" We ran back, only to find it stationary again. It didn't move as long as we stayed. So after some time, we moved along. This and similar experiences only heightened my interest in this strange mammal.

I had been learning and teaching about animals as highly integrated organisms. What is the secret to this decidedly passive animal? Is the sloth, as eighteenth-century natural philosopher Buffon claimed, a defective creature? I had a difficult time thinking that could be the case. But is it "physiologically perfect" in Goethe's sense? That was hardly obvious. So a journey into the whole-organism biology and ecology of the sloth ensued.

In the Rainforest

When you walk in a tropical rainforest, you may startle some monkeys and glimpse them scampering away among all the leaves and branches in the canopy above. You will also certainly hear and see birds. But even if you look hard and make lots of noise, you would most likely not startle or see the most prevalent tree-dwelling mammal in the Central and South American rainforests. The three-toed sloth will likely remain still and well concealed in the tree canopy.

To appreciate the sloth, we need to have a sense of the tropical rainforest. It is an ecosystem characterized by constancy of conditions. The length of day and night during the year varies little. On the equator there are 12 hours of daylight and 12 hours of night for 365 days a year. The sun rises at 6 am and sets at 6 pm. Afternoon rains fall daily throughout much of the year. The air is humid (over 90 percent) and warm. The temperature varies little in the course of the year, averaging 77°F (25°C).

Except in the uppermost part of the canopy, it is dark in the rainforest. Little light appears on the forest floor. The uniformity of illumination, warmth, and moisture—in intensity and rhythm—marks the rainforest. And it is hard to imagine a rainforest dweller that embodies this quality of constancy more than the sloth. From meters below, the sloth is sometimes described as looking like a clump of decomposing leaves or a lichen-covered bough. The sloth's hair is long and shaggy, yet strangely soft. The fur is brown to tan and quite variable in its mottled pattern. Especially during the wettest times of year, the sloth is tinted green from the algae that thrive on its pelage, which soaks up water like a sponge.[1]

Since the sloth moves very slowly and makes few noises, it blends into the crowns of the rainforest trees. It took researchers many years to discover that up to 700 sloths may inhabit one square kilometer of rainforest.[2] Only 70 howler monkeys inhabit the same area.

The sloth spends essentially its whole life in the trees. It sits nestled in the forks of tree branches (mostly) or hangs from branches by means of its long, sturdy claws (sometimes). With its belly directed heavenwards, the sloth's fur has a part on the mid-belly and the hair runs toward the back, unlike terrestrial mammals in which the part is on the mid-back and the hair runs toward the belly.

The sloth moves slowly through the forest canopy—rarely a few hundred feet in 24 hours. On average, sloths have been found to move during five to ten hours of the 24-hour day.[3] The remaining time they are essentially still and in one place. ("Resting" is the term often used to describe the sloth's inactive periods, but this expression is not actually appropriate for the sloth. From what activity is it resting?)

Figure 1.1. A three-toed sloth (*Bradypus variegatus*) in Brazil feeding in a *Cecropia* tree.

You are most likely to get a good view of a sloth where the forest borders an open area—along a waterway or next to a road. Instead of being surrounded by vegetation you can peer at the forest edge; you are outside looking in. I was in a small canoe-like boat with a group on a tributary to the Amazon River during the high-water season. It was early morning, near a small village, and we were passing by a number of *Cecropia* trees—a favorite species of sloths—surrounded by much open water. Since the water level was so high, we were at the height of the lower crown. To our fortune we saw a couple of three-toed sloths comfortably situated on limbs.

We observed one of the sloths for quite a while (not an issue from the sloth's perspective—it was more up to us how long we could remain active observers seeing so little happen). The sloth clearly noticed us, turning its eternally smiling face from time to time in our direction. It then began to move upward in the crown. This was stunning (at least for me). It was if we were watching a living fluid flow upward, so gentle and graceful were every arm, leg, neck and head movement. There was nothing jagged, jarring, or abrupt. At one moment it released its arms from the branch and slowly lowered its head and upper body until it hung down vertically.

It stayed in this position for a short time. Just as slowly, and seemingly without effort, it raised its head and upper body again and clawed onto the branch. It remained hanging from three claws until we left it.

Clinging in Tree Crowns

The sloth's ability to cling to branches and to hang from them for extended periods of time is related to its whole anatomy and physiology. About the size of a large domestic cat (weighing around eight to ten pounds), the sloth has very long limbs, especially the forelimbs. When hanging, the sloth's body appears to be almost an appendage to the limbs. Feet and toes are hidden in the fur. Only the long, curved and pointed claws emerge from the fur. The toe bones are not separately movable, being bound together by ligaments, so that the claws form one functional whole, best described as a hook (Figure 1.2).[4]

Figure 1.2. Two different three-toed sloths in typical "resting" positions.

The two different genera of sloths are named according to the number of claws they possess: the three-toed sloth (*Bradypus*) has three claws on each limb; the two-toed sloth (*Choloepus*) has two claws on the forelimb and three on the hind limb. (There are many differences in detail between these two genera of sloths. I am focusing here primarily on the three-toed sloth.[5])

With its long limbs the sloth can embrace a thick branch or trunk, while the claws dig into the bark. But the sloth can also hang by just its

Figure 1.3. A three-toed sloth flowing up a tree limb and then hanging from its short hind legs.

claws on smaller branches, its body suspended in the air. A sloth can cling so tenaciously to a branch that researchers resort to sawing off the branch to bring the creature down from the trees.

All body movements, or the holding of a given posture, are made possible by muscles rooted in the bones. Muscles work by means of contraction. While clinging, for example, some muscles in the limbs—the retractor muscles—are contracted (think of your biceps) while other muscles—the extensor muscles—are relaxed (think of your triceps). When a limb is extended (when the sloth reaches out to a branch) the extensor muscles contract, while the retractor muscles relax. All movement involves a rhythmical interplay between retractor and extensor muscles.

It is revealing that most of a sloth's skeletal musculature is made up of retractor muscles.[6] These are the muscles of the extremities that allow an animal to hold and cling to things and also to pull things toward it. The extensor muscles are smaller and fewer in number. In fact, significant extensor muscles in other mammals are modified in the sloth and serve as retractor muscles. A sloth can thus hold its hanging body for long periods

of time. It can even clasp a vertical trunk with only the hind limbs and lean over backward 90 degrees with freed forelimbs. (Just imagine doing this yourself and your belly muscles will already start to ache!)

At home as it is in the trees, the sloth is virtually helpless on the ground. Lacking necessary extensor muscles and stability in its joints, a sloth on the ground can hardly support its weight with its limbs. Researchers know little about natural terrestrial movement of sloths. Normally, a sloth will move from tree to tree up in the crowns, but in areas where roads divide parts of the forest, they may have no alternative but to cross the road. My brother was in Costa Rica and stopped his car to let a sloth, very slowly, drag itself across the road (see Figure 1.4). He stayed there for about five minutes to make sure other cars wouldn't run it over. A sad sight, but the sloth made it. With its limbs splayed to the side, it found holds with the claws of its forelimbs and gradually pulled itself forward, using its strong retractor muscles.

Since the sloth's main limb movements involve pulling, and the limbs do not carry the body weight, it is truly a four-armed and not a four-legged mammal. The hands and feet are essentially a continuation of the long limb bones, ending in the elongated claws, and do not develop

Figure. 1.4. A three-toed sloth in Costa Rica dragging itself across a road. (Photo by Tom Holdrege, used with permission)

as independent, agile organs as they do, say, in monkeys. We can also understand the dominance of the retractor muscles from this point of view. The human being, in contrast to most mammals, has arms as well as weight-bearing legs. The arms are dominated by retractor muscles, while the legs have more extensor muscles. Moreover, the arm muscles that move the arm toward the body are stronger than the antagonistic arm muscles that move the arms away from the body. This comparison shows us that the tendency inherent in the arm—the limb that does not carry a body's weight—permeates the anatomy of the sloth.

A sloth becomes quite agile if the forces of gravity are reduced, as in water. In water a body loses as much weight as the weight of the volume of water it displaces (Archimedes' Law). The body becomes buoyant, and in the case of the sloth, virtually weightless. As science writer Fiona Sunquist notes,

> Remarkably, sloths are facile swimmers.... They manage to move across water with little apparent effort. Where the forest canopy is interrupted by a river or lake, sloths often paddle to new feeding grounds. With no heavy mass to weigh them down, they float on their buoyant, oversized stomachs.[7]

With its long forelimbs the sloth pulls its way through the water, not speedily, but in a "beautifully easy going" manner.[8]

On the whole, sloths have little muscle tissue. Muscles make up 40 to 45 percent of the total body weight of most mammals, but only 25 to 30 percent in sloths.[9] One can understand how the reduction of weight in water allows them to be less encumbered in movement. Sloth muscles also react sluggishly, the fastest muscles contracting four to six times slower than comparable ones in a cat. In contrast, however, a sloth can keep its muscles contracted six times longer than a rabbit.[10] Such anatomical and physiological details reflect the sloth's whole way of being—steadfastly clinging in a given position, only gradually changing its state.

The tendency to the reduction of muscle tissue can also be found in the head. There is a reduction in the number and complexity of facial muscles.[11] Through the facial markings the sloth has an expressive face—it appears content and smiling. But this expression is a fixed image, rather than an active expression through movement, since the facial area itself is relatively

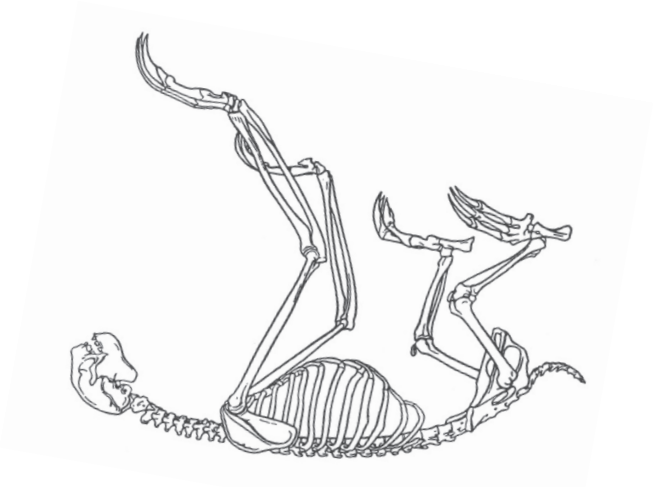

Figure 1.5. Skeleton of a three-toed sloth. (Adapted from de Blainville,1840; also reproduced in Young, 1973, p. 600)

immobile. The outer ears are tiny and are essentially stationary. The sloth alters the direction of its gaze by moving its head, not its eyeballs. This rather fixed countenance is dissolved at the lips and nostrils, which, as the primary gateways to perceiving and taking in food, are quite mobile.

Laxity

If we look for the embodiment of fixed form in the organ systems of a mammal, we come to the skeleton. The bony skeleton gives the mammal its basic form and is the solid anchor for all movement. The limb bones develop their final form in relation to both gravity and their own usage. An injured quadruped mammal will lose bone substance in the leg it is not using, which does not carry any weight. Conversely, in the other three limbs bone matter is laid down to compensate for the increase in weight carried and muscular stress.

Hoofed mammals like zebras or giraffes spend most of their lives standing and walking. By virtue of their skeletal architecture they can relax their muscles and even sleep while standing. Their legs are solid, stable columns that carry the body's weight. Active arboreal mammals, like monkeys, have, of course, nothing of the skeletal rigidity of ground-dwelling quadrupeds. They have flexible joints and muscular agility that allow for actively

Figure 1.6. Three-toed sloth. Note the orientation of the head.

swinging, jumping, and grasping. Their long tail serves as an extra limb for balance. They have an energetic lightness in movement and expression.

Then there is the sloth. Spending most of the day reclining on branches or hanging, the sloth gives itself over to gravity rather than resisting it and living actively within it. A sloth kept on the ground in a box developed raw feet from the unaccustomed pressure.[12]

The sloth has very loose limb joints. In his detailed study of the limbs of the two-toed sloth, Frank Mendel points out the unusual nature of the "poorly reinforced and extremely lax joint capsules."[13] This anatomical peculiarity allows a wide range of limb movement and is connected with the fact that the joints are not subject to compression as they are in weight-bearing limbs. Through clinging and hanging, the joints of a sloth are being continually stretched. Similarly, the sloth has a flexible, curved spine. The hoofed mammal, in contrast, has a stiff, straight spine, from which the rib cage and internal organs of the torso are suspended. A zebra would be as ungainly in a tree as a sloth is on the ground.

The laxity of the joints finds positive expression in the flexibility and fluidity of slow movement that the sloth embodies. A sloth can twist its forelimbs in all directions and roll itself into a ball by flexing its vertebral

column. It can move its head in all directions, having an extremely flexible neck. Imagine a sloth hanging from all four legs on a horizontal branch. In this position the head looks upward (like when we lie in a hammock). Now the sloth can turn its head—without moving the body—180 degrees to the side and have its face oriented downwards. As if this were not enough, the sloth can then move its head vertically and face forward—an upright head on an upside down body (Figure 1.6)! When it sleeps, a sloth can rest its head on its chest.

The sloth's neck is not only unique in its flexibility, but also in its anatomy. Mammals have seven neck (cervical) vertebrae. Even the long-necked giraffe and the seemingly neckless dolphin—to mention the extremes—both have seven cervical vertebrae. This mammalian pattern is abandoned by only the sloth and the manatee. The three-toed sloth often has eight or nine neck vertebrae, some of which occasionally fuse into one. The two-toed sloth usually has six cervical vertebrae. In both genera these neck "oddities" are accompanied by other changes in the spine, such as lumbar vertebrae that bear rudimentary ribs.[14]

It's interesting in this connection that three-toed sloths also show remarkable variation between individuals in the semicircular canals of the inner ear.[15] These canals are connected with the sense of balance as it is related to the head and its movements in different directions. In other species, such as squirrels or moles, there is much less variation between individuals. In the sloth the shape of the three canals, their thickness, and the angles between them—which in other animals hardly vary—vary widely. So here also, as in the neck, the sloth is less constrained or rigid in the shaping of an otherwise highly defined organ. The vestibule of the inner ear, which is also connected with the sense of balance, and the cochlea, which is connected with hearing, also show considerable variation, but not to the degree of that in the semicircular canals. What all this variability signifies for the sloth in its activities is unknown.

It is as if the sloth were saying, anatomically, "Does it really matter so much?" For the life it lives, evidently not.

Drawing In

The head is the center of the primary sense organs through which an animal relates to its environment. A sloth's eyesight is poor, and it is shortsighted.[16]

The eyes lack the tiny muscles that change the form of the lens to accommodate for changing distances of objects. As if to emphasize the unimportance of its eyes, the sloth can retract them into the eye sockets. The pupils are usually tiny, even at night. Clearly, a sloth does not actively penetrate its broader environment with its vision, as do most arboreal mammals like monkeys.

The outer ears are tiny and hardly visible on the head. While a female sloth clearly responds to the cries of her offspring, cries of a hawk flying overhead or the sound of a gun being fired can be wholly ignored (or not noticed?) by a sloth.[17] It is the drawing-in senses of smell and taste that dominate in the sloth (see the next section).

The head is relatively small and appears almost as a broadened neck. The first cervical vertebra (the so-called atlas) is nearly as wide as the widest part of the skull. The skull itself is rounded and self-contained—superficially resembling a monkey's skull more than a grazing herbivore's (Figure 1.7). Most herbivores have an elongated snout that they use as a limb—standing as they do on all four legs—to reach their food. The sloth's forelimbs have this function and thus its snout is short. The premaxillary bones—important in forming the elongated mammalian

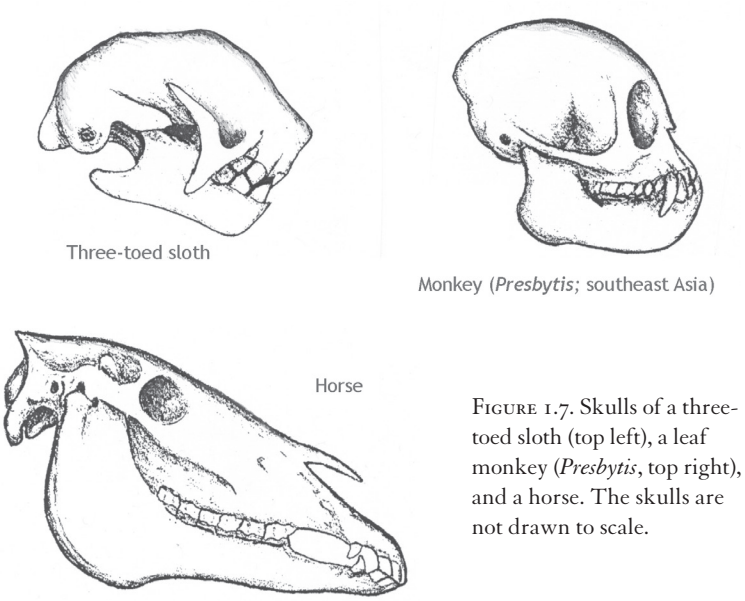

Figure 1.7. Skulls of a three-toed sloth (top left), a leaf monkey (*Presbytis*, top right), and a horse. The skulls are not drawn to scale.

snout—are tiny in the sloth. Moreover, the upper jawbones (maxillae) and the nasal bones are also short in the sloth. The sloth's skull does not project forward. Here we see the wonderful congruence of anatomy and behavior—the unity of an animal that recedes from active engagement.

The expression of pain is a barometer for the way an animal experiences its own body in relation to the environment. Pain is one way an animal experiences the external world penetrating and harming its biological integrity. Here's an example from a family that kept a sloth at their home in Brazil:

> 'Sloth burning!' … we leap to our feet and run frantically round trying to discover where [the sloth] has fallen asleep. On the kitchen stove? No! On the water heater in the bathroom? No! There he is on top of the floor lamp in the drawing-room, with his bottom touching the big electric bulb!... We struggle to get him down, but he clings desperately to his perch, refusing to budge and protesting with many ah-eees against our unwarranted disturbance of his slumbers.[18]

A burning behind and no response! Sloths are reported to "survive injuries that would be deadly within a short time to other mammals."[19] "I have known a sloth to act normally for a long time after it had received a wound which practically destroyed the heart."[20] These examples show that the sloth does not seem to notice such intrusions of its boundaries and continues to live despite them. It is somehow withdrawn; its form of embodiment is not one of sensitive reactive presence (think monkeys).

Feeding in a Sea of Leaves

Moving unhurriedly through the crown of a tree, the sloth feeds on foliage. We usually think of leaf browsing in connection with ground-dwelling mammals, such as deer. There are, in fact, only ten species of mammals that are specialized arboreal leaf eaters.[21] Leaves are an abundant and constant source of food, and plants need not be chased down. Spending virtually its entire life in the crown of trees, a sloth is literally embedded in and surrounded by its food at all times and in all directions. Tropical trees do lose their leaves, but usually not all at once. Sometimes one and the same tree may lose its leaves on one branch, while it sprouts new ones on others.

Sloths don't eat just any leaves. They seem to prefer younger leaves, and

each individual animal has its own particular repertoire of about 40 tree species from which it feeds.[22] A young sloth feeds together with its mother, often licking leaf fragments from the mother's lips. After its mother departs, leaving it at the age of about six months on its own, the young sloth continues to feed from those species it learned from its mother.

This specificity is probably a major factor in the inability to keep three-toed sloths alive in zoos. They usually die of starvation after a short period of time. In contrast, the two-toed sloth is more flexible and survives well in captivity, eating assorted fruits and leaves.

In finding and assessing food, the sloth relies not so much on vision as on a sense that entails drawing the environment into itself: the sense of smell. Naturalist William Beebe gives a nice description:

> I placed a sloth, hungry and not too disturbed, on an open area under the bamboos, and planted four shoots twenty feet away in the four directions of the compass. One of these was *Cecropia* [a primary food of three-toed sloths] camouflaged with thin cheesecloth, so that the best of eyesight would never identify it, and placed to the south, so that any direct wind from the east would not bring the odor too easily. The sloth lifted itself and looked blinkingly around. The bamboos thirty feet above, silhouetted against the sky, caught its eye, and it pitifully stretched up an arm, as a child will reach for the moon. It then sniffed with outstretched head and neck, and painfully began its hooking progress toward the *Cecropia*.... Not only is each food leaf tested with the nostrils, but each branch.[23]

So we need to imagine the sloth orienting itself in a sea of wafting scents.

When a sloth is in the immediate proximity of leaves it feeds on, it slowly extends its forelimb or hind limb, hooks the branch with the claws, and brings the leaves to its mouth. Remarkably, sloths can feed in all positions, even hanging upside down. A young captive two-toed sloth showed "decided preference for eating upside down in the manner of adult sloths."[24]

Having no front teeth (incisors or canines), it tears off the leaves with its tough lips. While feeding, the sloth continuously chews with its rear, peg-like teeth, and simultaneously moves food backward with its large tongue in order to swallow.

Unlike most leaf-eating mammals, the sloth lacks many deeply rooted, hard, enamel-covered, and distinctly formed grinding teeth—enamel is the hardest substance a mammal can produce. The sloth also has comparatively few teeth (18 compared to 32 in most deer). Lacking enamel, the teeth wear easily, but in compensation they grow slowly throughout the animal's life. Growth and wear are in balance. The sloth's teeth emerge as simple cones and take on a characteristic form in the course of life.[25]

That the teeth lack enamel and allow wear and tear to form them is not at all characteristic for a mammal. Usually mammal teeth emerge highly formed, and scientists can determine a species by the tooth characteristics. But "since sloth teeth acquire their individual characteristics through wear, it is very difficult to distinguish the young of one genus from those of another based upon shape or location of dentition."[26]

The softness and lack of distinct, species-determined tooth form indicate a kind of anatomical passivity, if I may call it that. It seems to be a signature characteristic of the sloth to let itself be so strongly formed through the environment—whether in tooth form or the green tint of its fur. We will discover more features of this nature.

Centered in its Stomach

Digestion in the sloth occurs at a remarkably slow rate. In captive animals "after three or six days of fasting the stomach is found to be only slightly less full."[27] Leaves are hard to digest and not very nutrient-rich, consisting primarily of cellulose and water. Only with the help of microorganisms in the stomach can the sloth digest cellulose, breaking it down into substances (fatty acids) that can be taken up by the blood stream.

The sloth's stomach is—remarkably—multichambered, somewhat resembling that of ruminants (such as bison or cows), and is clearly the center of the digestive process. The stomach is enormous relative to the animal's overall size. It takes up most of the space of the abdominal cavity and, including contents, makes up from 17 to 37 percent of total body weight.[28] Food stays a long time in the stomach, and it takes a long time to digest the leaves. On the basis of field experiments, researchers Montgomery and Sunquist estimate that it takes food about ten times longer to pass through a sloth than through a cow. Moreover, the sloth also digests less of the plant material than most other herbivores.[29]

Through its stomach a mammal senses hunger. Most grazing mammals spend a large part of their time eating, so that food is continuously passing through their digestive tract. The sloth is, once again, an atypical herbivore since it feeds for a comparatively small portion of its day—one to four hours of a 24-hour day.[30] A small rainforest deer, the same size as a sloth, ate six times as much during the same period of time.[31] The howler monkey, which also lives in the canopies of Central and South American rainforests and whose diet comprises only about 50 percent leaves, eats about seven times as many leaves as do sloths. With its slow metabolism and digestion, the sloth's stomach remains full, although the animal eats so little.

As a stark contrast, we can think of carnivores like wolves or lions that regularly, as a normal part of their lives, experience empty stomachs. Their hunting drives are directly connected to their hunger. Hunger brings about the maximal aggressive activity of these animals. When a lion has gorged itself on 40 pounds of meat, it becomes lethargic and sleeps for an extended period of time. The sloth's constantly full stomach is a fitting image for its consistently slow-paced, phlegmatic, and nonaggressive way of life.

After about a week of feeding, sleeping, and external inactivity, a change occurs in the sloth's life. It begins to descend from its tree. Having reached the forest floor, it makes a hole in the leaf litter with its stubby little tail. It then urinates and defecates, covers the hole, and ascends back into the canopy, leaving its natural fertilizer behind.[32]

The feces decompose very slowly. The hard pellets can be found only slightly decomposed six months after defecation. Normally, organic material decomposes rapidly in the warm and moist conditions of the rainforest. For example, leaves decompose within one to two months (a process that can take a few years in a temperate-climate forest). Ecologically, sloth feces "stands out as a long-term, stable source [of nutrients] ... and may be related to stabilizing some components of the forest system.... Sloths slow the normally high recycling rates for certain trees."[33] Sloths contribute not only slow movement to the rainforest but slow decomposition as well! How fitting.

It is estimated that a sloth can lose up to two pounds while defecating and urinating, more than one-fourth of its total body weight.[34] If one imagines a sloth with a full stomach (which it always seems to have) just prior to excreting, then more than half of its body weight is made

up of its food, waste, and digestive organs! This quantitative consideration points to the qualitative center of gravity in the animal's life. But the sloth's stomach is more like a vessel that needs to remain full than a place of intensive muscular activity, secretion, mixing, and breaking down, as it is, for example, in the cow.

Stretching Time

"Sloths have no right to be living on this earth, but they would be fitting inhabitants of Mars, whose year is over six hundred days long."[35] In his typical humorous way, naturalist William Beebe expressed with these words his awe of the sloth's ability to "stretch" time, another way of characterizing their slowness. We have seen how this quality permeates every fiber of their day-to-day existence. It is therefore not so surprising to find that the development of sloths takes a long time.

Three-toed sloths have a gestation period of around six months, compared to a little over two months in the similar-sized cat, while two-toed sloths give birth only after eight to ten months.[36] Initially more surprising was the rediscovery of a female sloth in the rainforest 15 years after she had been tagged when she was already an adult. This means she was at least 17 years old, "an unusually long life span for such a small mammal."[37] Thus, regarding time, the qualities of the sloth certainly speak a unified language.

Going with the Flow

Since sloths are externally inactive a good portion of the 24-hour day and the remaining time is spent slowly moving and feeding, they perform about 10 percent of the physiological work of a mammal of similar size.[38] All metabolic processes are markedly measured in tempo and intensity. The basal metabolic rate, which is a measure of how much energy an animal uses to carry out its life functions in a resting state, is about 40 percent less in three-toed sloths than in other mammals of comparable size.[39] Sloths use little oxygen, breathe slowly, and the respiratory surface of their lungs is small. While an inactive sloth takes on average nine breaths per minute, a cat takes about 20, and breathing out takes up about 70 percent of the time of one in-breath and out-breath cycle.[40]

All metabolic activity produces warmth. Warmth is also needed for activity, for example, in the exertion of muscles, which in turn results

in more warmth production. Birds and virtually all mammals not only produce warmth, but also maintain a constant body temperature. This is a striking physiological feat. A warm-blooded (endothermic) animal is like a radiating, self-regulating center of warmth. Warmth constantly permeates the whole organism.

Most mammals maintain a constant core body temperature of about 98°F (36°C), which changes only little despite variations in environmental temperatures. For example, in a laboratory experiment a mouse's internal temperature changes only four-tenths of one degree Celsius when the outer temperature rises or falls twelve degrees.[41] A sloth does not create so much warmth, and its body temperature can vary markedly.

During the morning, as the ambient temperature rises, its body temperature rises. When found on sunny days, sloths are often on an outer branch, belly-side up and limbs extended, basking in the sun. Body temperature usually peaks at about 96–100°F (36–38°C) soon after midday.[42] It then begins to fall, reaching a low point of about 86–90°F (30–32°C) in the early morning. The body temperature is usually about 12–18°F (7–10°C) higher than the ambient temperature. Interestingly, sloths eat more when the ambient temperature is higher, unlike many mammals that eat more when it is cold.[43]

Although sloths are often active at night, their body temperature does not rise with their increased activity. This shows, in contrast to other mammals, that the sloth's body temperature is less affected by its own activity than by the ambient temperature. According to scientist Brian McNab, the sloth "almost appears to regulate its rate of metabolism by varying body temperature, whereas most endotherms [warm-blooded animals—mammals and birds] regulate body temperature by varying the rate of metabolism."[44]

Beneath its outer hair, a three-toed sloth has an insulating coat of fur comparable to that of an arctic mammal, which seems at first rather absurd for a tropical animal. It has, like an arctic fox, an outer coat of longer, thick hair and an inner coat of short, fine, downy fur. These allow the sloth to retain the little warmth it creates through its metabolic processes. But, characteristically, the sloth cannot actively raise its body temperature by shivering as other mammals do. Shivering involves rapid muscle contractions that produce warmth.

Clearly, the sloth is at home in the womb of the rainforest. Not only by virtue of its coloring and inconspicuous movements does the sloth blend into its environment, but also through its slowly changing body temperature.

Sloth as Habitat

As if to emphasize its passive, somewhat withdrawn character, the sloth becomes a habitat for myriad organisms. I have mentioned the algae that live in its fur, giving the pelage a greenish tinge. In addition to the usual ticks and flies that infest the skin and fur of other mammals, a number of sloth-specific moth, beetle, and mite species live on the sloth and are dependent upon it for their development.[45] The sloth moths and beetles live as adults in the sloth's fur. Some species live on the surface, and others inhabit the deeper regions of the fur. They are evidently not parasitic; their source of food is unknown.

When the sloth descends from a tree to defecate and urinate, female moths and beetles fly off the animal and lay their eggs in the sloth's dung. The wings of one moth species break off soon after they inhabit the sloth, and they crawl around deep in the sloth's fur. Evidently, the sloth's relatively long period of defecation, which lasts a few minutes, gives the insects the time they need to make their journey off the sloth. In this way the slowness of the sloth serves these most "slothful" of sloth moths!

Larvae develop out of the eggs and then feed on the dung (which, you remember, decomposes slowly). The larvae pupate in the dung and the winged adult moths (or beetles) fly off to inhabit another sloth. Various species of insects and mites inhabit any given sloth, and the numbers of specimens of each species varies greatly, ranging from a few to over a hundred. In one single sloth 980 beetles of a particular species were found.

The sloth has been observed grooming its fur. This is typical mammalian behavior and does rid an animal of some of its "pests." From this utilitarian point of view, the sloth's grooming is not very effective. Typically, sloths groom slowly, and sloth moths "may be seen to advance in a wave in front of the moving claws of the forefoot, disturbed, but by no means dislodged from the host."[46] Its measured pace of life, its unique excretory habits, and the consistency of its dung allow the sloth to be a unique habitat for such a variety of organisms.

One research team has investigated the ecosystem of the sloth fur in more detail and discovered that sloths lick their fur and ingest some of the algae living there.[47] The algae are more easily digestible and have a higher lipid content than the leaves sloths primarily feed on. So sloths are "grazing the 'algae gardens'" that their fur lets grow. The "algae gardens," in turn, are evidently fertilized by nutrients provided by their insect inhabitants (through urine, feces, and decomposing body parts). So sloth fur is a kind of a microcosm of the larger ecosystem of which it is a part.

Other animals haven't overlooked that sloths are a habitat teeming with life. For example, researchers observed two birds—yellow-headed caracaras—"picking from the fur of the sloth.… The sloth showed no sign of defensiveness or aggression toward the caracaras even when they were foraging on its head and neck. It assumed a relaxed posture, reclining on a branch with its front legs extended behind its head. The behavior continued for 5-10 min[utes]."[48] Why not let birds do a bit of feeding and grooming?

Sloth, tree, moth, beetle, bird, and algae all interweave. On the one hand, each of these organisms—as a center of form and activity—is itself, is its own being. On the other hand, the existence of each is bound up with and made possible by myriad other creatures and, of course, light, warmth, air, and rain. Because every organism is itself by virtue of others, there are no hard and fast boundaries in the living world. In the chapter on the bison I will look more closely at the question of where an animal ends.

Encircling the Unspeakable: The Animal as a Whole

I'd like to return to the statements quoted at the beginning of this chapter. George Louis Leclerc, Comte de Buffon, was a well-known eighteenth-century French natural philosopher (as scientists were called in those days) who studied many animals, among them the sloth. He came to the conclusion that "one more defect and they could not have existed."[49] The sloth's remarkable characteristics were for him defects. And they are, if you take the point of view of a horse, eagle, jaguar, or human being.

But William Beebe had a great retort to Buffon: "A sloth in Paris would doubtless fulfill the prophecy of the French scientist, but on the

other hand, Buffon clinging upside down to a branch of a tree in the jungle would expire even sooner."[50] Beebe recognized how each creatures has its unique manner of existence. Writing some years after Buffon's death, the poet and scientist J. W. von Goethe articulated such an integrative view of animals:

> We conceive of the individual animals as a small world, existing for its own sake, by its own means. Every creature is its own reason to be. All its parts have a direct effect on one another, a relationship to one another, thereby constantly renewing the circle of life; thus we are justified in considering every animal physiologically perfect.[51]

When Goethe calls an animal "perfect," he means that each animal has its own unique way of being—its specific integrity that we can try to understand. But this is no simple matter. Goethe recognized that "to express the being of a thing is a fruitless undertaking. We perceive effects and a complete natural history of these effects at best encircles the being of a thing. We labor in vain to describe a person's character, but when we draw together actions and deeds, a picture of character will emerge."[52]

In this portrayal of the sloth, I have discussed many details, because through them the whole lights up. Henri Bortoft puts it well when he says, "The way to the whole is into and through the parts. The whole is nowhere to be encountered except in the midst of the parts."[53] The emergent picture of the whole does not and cannot encompass the totality of its characteristics and interactions. We can always discover new details. It is not about knowing all the facts, but about seeing them in relation to one another and as expressions of the wholeness of the animal. Such understanding hinges on our ability to overcome the isolation of separate facts and to begin to fathom the animal as a whole, integrated organism—which includes its relations to other creatures, substances, and forces that support its existence.

The whole is elusive and yet, at every moment, potentially standing before the mind's eye. When we begin to see how all facets of the animal are related to each other, then it comes alive for us. Or, putting it a bit differently, the animal begins to express something of its life in us. Every detail can begin to speak "sloth," not as a name, but as a qualitative concept to which no definition can do justice.

I have tried to describe the sloth in a way that allows us to catch glimpses of its wholeness. I can now refer to such characteristics as slowness, inertia, blending in with the environment, receding or pulling in, and not actively projecting outward. Each expression is a different way of pointing to the same coherent whole. Taken alone, as abstract concepts or definitions, these pointers are empty. They are real only inasmuch as they light up within the description or perception of the animal's characteristics. But they are not things like a bone or an eye. They are, in context, vibrant concepts that reveal the animal's unique way of being.

Let's return to the sloth, up in the crown of a rainforest tree, nestled on a branch. In its outer aspect, it blends in with its environment. The sloth's body temperature rises and sinks with the ambient temperature. There are no sudden or loud movements. Its green-tinged, mottled brown coat lets it optically recede into the wood and foliage of its surroundings. And like the tree bark, the sloth's fur is teeming with life.

The round form of its head is the anatomical image of the sloth's withdrawn relation to its environment. There are no large, movable, reactive outer ears. And the eyes are rarely, if ever, moved. The sloth has no protruding snout. It draws the scents of the environment, especially of the leaves it feeds upon, into its nose. But much of the day the sloth is inactive. Even when awake, the sloth seems not to live as intensely in its body as other mammals, being quite insensitive to pain.

The sloth does not carry its own weight; rather, it clings to or rests on an outer support. Its skeletal system is not characterized by stability, but by looseness. This laxity allows the sloth to adopt positions that would be contortions in other animals. The sloth makes mostly steady pulling movements with its long limbs, a capacity based on the dominance of retractor muscles. With its loose-jointed body, it "flows" when it climbs.

Developing slowly in the womb, the sloth also has a long, slow life. It moves unhurried through the crowns, feeding on the leaves that surround it from all sides, bathing in its food source. The leaves pass through the animal at an almost imperceptibly slow rate. The sloth's

stomach is always filled with partially digested leaves—leaves that previously surrounded it in the tree canopy. Even its dung disappears slowly, moderating the otherwise rapid decomposition processes that characterize the warm and humid rainforest climate.

Almost merging with the vegetative life of its environment, the sloth brings—as an animal and ever-"smiling"—a plantlike slowness into its world.