CHAPTER 1

BEATRIX versus the BOTANISTS

Where observation is concerned, chance favors only the prepared mind.

LOUIS PASTEUR, 1854

Had Beatrix Potter been allowed to follow her vocation, Peter Rabbit and Mrs. Tiggy-Winkle might never have been born. Instead of writing and illustrating stories loved by children all over the globe, she would have been writing groundbreaking articles for scientific journals. Beatrix's ambitions were thwarted not only because she was a young woman attempting to contribute to a profession almost entirely dominated by Victorian men, but also because she was a symbiologist—a proponent of the dissident theory that some organisms were composed of not one but two different beings. Her story has become a legend of youthful scientific inquiry stifled by pomposity and prejudice, and of a heresy that was later vindicated.

No one who has encountered Beatrix Potter's graphic contributions to biology is surprised at the beautiful natural detail of the pictures in her books, such as *The Tale of Squirrel Nutkin* and *The Tale of Jemima Puddle-Duck*. They depict animals, dressed as human beings, immersed in the fairy-tale activities of a sanitized Victorian village. Virtually every picture includes features of the surrounding landscape—a carpet of wildflowers, the rough bark of an oak tree, or a mossy stone. During her own childhood, she loved nothing more than recording the subtle details of the living world. Often neglected by her parents, who like many Victorian aristocrats had decided not to send their daughter to school, she used to take herself on expeditions to the Natural History Museum, just round the corner from their London house. Here she would sketch anything that caught her eye, returning to the museum day after day. Animals were to form the central characters of her books, but as a child she would be just as enthralled by the fine structure of the gills on the underside of a mushroom as by the arrangement of feathers on a bird's wing.

Beatrix's childhood holidays were spent in Perthshire, Scotland, and in the English Lake District, where she was in her element. Here, accompanied by her brother, she could explore the natural world and draw exactly what she wanted. She soon developed into a superb watercolor painter, able to produce pictures that were both aesthetically satisfying and scientifically accurate. As she gained

confidence, Beatrix started to compare her findings with those of other botanists of her day. In Perth she befriended the local postman and amateur naturalist Charlie Macintosh, whose studies of mosses and fungi can still be seen at Perth Museum. Macintosh liked her drawings. "His judgement," wrote Beatrix in secret code in her diary, "speaking to their accuracy in minute botanical points, gave me infinitely more pleasure than that of critics who assume more, and know less than poor Charlie. He is the perfect dragon of erudition, and no gardener's Latin either."

Middle-class Victorian society was in awe of the apparent power and moral superiority of the scientific worldview. Keen to make her own contribution, Beatrix kept careful notes of everything she saw, and compared them with what other naturalists had observed. During her teens, she also made detailed studies with her microscope of various botanical specimens. She quickly discovered that one of her favorite subjects of study, the lichen, was the battleground of an increasingly heated scientific controversy.

Lichens are the crusty green and gray covering of rocks and tree trunks. Often confused with the damp-loving mosses, lichens are less intricate but usually longer lived than their larger cousins. Worldwide, these lowly lifeforms cover ten times as much of the earth's surface as tropical rain forests. From the Arctic to the Tropics, lichens are a biological realm hidden in plain sight. Thousands

of different species range in color from orange and black to brown and green. On a walk along a rocky coastline you might see only a handful of different wildflowers, but you could have walked past 80 or 90 different lichen species. With their variety of rock types, shading, and nutrients, British churchyards are paradises for lichens, with 180 different kinds having been counted around a single church.

Carolus Linnaeus, the eighteenth-century botanist and the founder of modern plant taxonomy, had no time for lichens. He called them the "poor peasants of the plant world." Thinking them to be either a primitive moss or an unusual fungus, his successors dismissively classified these curiosities as the "lower plants." The Swiss botanist Simon Schwendener begged to differ. In 1869 he startled the scientific world with a "dual hypothesis" for the taxonomy of lichens. He proposed that all members of the group came into being via the liaison between a fungus and an alga. The alga was useful to the fungus, which nurtured it, he claimed.

Most biologists treated Schwendener's ideas with contempt. They could not believe that even the most bizarre form of parasitic relationship could lead to a permanent merger between two organisms. It also seemed extraordinary to suggest that a composite organism could function as an integrated and successful whole. In the introduction to his classic *Lichen Flora of Great Britain, Ireland and the Channel Islands,* the Reverend Leighton

scoffed, "I have purposely omitted any mention of the Schwendenerian Theory of Lichens, as I cannot but regard it as purely imaginary, the baseless fabric of a vision."

All the studies she made of the fine details of lichens, algae, and fungi drew Beatrix to share Schwendener's conclusion: lichens were made up of two completely different kinds of organism. Yet opposition to the dual hypothesis by the British Empire's most eminent botanists was becoming fiercer than ever. Finding it inconceivable that organisms could somehow be a mixture of creatures from different kingdoms, they clung to the idea that all organisms were exclusively either animals or plants. Reverend James Crombie, a prominent English naturalist, scolded: "A useful and invigorating parasitism—who ever before heard of such a thing?" So vocal were these scientists against what Crombie dubbed "this sensational Romance of Lichenology," the "unnatural union between a captive algal damsel and a tyrant fungal master," that they even influenced everyday speech in the late Victorian era. Calling somebody a "Schwendenerist" became a term of abuse for someone who dithered between two competing explanations for an event. "Even if endorsed by the nineteenth century," remarked botanist M. C. Cooke in 1879, such ludicrous symbiotic ideas "will certainly be forgotten in the twentieth."

At first, Beatrix was unperturbed by this opposition. Her uncle, the chemist Sir Henry Roscoe, had confidence

in her and her belief in Schwendenerism. He urged that she give a paper at a scientific society, such as the Linnaean. Housed behind a grand facade in London's West End, the Linnaean Society was an international forum for naturalists and evolutionary biologists, as it had been when Charles Darwin and Alfred Russel Wallace had announced their theories of evolution there earlier in the century. But while Roscoe could contribute to the society's proceedings, Beatrix was, like all women, barred. Although now in her late twenties and gaining a reputation for her acute observations of nature, she was not even allowed to attend the society's open meetings. Her uncle eventually won the right to read her paper at a meeting of the society himself, but the official record of the meeting has been lost. We can only imagine the mixture of smirks and tut-tuts that greeted her findings. Beatrix, already a shy and reclusive character, recorded in her diary her feelings of humiliation at her treatment. Worse was to follow.

In 1896, just after the Linnaean debacle, Beatrix made an appointment with Mr. W. H. Thiselton-Dyer, director of the Royal Botanic Gardens, Kew, in order to show her drawings to him and his staff. Many were vivid illustrations supporting Schwendener's radical lichen theory. Although she expected the Botanic Gardens' staff to be skeptical of her observations, the sexual and scientific prejudice she found at Kew shocked and upset her. Having seen the outdated and demeaning uniform that female

staff were forced to wear on her many previous visits to the gardens, she already had an idea of what treatment she was letting herself in for from the director. "I fancy he may be something of a misogynist," she wrote, "*vide* the girls in the garden who are obliged to wear knickerbockers."

When Beatrix entered his room, Thiselton-Dyer was puffing on his cigarette. He ignored her and started boasting to her uncle about the gardens' hyacinths being even better than those in Holland. When Beatrix pressed him for an opinion on her drawings he refused to even look at them, referring her instead to the botanical gardens at Cambridge. "I fear he is jealous of outsiders," wrote Beatrix afterward, "But it is odious to a shy person to be snubbed as conceited, especially when the shy person happened to be right, and under the temptation of sauciness."

After what she describes as a "storm in a teakettle" she left Kew, never to enter the world of professional biology again. She disliked what she sarcastically called the "grown-up world" of science. Two venerated institutions, which had embraced the theory of evolution by natural selection forty years earlier, were now shattering the aspirations of one of Darwin's most able successors.

Beatrix was dispirited that the excitement of the last few years, and the great hopes of being able to make a significant contribution to science, had so cruelly and abruptly been snuffed out. She knew her passion for lichens and fungi would now only lead to further public ridicule, both for herself and for her favorite uncle. One

by one, she laid her treasured folios of watercolors aside. It would be 1967 before William Findlay, president of the British Mycology Society, returned them to their rightful place as outstanding scientific studies of nature, when he used them to illustrate his field guide to the fungi and lichens of the British Isles.

Despite their initially vicious reception, the ideas of Schwendener and Potter were accepted by most biologists within a few decades. Lichens were shown to be true dual entities, the association of a bacterium or an alga with a fungus. In 1929, H. G. Wells and Julian Huxley remarked in *The Science of Life* that "a lichen is no more a single organism than a dairy farm is a single organism." In this encyclopedic textbook, the authors describe a diverse range of similar alliances that had been recorded in a wide variety of plants, animals, and fungi. Far from being primitive taxonomic obscurities, irrelevant to the rest of evolution, lichens could be, they suggested, the dual ancestor common to all plants. More recently, Schwendenerism has not only been rehabilitated, but has provided the key to understanding the role of intimate associations in the evolution of our plant-dominated landscapes. Arriving with their radical networking manifesto 400 million years ago, fungi are the alliance-building kingdom that built the power supply for almost all terrestrial life.

In the world of picture books, lichen illustrations on their own had little chance of being appreciated. But in

her 1904 *The Tale of Benjamin Bunny* and many subsequent books, Beatrix Potter included trees in the background to her main story whose bark was studded with luxurious encrustations. In editions printed after her death, however, this last legacy of Beatrix's earlier intellectual bravery was erased. Now, as these kinds of alliances between organisms begin to be celebrated rather than dismissed, it is surely time for the original lichen-enriched editions to be returned to nurseries and playrooms around the globe. Having received posthumously an official apology from the Linnaean Society for its treatment of her, at a meeting held in her honor in 1997, exactly one hundred years after it had barred her from speaking, Beatrix Potter is now beginning to receive the recognition she so richly deserves.

Early Schwendenerists would have been emboldened in their convictions if they had had the benefit of current insights into the chemical logic and hand-in-hand evolutionary consequences that underlie the lichen's liaison. On one hand there are the algae, the common name for yellow, brown, red, and green microbes. They manufacture themselves almost out of thin air—from water, carbon dioxide in the atmosphere, and the absorbed rays from the sun. The ability to make their own food autonomously by the process of photosynthesis has led scientists to describe them as autotrophic—literally "self-feeding"—a category in which they are they are joined by many kinds of bacteria. On the other hand are the fungi, which along

with most animals depend, by contrast, on various kinds of "heterotrophic" metabolism. In other words, mushrooms, like mice and monarch butterflies, derive their nutrition from compounds made by other organisms.

Intimate liaisons often arise between organisms of the auto- and hetero- classes of trophism. Such relationships are commonly known as symbioses—literally meaning "together-living"—the long-term association of two different organisms. Why does this happen? One of the key reasons is that, at the microchemical level, the cells of all organisms slowly leak their contents like tiny tea bags. In lichens, green algae cannot prevent some sugars from passing through their cell walls, while fungi leak essential nutrients such as nitrates and phosphates through their outer membrane. Because most chemicals leaked by one associate are useful to the other, the integration of the two over evolutionary time has turned the passive leakage into a process of active transport by which means materials are passed at a far higher rate than natural diffusion, and both algae and fungi are provided with ready food generation after generation.

In addition, the lichens' particular lifestyle allows them to tolerate a wide range of conditions of intense cold, heat, light, and barren rock, which neither the fungi nor the algae on their own, let alone larger plants, could tolerate. When Edmund Hillary and Tenzing Norgay reached the summit of Mount Everest in 1953, they might have been surprised to notice that lichens, too, had scaled its

heights. Often visible only as black specks that you would be forgiven for mistaking for pieces of soot, they can be found on almost any piece of rock on Earth.

In the year 1066, a more noticeable lichen served as an important landmark in Britain. As King Harold tried in vain to fend off the Norman invasion at the Battle of Hastings, he instructed his noblemen to assemble with their armies at the "hoar" apple tree on Caldbec Hill, meaning a tree that was gray and shaggy with lichen. The British still use expressions such as hoarfrost, meaning a frost that covers grass and tree twigs with a fur of ice crystals.

Lichens are a powerful symbol of endurance as well. In one of his sonnets, Shakespeare identifies lichens as the organism that betrays the age of rocks:

> Not marble, nor the gilded monuments
> Of princes, shall outlive this powerful rhyme;
> But you shall shine more bright in these contents
> Than unswept stone, besmear'd with sluttish time.

And an unknown medieval elegist meditating among the Roman ruins in the city of Bath describes lichens as a model of stoicism in the face of changing fortune and bloody wars:

> Time and again this wall endured,
> Lichen grey and red stained,
> As kingdom follows kingdom follows kingdom.

Across Renaissance Europe, knowledge of lichens contributed to a revival of interest in herbal medicine. John Gerard's *The Herball, or Generall Historie of Plantes,* published in 1597, contains woodcut pictures of five lichens, including tree lungwort and coral moss, along with their medicinal uses. According to the "Doctrine of the Signatures," which held that the Creator had marked those plants suitable for treating diseases by a resemblance to a specific part of the human body, lichens found growing on human skulls were considered a uniquely potent cure for epilepsy. Many more conventional lichen-derived medicines are still listed in the drugstore pharmacy manuals. Antibiotics such as usnic acid, found in the lichens *Evernia* and *Usnea* and over half all other lichen species, are used in products such as skin creams and antidandruff shampoos. Iceland moss is a lichen widely used to brew a tea that is effective against respiratory infections and to make throat lozenges. And as every science student knows, lichen extracts were the origin of litmus paper—the most simple means of testing whether a liquid is acid or alkaline.

During the height of the Napoleonic Wars, lichen dyes played a role in a famous military victory. In February 1797, a French army landed in Fishguard, Pembrokeshire. The British army was nowhere to be seen, yet the nervous French soldiers mistook the red-lichen-dyed cloaks of a number of distant Welsh women mounted on hill ponies for the uniforms of advancing battalions of

regular soldiers. They surrendered without a shot being fired.

More recently this crusty clan, which together produce over four hundred compounds found nowhere else in nature, have been used to monitor pollution. The different lichen species present in a particular location act as a litmus paper for the atmosphere. Just a 5 percent increase in sulfurous oxides eliminates one leafy group—the foliose lichens. But like many organisms engaged in intimate association, the correct identification of different species demands a keen and sympathetic eye.

The same crustlike lifestyle that leaves lichens so easily ignored also allowed them to be the first significant colonizers of the land, perhaps as long as a billion years ago. Though bacteria were already present, living within cracks in rocks and at the edge of shallow pools, the lichen invasion began a more fundamental transformation in terrestrial ecology, that from rock to soil.

Today it is clear that the only scenario more remarkable than the evolution of the lichen would be one in which this joint organism had not evolved; the metabolisms of algae and fungi complement each other perfectly. Plugging into a range of ecological services via their intimate alliances, the plant kingdom has become the master of evolution by association. Neither Victorian prejudice nor the marginalizing of her favorite life-forms by twentieth-century evolutionists could prevent Beatrix's symbiotic manifesto from finally proving its scientific

worth. Nature may, as Darwin seemed to imply, be red in tooth and claw, but it also, as Beatrix taught us, survives by being green-fingered.

In her last secret diary entries written soon after her rebuff at Kew, Beatrix Potter wished she could study the fungi and lichens again someday. "The funguses will come up again and the fossils will keep," she wrote. "I hope I may go back again when I am an old woman." By the age of thirty-nine she had. Potter bought a farm in her beloved Lake District, from where she spent forty years writing her children's books and enjoying the local farmers' tradition of breeding Herdwick sheep. Even if no more than a handful of the thousands who flock annually to Hill Top Farm understand that the real intellectual passion of her life was not Jemima Puddle-Duck and Benjamin Bunny, it is still comforting to know that this brave woman, so poorly treated as a scientist, was finally able to spend half her life there studying her forgotten symbionts away from the gaze of "grown-up" science.