A photograph of Jane Goodall in a lush green forest. She is wearing a light-colored, short-sleeved button-down shirt and dark pants. She has her left hand resting on a tree trunk and is looking upwards. The background is filled with dense foliage and tree trunks.

JANE GOODALL

WISDOM
AND WONDER
FROM THE
WORLD OF
PLANTS

SEEDS OF HOPE

WITH GAIL HUDSON

FOREWORD BY MICHAEL POLLAN

SEEDS OF HOPE

WISDOM AND WONDER
FROM THE
WORLD OF PLANTS

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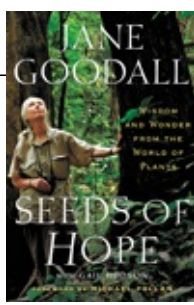
with

GAIL HUDSON



GRAND CENTRAL
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This book is dedicated to Danny, Olly, and Uncle Eric, who created a magic garden during my childhood; and to Judy, Pip, and Wayne, who keep it alive today; to the scientists, naturalists, and traditional healers whose fascination with the Green Kingdom has helped me to understand many of its mysteries; to all those who dare to speak out against “conventional” farming and genetically modified plants and the poisoning of our planet; and to the glorious diversity and resilience of the plants and trees themselves.

Foreword by Michael Pollan



My first reaction upon learning that Jane Goodall was taking a break from animals to write a book about plants was that this was very good news indeed for the plants. Plants don't get nearly as much ink or respect as the animals do, something I've always felt was deeply unfair, if entirely understandable. Animals are much easier for humans to identify with, sharing with us, as they do, such traits as consciousness, emotion, locomotion, and communication skills. You can tell stories about animals that have the same dramatic shape as stories about people, with heroes and villains, journeys, and conflicts. That's not so easily done with plants, which seem simple by comparison and rather opaque.

It is worth remembering that before Jane Goodall came along and introduced us to a society of chimpanzees at Gombe, in Tanzania, even the primates seemed much simpler and more opaque to us—much more difficult for us to identify with. It was her meticulous observation and chronicling of the lives of Mike and Humphrey, of Flo and Gigi and Frodo—all of them chimpanzees—that demonstrated once and for all that animals were far more like us than we had imagined or cared to admit. They, too, made and used tools, learned and passed on cultural information, and formed communities of individuals with distinct “personalities”—a word that in light of her work needs some rethinking. More than any other scientist or writer I can think of, Jane Goodall expanded the circle of human empathy to take in the emotional lives of other creatures.

I'm not sure whether plants have emotional lives exactly, but anyone who reads *Seeds of Hope* cannot fail to come away thinking that they are far more complicated and interesting creatures than we give them credit for. I suspect the habit of underestimating them has its roots in our self-centered definition of what constitutes complexity or sophistication. We prize things like self-consciousness or abstract reasoning or language simply because these have been the destinations of our own evolutionary journey—the particular tools we evolved to help us cope with living on this earth. Yet the plants have been evolving even longer than we have, evolving their own tools for living, and they are easily as sophisticated as ours, just different. So while we were working hard on locomotion and consciousness, they were getting really, really good at biochemistry, up to and including their mastery of the astonishing trick of eating sunlight and turning it into food. Photosynthesis might be a skill hard for us to identify with, but—you've got to admit—it puts something like the opposable thumb, or even trigonometry, right in its place. The world could get by just fine without those little tricks, but without photosynthesis it would be a much, much duller place, lacking, among a great many other things, *us*.

In the pages of *Seeds of Hope*, Goodall introduces us to plants capable of the most extraordinary biochemical feats. There are the trees that alert one another to the arrival of an insect pest, causing the entire forest to produce compounds that render the flavor of its leaves unappetizing to the bug. (What said plants don't have communication skills?) And though plants may not themselves posse

consciousness, at least as we understand it, they do know how to manipulate the consciousness of other supposedly “higher” creatures, manufacturing chemical compounds that can change animal minds in the most striking ways—and thereby get the animals to do the bidding of the plants. We meet plants in this book that are masters of metaphor and simulation: “carrion plants” that mimic the stench of rotten meat to lure insects, and orchids that adorn themselves so as to resemble the hindquarters of female bees. Why? To trick credulous male bees into performing acts of “pseudocopulation” that unbeknownst to them, are actually acts of pollination. In fact there are so many stories in this book about plants getting the better of animals that you really have to wonder which kingdom of creatures is really calling the shots, even in an enterprise as seemingly humanocentric as “agriculture.” To read *Seeds of Hope* as a member of the animal kingdom is, among other things, a humbling experience.

In writing about plants, Goodall combines the cozy traditions of English garden writing—the epistolary ease and familiarity with horticulture—with the authority of an intrepid scientist who has spent not just days or weeks but years living in the forest among the trees. She has cultivated that way of being in (and with) nature E. O. Wilson had in mind when he coined the word *biophilia*. Though the book is steeped in science, Goodall’s feelings for the plants are spiritual—and her concern for their fate in the modern world is forthrightly political.

Seeds of Hope is not just a love letter to the plant world, though it is certainly that. It’s also a call to arms, sounding the alarm about habitat destruction, the violence of industrial agriculture, and the risks of genetic engineering. In our own time, the long, beautiful, and mutually beneficial coevolutionary journey of plants and animals has arrived at a critical new juncture, Goodall suggests, and this gives *Seeds of Hope* its sense of urgency. Jane Goodall wants nothing less than to expand the circle of human affection once again, make it wide enough to take in the sunlight eaters. For both their sake and our own, let us hope she succeeds.

PART ONE



My Love for the Natural World

Chapter 1



A Childhood Rooted in Nature



Me, at about three years old, setting out to explore the forest. (CREDIT: W. E. JOSEPH, "UNCLE ERIC")

“Jane Goodall has written a book about plants? Surely not—isn’t she the one who studied chimpanzees in Africa?” I can hear the comments. Indeed, I have been hearing them for the past couple of years as I collected information for this book. Of course I am best known—thanks especially to *National Geographic’s* magazine articles and documentaries—for the study of the Gombe chimpanzees. In 2010 we celebrated fifty years of research there. But there would be no chimpanzees without plants—nor human beings either, for that matter. And the chimpanzee might never have materialized for me had I not been obsessed, as a child, with stories of the wilderness areas of the planet and, most especially, the forests of Africa.

From my window, as I write in my house in Bournemouth, England, I can see the trees that I used to climb as a child. Up in the branches of one of them, a beech tree, I would read about Doctor Dolittle and Tarzan, and dream about the time when I, too, would live in the forest.

When war broke out in Europe, my father went off to fight for his country against Hitler and the Nazi scourge. This is when I came with my sister and my mother to live with her two sisters, Olly and Audrey, and her mother—known by all as “Danny” (as I could not say “Granny” when I was small)—in this 1872 red-brick Victorian house, with huge sash windows and high ceilings. *The Birches*.

We had little money between us—and anyway, it was wartime rationing, tightened belts, and so on. But we had a big garden (or yard) with a lawn where moss insisted on growing, and a good many trees

There was my beech and three magnificent silver birch trees, with their smooth, silvery trunks and graceful branches. There was a mountain ash, or rowan, glorious with red berries in autumn, and two Spanish chestnut trees—one of which produced minute chestnuts each year, hardly worth the bother of opening the prickly cases, while the other—which we named “Nooky”—had been maimed. The upper half of his trunk and branches had been sawed off so that he was, in effect, little more than a twenty-foot-tall stump. A stump that sprouted prolific branches that reached up to the sky for another twenty feet or more, as though to compensate for the missing trunk. Nooky never produced a flower, let alone a chestnut.

All around the garden was a tall hedge of privet interspersed with the occasional trimmed holly tree. It was not a “bright” garden, because it was shaded by two big fir trees and five pines, and there were rhododendron bushes and ivy all over the place. And so, although Danny and Olly worked hard trying to grow vegetables for the war effort, what with the shade and the sandy soil (we are just a ten-minute walk from the ocean), and the acidity caused by the rhododendrons and pines, it was only runner beans and Danny’s parsley and mint that really flourished.

But some things grew. All year-round, except in the very cold months, there were daisies all over the lawn. I wonder how many daisy chains we made each year. And dandelions appeared everywhere—almost impossible to dig up with their long, long roots. Every spring we watched for the first snowdrops pushing through soil still hard from winter frosts. They were followed by crocus and then, as the ground warmed, the primroses, foxgloves, bluebells, buttercups, and Wordsworth’s “cloud of dancing daffodils.” And all the time the buds on the trees were growing fat and bursting into tiny infant leaves. Then came the glorious awakening of the white blossom on the hawthorn, the rich pink red of the may, the bright yellow of the laburnum, and the purple of the lilac. And, best of all for me, the lilies of the valley with their heady fragrance that, today, poignantly reminds me of those childhood days.

Later, as spring changed to summer, Olly’s roses began to bloom, one after the other, as did her azalea that grew beside her beloved rhubarb plant, and Danny’s special dark-red peonies surrounded by her precious runner beans. And the leaves on the trees, fed by the rising sap, reached their full maturity and worked each day to change sunlight into food for the tree or shrub that had nurtured them growing.

My love of plants and trees was heightened by hours of roaming, together with my dog Rusty, through the wild cliffs that drop down to the sandy beach below. They are intersected by a series of dry streambeds that are known, in these parts, by an archaic French word—*chine*. Our house stands on Durley Chine Road. Every spring, gorse bushes blossom into a blaze of yellow on the lower slopes of our chine, and tiny sweet-scented violets appear in one spot. I used to try to find the very first tiny purple flowers to take to Olly. Violets were her passion.

When the rhododendrons bloom in the summer, the steep sides of Middle Chine are glorious with the mauve color of their exotic flowers—they grew thickly in our school grounds as well. Danny had his favorite outside the kitchen window that had rich-red blooms.



Rusty and I spent as much time in the garden as we could. (CREDIT: JANE GOODALL)

Autumn was a time I loved. The verdant green of summer changed to soft yellows and gold, and here and there a splash of red leaves. Gradually the leaves fell and the ground was carpeted with the glowing colors until they rotted into rich loam or were swept from the lawn and burned on a bonfire at the bottom of the garden, where we baked potatoes in the hot ashes.

On the cliffs there were a few oak and beech trees, but mostly a host of pine trees that were planted on the original heath land in the massive landscaping project that started early in the nineteenth century. There were a couple of ancient Spanish chestnuts that, while they did not produce the large chestnuts sold commercially, were two or three times the size of those in our garden, and we loved to roast them around the grate of our small sitting-room fire.

During my childhood, Danny's one son, my uncle Eric, would bring us nuts from the huge and ancient walnut tree in his garden, and he brought apples too. We would pick blackberries on the cliffs and Danny would make blackberry-and-apple pies. She also made elderberry wine from the clusters of black fruits from our own elder. It was nonalcoholic, but the very fact that it was called "wine" gave us children a sense of being grown up when we drank it at Christmastime in grown-up wineglasses.

I have no doubt that growing up in this idyllic home and landscape of England was the foundation of my lifelong love of the plant kingdom and the natural world. The other day, when I was looking through a box of childhood treasures that had been lovingly preserved by my mother, I came across a "Nature Notebook" in which the twelve-year-old Jane, with great attention to detail, had sketched and painted a number of local plants and flowers. Beside each drawing or watercolor I had handwritten a detailed description of the plant, based on my careful observations and probably a bit of botanical research.



A painting from my childhood, “Nature Notebook.” This is a primrose, one of my favorite flowers from our garden. (CREDIT: JANE GOODALL)

This was not a schoolbook. This wasn’t done for an assignment. I just loved to draw and paint and write about the plant world. In a sense, I began writing *Seeds of Hope* over sixty years ago!

Of course, even as I was becoming increasingly aware of plants—well, trees really—as individual beings, I was, at the same time, learning ever more about the animals. I especially loved the barn owls that would punctuate the night with their eerie calls, the bullfinches with their glowing red-pink breast feathers, and the herring and black-headed gulls who flew low over the garden, screaming and waiting for one of us to go out and throw them bread crusts. Blackbirds, song thrushes, robins, and many kinds of tits nested in our tall, tangled hedges and in the trees. There were still one or two red squirrels left on the cliff back then, but the gray invaders were rapidly taking over the real estate. Occasionally we took a bus to the New Forest, woods interspersed with moors covered in heather, where there were New Forest ponies and deer, and if we were lucky, we might glimpse a fox.

And let me not forget the insects. In those days there were buzzings and hummings and chirping of bugs of all sorts. In the daytime there were the shimmering, fluttering wings of butterflies (surely they were originally “flutterbys” until some medieval scholar got his *f*’s and *b*’s confused?). Then in the evening came the irritating high-pitched whine of the mosquitoes, and at night the moths arrived attracted by the white blossoms and night fragrance of the syringa and white lilac—and, unfortunately, by our lights.

There were Olly and Danny’s enemies, the slugs and snails. My sister, Judy, and I loved snails and often kept them so that we could race them. Years later I learned that snail racing was at one time a popular pastime among elderly gentlemen in France! Our garden had its full quota of those invaluable little helpers, the earthworms, eating their way through the soil, aerating it, an important part of the ecosystem. I once took a whole handful to bed with me when I was just eighteen months old. My wise mother, instead of scolding, told me they would die, for they needed the earth, and together we took them back to a flowerbed.

And then there were the bees, the pollinators so absolutely essential to the gardener. I watched them for hours—honeybees flying busily from flower to flower, the “breadbaskets” on their legs gradually filling with bright-yellow pollen as they performed that all-important task of pollination. The big, furry-coated bumblebees, jet black with one or two bright-yellow stripes on the abdomen—who really did “bumble” from flower to flower—seemed almost lazy by comparison with the honeybees. It was fascinating to see them push their way into the foxglove flowers and watch as the blooms trembled while the invisible visitor probed for nectar.

When I got my first job—as a secretary—in Oxford, I was able to explore a different part of England. Every weekend I set off on my bicycle into the surrounding countryside, exploring lanes and hedgerows, which, in those halcyon days of the mid-1950s, were a riot of wildflowers. I would leave my bike and wander through the fields, past grazing cows (keeping a wary eye out for the occasional bull), and getting familiar with cow parsley (or Queen Anne’s lace), campion, speedwell, ragwort, robin, and the mauve sweet-scented clover that was so beloved by bees—and cattle and horses too.

Sometimes in the evening I would hire a little canoe for an hour and paddle, silently, past bulrushes and reed beds, nosing in toward the bank, where I could be hidden in a cave of green under the trailing branches of a huge weeping willow to watch the mallard ducks. I remember that a couple of verses of a very different sort of poem would sometimes repeat themselves in my mind in a somewhat annoying way—they came from one of my favorite childhood books, *The Wind in the Willows*.

*All along the backwater,
Through the rushes tall,
Ducks are a-dabbling,
Up tails all!
Ducks’ tails, drakes’ tails,
Yellow feet a-quiver,
Yellow bills all out of sight
Busy in the river!*

I could only paddle about a mile upriver—partly because I could only afford the canoe for an hour but also because one then came to a stretch of river that was forbidden to women—named Parson’s Pleasure, it was reserved for gentlemen who desired to disport themselves in their “birthday suits.” I knew of girls who would hide for hours in thick undergrowth to get a glimpse of certain body parts, and I suspect the men were well aware of those immodest eyes!

Not only did my mother preserve my “Nature Notebooks,” she also saved the only three copies ever produced of “The Alligator Magazine,” written at about the same time as I was painting local wildflowers. They were put together for the benefit of the four members of “The Alligator Club”—me and Judy and the two friends who came to stay almost every holiday, Sally and Susie. I was the eldest and bossed the others around and planned the games we would play and the things we would do.

Sally (a year my junior) and I were the real tomboys. Sue and Judy—the “Little Ones” (three and four years younger than me, respectively)—were not quite as keen on climbing trees and pretending to be Robin Hood and his men. But we got on well together—and, when I was about eleven, I started the Alligator Club. Why I picked the name *alligator* I have absolutely no idea!

It was a club for nature lovers. We watched the plants and animals and wrote little stories in our nature notebooks about them. Well, to be really truthful, I did those things and did my best to persuade the others to do the same. This was easier when we were together, but when Sally and Susie went home after the holidays, it was hard.

So I put together a magazine. I wrote—by hand as there was no other option at the time—articles about all sorts of things, and asked the others to make contributions. Of course, there was only one copy, so after they read it, Sally and Sue had to return it. In the next edition I asked questions about the articles I had written in the one before. The members were supposed to put their answers in the “letter box”—an envelope glued to the inside of the cardboard cover at the back. After four “editions”

I tired of producing this magazine, since it was almost impossible to get the others to contribute, and only Judy answered the questions, and only because I bullied her into doing so! But it taught me a lot.

In fact it may well have been my experience with the Alligator Club that enabled me to persevere in developing what is, today, a movement for young people from kindergarten through university, now in over 130 countries—Jane Goodall's Roots & Shoots (R&S). The Alligator Club had only four members, including myself. Roots & Shoots is encouraging hundreds of thousands of young people to take action and try to make this a better world for all living things.

Looking at my nature notebook with the carefully drawn and painted flowers, and looking through those magazines, preserved from a time long gone, brought those magical days of childhood alive. I found myself thinking about cold, wet winter days when I used to read, curled up in front of the fire on winter evenings. Then I traveled in my imagination to *The Secret Garden* with Mary and Colin and Dickon. I was entranced by C. S. Lewis's *Voyage to Venus*, in which he describes, so brilliantly, flowers and fruits, tastes and colors and scents, unknown on Planet Earth. I raced through the sky with little Diamond, who was curled up in the flowing hair of the Lady North Wind, as she showed him what was going on in the world, the beauty and the sadness and the joy (*At the Back of the North Wind*). And of course I was utterly in love with Mole and Ratty and Mr. Badger in *The Wind in the Willows*. If *The Lord of the Rings* had been written when I was a child, there is no doubt I would have been entranced by Treebeard and the ancient forest of Fangorn, and Lothlorien, the enchanted forest of the elves.

Of course, at the same time I was reading more and more about the animals who lived in the wild places of the world. I am so glad TV had not been invented then—it meant I had to, and most certainly did, exercise and develop my powers of imagination.

Those two worlds of my childhood—that of the imagination and that of nature—were, I think, equally important in shaping the person I have become. But although the memories are beautiful and precious, they are bittersweet. Today, most of the fields where I roamed have been sold to the developers, and those that remain have been destroyed by chemical pesticides and fertilizers and herbicides and fungicides and the hedges hacked down to provide more land for more farming. The wildflowers have disappeared from the fields, and many of the songbirds that sang to my young ears are in steep decline. Of course there was always war between the farmers and the animals that sought to share the bounty of their labors, the shooting of rabbits and pigeons, but the mass destruction of wildlife caused by the introduction of chemicals in agriculture did not happen until after World War II. Since then our wildflowers (along with so much wildlife) have been decreasing, becoming extinct in place after place.

And it is the same in so many parts of the world. The health of the soil has gradually been weakened, sometimes altogether destroyed. These days there are acres and acres of farmland where no crops will grow without massive doses of chemical fertilizer. And the chemical poison contaminating the groundwater, the streams, and the rivers, bringing death to animals and plants alike. Tropical and old-growth forests, those magical places to which I had traveled in imagination, are disappearing at a terrifying rate. The same goes for other types of landscape—woodlands, wetlands, prairies and grasslands, moors and heaths. Indeed, the list is limited only by the types of environments found on Planet Earth.

Everywhere the natural world with its rich diversity of living things is under attack from human population growth, development, industrial agriculture, pollution, and shrinking supplies of freshwater. Habitat loss is a theme that comes up again and again, diminishing the biodiversity and causing local extinctions in place after place. And over and above everything else looms the reality of

climate change. The ice is disappearing from the North and South Poles and from the mountaintops.

Yet here in Bournemouth some things have changed but little. The garden at The Birches has continued to provide a magical playground for children—first Judy and me, then our children, and now our grandchildren. Judy has taken on the role of gardener, helped by her daughter, Pip, and our good friend Wayne Caswell. More species of flowers and vegetables are growing—the answer was to acquire better soil and grow a lot of plants in tubs. So today we have sweet peas and morning glories, geraniums and pansies, and many more. And they grow in between peas, tomatoes, spinach, potatoes, and courgettes (zucchini). The bright-red flowers of the runner beans still brighten the garden on a dull day, and now there are the glossy-black flowers of the broad bean, as exotic as the white fur that you find inside the seedpod when you open it. Danny’s parsley still grows outside the kitchen window and the little pink flowers on which she waged war have obstinately remained, though not in their original profusion. My precious lilies of the valley have all but gone—the hens we rescued from the battery farm, thrilled with their new freedom to forage in a garden, ate all but a few bulbs! Olly’s greenhouse overflows with cucumbers and little seedlings of all sorts waiting to be planted outside. The pines and firs and Spanish chestnuts are still here, but our birch trees died in the 1975–76 drought and only one of the three we planted to take their place survived a recent very dry summer. Nooky was trimmed by a tree surgeon—the branches from the old trunk were getting too big and heavy. And amazingly this produced, for the very first time, a massive crop of chestnuts—tiny ones of course.

The neighborhood—the streets, the cliffs, and the chines—is much as it was in my childhood. There has been some “manicuring”—the vegetation growing up the sides of the chines has been thinned out in some places, mainly because it provided an environment for winos and people doing drugs. Branches have been trimmed and some trees felled lest a passerby should be hurt by a falling limb and the city council sued. But the whole area is a conservation area. No one can cut down a tree without permission from the city council, and so the gardens are still green and leafy. When I am here between my endless lecture tours around the world, there is always a dog to accompany me when, each day, I return to the haunts of my childhood. The current one is Charlie, a boxer cross—before her was Astro, who followed Whiskey, who was preceded by Cida—there have always been dogs at The Birches.

As I reflect on my early life and the experiences that shaped my thinking, I realize that it is not strange at all that I have written this book. What *is* strange is that this is not the book I first planned to write—that was to be simply a companion to *Hope for Animals and Their World*, for which I had written a whole section on the kingdom of the plants. But the manuscript for *Hope for Animals* was too long, and almost all of the plant section had to be cut. I was sad about that—many of those who had contributed their plant stories had been so generous and so pleased for me to write about their work. So I planned to write a short book, simply adding a little to that original plant section. It was to have been about plant species rescued from the brink of extinction. But it has not worked out that way.

It was as though the plants wanted me to write a different kind of book and sent gentle roots deep into my brain. They wanted me to fully acknowledge their importance in human history, their amazing powers of healing, the nourishment they provide, their ability to harm if we misuse them, and ultimately, our dependence on the plant kingdom. The plants seemed to want me to share with the world my own understanding of their *beingness*, so that people might better honor them as important partners in so many of our endeavors.

The more I followed these promptings, the more avenues of thought I pursued, the more I talked with botanists and horticulturists and conservationists, the more fascinated I became and the more horrified at all that we are harming and destroying.

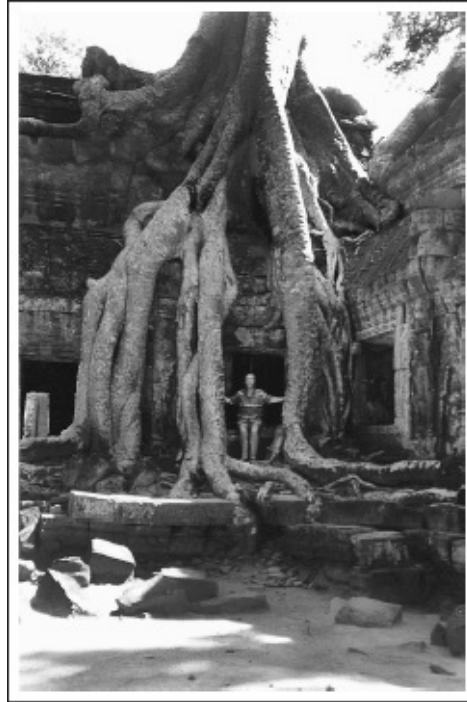
At the same time I was learning so much about the efforts that are being made, all around the globe, to protect and restore the natural world. The plant species that have been saved, in the nick of time, from extinction and given another chance. The work of the botanical gardens, introducing millions of people to the wonder of the plant world while, at the same time, carrying out cutting-edge research on the best ways of propagating endangered species. The people who are growing native plants in their gardens, creating havens for wildlife and insects. The increasing number of those who are prepared to fight for the plants and the trees, the grasslands and the forests. That is the hope.

And so I have written a book to acknowledge the enormous debt we owe to the plants and to celebrate the beauty, mystery, and complexity of their world. That we may save this world before it is too late.

Chapter 2



The Kingdom of the Plants



This strangler fig's roots are now an integral part of the ancient temple at Angkor Wat in Cambodia. I shall never forget the feeling of stepping back in time, the sense of wonder at these extraordinary ruins deep in the forest. (CREDIT: © JANE GOODALL INSTITUTE / E

MARY LEWIS)

Science divides the natural world into six kingdoms, including the animal kingdom and the plant kingdom. And in both we find huge diversity of form and size and color, and so many fascinating and complex societies. Most people are more familiar with the inhabitants of the plant kingdom, for they are all around us, just about all the time. I have spent a lifetime loving plants, even though I have never studied them as a scientist. And over the years, people have given me marvelous books—collections of photographs of various habitats, and of exotic fruits and seeds and flowers that might have been drawn from the imagination of artists high on psychedelic drugs.

I have walked through forests in many parts of the world and marveled at ancient trees festooned with vines, ferns spreading their graceful fronds beside fast-flowing streams, and rocks clothed in mosses. I have a special love for old-growth forests with their wealth of interconnected life-forms—I always feel that I belong there. But there is so much more to marvel at in the kingdom of the plants. I often use the zoom setting of my camera to photograph the exquisite flowering of tiny plants that most people walk past or trample on, not noticing.

The first time I visited the tundra, in Greenland, I was humbled to see small plants that had sprung into life after enduring eight months under snow and ice. And amazed to learn that they were actual trees—but although they had managed to survive in those bleak conditions they could never attain the

typical height of their species. How different that arctic habitat is from the exotic riot of color, the sheer enchantment, of an alpine meadow in spring, with its myriad of flowers, the humming and buzzing and droning as a host of insects feast on nectar, pollinating the flowers so that they will reappear next year.

When I first saw the spring flowers blanketing the California hillsides, I wanted to walk out among the lupines and poppies and wild mustard, and simply lie among them, looking up into the blue, blue sky. But I was restrained, warned of snakes among the flowers, and had to be content just to feast my eyes on their colors and inhale their sweet fragrance.

The plants of the arid parts of the world—the dry plains and the desert—are also fascinating. These are the places where succulents and cacti have adapted to survive long periods without water, storing it in their leaves and stems and roots. Just this past spring I spent a couple of hours wandering in the semidesert of Santa Fe, New Mexico, utterly captivated by the strange shapes of the cacti. I was lucky for most of them were in bloom, their yellow and red and deep-purple flowers like gifts from Mother Nature in the dry landscape. And I have marveled to see how, after a long period of drought, the first rains will carpet the Serengeti Plain of East Africa with white and golden flowers shining through the dry, trampled grass. Here and there the vivid coral-colored flowers of the aloe plants peek through.

Recently, as I drove from Johannesburg to Nelspruit, in South Africa, I desperately wished there was time to stop off and find an elephant root tree (*Elephantorrhiza elephantina*), which, presumably able to withstand the cold, dry winters of its harsh upland habitat, lives almost entirely underground. If you walk among the branches of what seem like small bushes, rising only some three feet above the ground, you will actually be walking on the canopy of a very large and very ancient tree that is mostly out of sight beneath you.

It would be absurd in a book like this to try to describe the fantastic variety of plants, from the tiniest mosses to the mighty redwoods. A recent inventory lists 298,000 different plant species (and 611,000 species of mushrooms, molds, and other fungi). And the authors reckon that as many as 86 percent of all plant and animal species on land, and up to 91 percent in the seas, remain unnamed. All I can do here is to share some of what I find particularly compelling about this vast and wondrous kingdom of the plants.

Roots

Wouldn't it be fantastic if we had eyes that could see underground so that we could observe everything down there in the same way that we can look up through the skies to the stars? When I look at a giant tree, I marvel at the gnarled trunk, the spreading branches, the multitude of leaves. Yet that is only half of the tree-being—the rest is far, far down, penetrating deep beneath the ground. The roots. Bit by bit they work their way through the substrate, pushing aside small pebbles, growing around big rocks, coiling around one another, taking from the soil the water and minerals needed by the partner up above, and creating a firm anchor for it. In many trees, the roots go as deep below the ground as the height of the tree above the ground, and spread out about three times farther than the spread of the branches. One root system, recorded during excavation of a building site in Arizona, had grown down some two hundred feet.

Some of the so-called “weeds” that colonize our gardens as unwanted guests have very deep roots. The dandelion goes down so far it is almost impossible to get the whole thing out of the ground. I can see my grandmother Danny now, kneeling on her little rubber pad, digging down around the roots of

one dandelion plant after another, then trying to yank them out of the ground with that tool that looks like the end of the hammer that you use to pull out old nails. But she never got the whole root out.

There are so many kinds of roots. Aerial roots grow above the ground, such as those on epiphytes—which are plants growing on trees or sometimes buildings, taking water and nutrients from the air and rain—including many orchids, ferns, mosses, and so on. Aerial roots are almost always adventitious (I called them “adventurous” when I was a child), roots that can grow from branches, especially when they have been wounded, or from the tips of stems. Taproots, like those of carrots, act as storage organs. The small, tough adventitious roots of some climbing plants, such as ivy and Virginia creeper, enable the stems to cling to tree trunks—or the walls of our houses—with a viselike grip.

In the coastal mangrove swamps of Africa and Asia I have seen how the trees live with their roots totally submerged in water. Because these roots are able to exclude salt, they can survive in brackish water, even water that is twice as saline as the ocean. Some mangrove trees send down “stilt roots” from their lowest branches; others have roots that send tubelike structures upward through the mud and water and into the air, for breathing.

Then there are those plants, such as the well-known mistletoe, beloved by young lovers at Christmastime but hated by foresters, that are parasitic, sending roots deep into the host tree to steal its sap. The most advanced of the parasitic plants have long ago given up any attempt at working for their own food—their leaves have become like scales, or are missing altogether.

The strangler fig is even more sinister. Its seeds germinate in the branches of other trees and send out roots that slowly grow down toward the ground. Once the end touches the soil, it takes root. The roots hanging down all around the support tree grow into saplings that will eventually strangle the host. I was awestruck when I saw the famed temple at Angkor Wat in Cambodia, utterly embraced by the gnarled roots of a giant and ancient strangler fig. Tree and building are now so entwined that each would collapse without the support of the other. I noticed that strangler figs have been at work on many of the Mayan ruins in Mexico as well.

The so-called clonal trees have remarkable root systems that seem capable of growing over hundreds of thousands of years. The most famous of them—“Pando,” or “The Trembling Giant”—has a root system that spreads out beneath more than one hundred acres in Utah and has been there, we are told, for eighty thousand to one million years! The multiple “stems” (meaning the tree trunks) of the aspen colony age and die, but new ones keep coming up. It is the roots that are so ancient.

One of the most important things about roots is that they hold the soil in place. When the early settler farmers moved onto the American prairies, they cut down the trees that grew there and plowed up the land, destroying the native grasses so that they could grow agricultural crops. Over countless thousands of years those native grasses had developed root systems that delved deep, deep into the ground, holding the soil together so that it could withstand the constant stress of the wind. Human interference in this ancient system led to the Dust Bowl of the 1930s, when the soil was blown away in great clouds, much of it ending up in far-off oceans. Something similar happens in China today, where clouds of dust are blown from the deforested center of the country and darken the skies over faraway Beijing for days on end.

Leaves

I always love to walk through the trees in the evening, when the sun is low and the leaves are backlit. And each single leaf so beautiful with all its veins etched so clearly, some with an incredibly intricate

branching pattern. These veins are the end point of the system that carries water and nutrients up, and from root to leaf. And they are the start of the system that carries the sap, with its dissolved sucrose back out of the leaf to provide nutrients to the mother tree.

When I was a child, I used to spend hours searching under the trees, looking for the skeletons of leaves—when all the soft material has rotted away and only the veins remain. It is rare to find a perfect one, without tear or holes, but it is worth searching diligently—for the one that is without blemish is truly a work of art. I still search when I am walking through the Gombe forests.

The variety of leaves seems almost infinite. They are typically green from the chlorophyll that captures sunlight, and many are large and flat so as to catch the maximum amount. Indeed, some tropical leaves are so huge that people use them for umbrellas—and they are very effective, as I discovered during an aboriginal ceremony in Taiwan, when we were caught in a tropical downpour.

Orangutans have also learned to use large leaves during heavy rain. My favorite story concerns an infant who was rescued from a poacher and was being looked after in a sanctuary. During one rainstorm she was sitting under the shelter provided but, after staring out, rushed into the rain, picked a huge leaf, and ran back to hold it over herself as she sat back in the dry shelter!

Some leaves are delicate, some are tough and armed with prickles, yet others are long and stiff like needles. The often-vicious spines of the cactus are actually modified leaves—in these plants it is the stems that capture the energy from the sun. I used to think that the brilliant red of the poinsettia and the varied colors of bougainvillea were flowers, but of course they are leaves adapted to attract pollinating insects to the very small insignificant-looking flowers in the center. And there are those leaves adapted to capturing insects, some covered with resin-tipped glands that curl over and imprison the prey, others able to snap shut in an instant when an insect touches the hairs, which act as triggers.

And then there are the most extraordinary leaves of that bizarre plant, *Welwitschia mirabilis*. Each adult plant has only two leaves. When the seed germinates, it produces two cotyledons—embryonic first leaves. These survive only until the first true leaves have grown big enough. They look ordinary enough, these two long leaves. But they are not. For they continue to grow, those exact same two leaves, for as long as the plant lives—which can be more than a thousand years.

The *Welwitschia* was first discovered in Africa's Namib Desert by Dr. Friedrich Welwitsch in 1859, and it is said that he fell to his knees and stared and stared, in silence. He sent a specimen to Sir Joseph Hooker, at the Royal Botanic Gardens, Kew—and Sir Joseph for several months became obsessed with it, devoting hours at a time to studying, writing about, and lecturing about the botanical oddity. It is, indeed, one of the most amazing plants on Earth, a living fossil, a relict of the cone-bearing plants that dominated the world during the Jurassic period. Imagine—this gangly plant, which Darwin likened to a duckbill platypus of the vegetable kingdom, has survived as a species, unchanged for 135 to 205 million years. Originally its habitat was lush, moist forest, yet it has now adapted to a very different environment—the harsh Namib Desert.

The photograph in the color insert shows what looks like many untidy leaves, but they are really only the two. They first appear as the seed germinates—and as the years pass, they become increasingly leathery and tattered, nibbled by animals and buffeted by the wind—but they are never replaced. The tallest plant known is only five feet high; most are no more than twenty inches. Some *Welwitschia* plants growing in the wild have been carbon-dated and are between five hundred and six hundred years old, but it is thought that some of the largest could be two thousand years old.

Capturing Sunlight

At school I had to learn in my biology lessons about photosynthesis—which literally means “synthesis with the help of light.” When I looked at my son’s biology textbook some thirty years later, I was amazed—and shocked actually—by the complex chemical process that he was supposed to learn as a schoolboy. It was the sort of information that was once reserved for university students specializing in botany—the kind of stuff that would have totally disenchanted me from the wonder of plants. And indeed, it is pure chemistry.

The point is that plants can capture energy from sunlight. I love how this was described by the German surgeon Julius Robert Mayer in the 1800s. Nature, he said, has solved “the problem of how to catch in flight light streaming to the Earth and to store this most elusive of all powers in rigid form.”

Plants do this through extremely complex chemical reactions, which can, however, be described quite simply. There are special cells, usually in the leaves, that store chlorophyll molecules. This is the source of their green color. These chlorophyll molecules interact with nearby carbon dioxide (CO_2) (which they absorb from the atmosphere) and water (delivered by the plant’s roots) to synthesize glucose and oxygen. The glucose is either used at once, for energy needed by the plant, or is changed (by another complex chemical process) into starch, which is stored until the plant needs it. Meanwhile oxygen, which is actually considered a “waste product,” is released into the atmosphere where animals and plants use it for their respiration. It amused me, when I read about this, to think of our so-precious oxygen as a “waste product”—that is chemistry talking. The small amount of CO_2 produced by the plants during *their* respiration (basically their exhalations) is quickly used up by the ongoing photosynthesis process.

Think about all this for a moment. Our exhalations are nourishing the plants as they capture CO_2 and the plants’ exhalations allow us (and them) to breathe. How utterly amazing—awe-inspiring—really. *One cupful of CO_2 , a few tablespoons of water, mixed with a beam of sunlight:* the ultimate and only recipe for the food that supports all plant life, including algae and other such forms. And since we depend on plants, either directly, by eating them, or indirectly, by eating animals that themselves depend on plants, the process of photosynthesis supports almost all life on Earth.

Carnivorous Plants

I am not a devotee of science fiction books, but John Wyndham’s *The Day of the Triffids*, published in 1951, utterly captivated my imagination. “Triffids” are seven to ten feet tall, have three leg-like appendages that can be rooted into the ground, a sort of trunk, and a funnel-like head containing a sticky substance that attracts and captures insects that are then digested. Within this funnel there is also a stinger that, when fully extended, can measure up to ten feet. Sometimes a triffid will shuffle along the ground on its “legs” and, when it contacts a person, will aim at the face with its stinger. The victim dies quickly, and the triffid roots itself near the body, which it can digest as the flesh decomposes.

Science fiction, yes, but Mother Nature has designed monsters too—they are smaller, they cannot harm people, but the behavior of some of the carnivorous plants would make terrifying bedside reading for the tiny prey they capture. Take the *Darlingtonia* pitcher plant, also known as the cobra pitcher or cobra lily. It has a well-developed forked protrusion on the end of the modified leaf that forms the lip of the pitcher, which is designed to capture insects. This protrusion offers a convenient platform on which a flying insect can land, attracted to the nasty smell from inside the pitcher—we find it nasty to us but obviously irresistible to the insect.

The hapless prey then slips down the walls, helped on its way by both lubricating secretions and downward-pointing hairs, and falls into the water-and-enzyme soup. The small exit is cunningly curled downward and thus hidden from the trapped insect, which exhausts itself by repeated crawling up the many translucent false exits. Eventually it will drown, and as it gradually decomposes it will be absorbed by the plant. Unlike other pitcher plants, this one does not trap rainwater in its pitcher, but pumps up water from its roots, reabsorbing it if the level gets too high.

This is just one of the plants that have become carnivorous, capturing flies and other insects in a whole variety of ingenious ways and then slowly digesting them in special juices. There are about 630 species in six genera with five different kinds of traps, known as pitfall, flypaper, snap, bladder, and lobster traps. Scientists estimate that they first appeared some two hundred million years ago in marshy, infertile soils that were lacking in essential minerals, especially nitrogen. Only by devising a novel way of getting the necessary nutrients could these plants survive. I get so carried away reading about these cunning plants—it would not be difficult to write a whole chapter about them.

The best known are the pitcher plants, sundews, Venus flytraps, and bladderworts. I remember our biology teacher bringing a sundew to school for us to see. Somehow my imagination had created a much more impressive being, and I was disappointed to see such a tiny plant, though fascinated by its behavior. Each leaf has a number of resin-tipped glands that serve to attract and capture small insects. Our biology teacher placed an unfortunate fly on this trap and we watched as the leaf curled slowly over it.

There is one carnivorous genus, *Roridula*, that has just two species. They are small shrubs with leaves covered by sticky resin glands. The plant cannot absorb or digest the insects that it catches, but it has a partner, an insect similar to and usually referred to as an assassin bug (*Pameridea*, to give it its proper name). The bug is impervious to the resin because of its thick, greasy covering. It waits among the leaves and quickly pounces on less fortunate insects, then settles down to suck out their innards. Subsequently it produces dung—and it is this that the plant is able to absorb.

One of these plants, growing in the botanical gardens of Leiden University, once captured a jay. My Dutch botanist friend Rogier van Vugt told me how he had to rescue the bird—with great difficulty! Of course, says Rogier, “Neither the plant nor the insects would eat a bird, but it shows how strong the resin is.”

Seeds and Fruits

If plants could be credited with reasoning powers, we would marvel at the imaginative ways they bribe or ensnare other creatures into carrying out their wishes. And no more so than when we consider the strategies devised for the dispersal of their seeds. One such involves coating their seeds in delicious fruit and hoping that they will be carried in the bellies of animals to be deposited, in feces, at a suitable distance from the parent.

Charles Darwin was fascinated by seed dispersal (well, of course—he was fascinated by everything) and he once recorded, in a letter, “Hurrah! A seed has just germinated after twenty-one and a half hours in owl’s stomach.” Indeed, some seeds will not germinate unless they have first passed through the stomach and gut of some animal, relying on the digestive juices to weaken the hard coating. The antelopes on the Serengeti Plain perform this service for the seeds of the acacia.

In Gombe the chimpanzees, baboons, and monkeys are marvelous dispersers of seeds. When I first began my study, the chimpanzees were often too far away for me to be sure what they were eating, so

in addition to my hours of direct observation I would search for food remains—seeds, leaves, parts of insects or other animals—in their dung. Many field biologists around the world do the same.

Some seeds are covered in Velcro-like burrs (where do you think the idea of Velcro came from anyway?) or are armed with ferocious hooks so that a passing animal, willy-nilly, is drafted into servitude. Gombe is thick with seeds like this and I have spent hours plucking them from my hair and clothes. Sometimes my socks have been so snarled with barbs that, by the time they are plucked out, the socks are all but useless. Some seeds are caught up in the mud that waterbirds carry from place to place on their feet and legs.

I wonder how many dandelion “clocks” are picked and blown by lovesick adolescent girls: “He loves me, he loves me not. He loves me, he loves me not,” and calculating the strength of the late summer breaths so that they can end, triumphantly, “He loves me!” Those little seeds, each suspended from a perfect parachute, are carried away in the thousands by the summer and autumn winds, colonizing gardens and parks—almost anywhere that plants can grow—and often where they are most definitely not wanted.

The kapok seed floats through the air attached to the softest white fluff. I watched one chimpanzee infant as he gazed, as though entranced at this spectacle, then reached out to try to catch some. Sometimes he sometimes do the same! And I have always loved to watch the seeds of the sycamore trees growing in Bournemouth as they set off on their journey in pairs, fastened between two propeller-shaped wings that spin around and around like the blades of a miniature helicopter as they spiral down toward the ground.

Other seeds, lacking such convenient mechanisms, rely on their pods to shoot them as far away as possible. From my window, at school, I could hear the little *pops* of the broom pods as they burst open when the seeds were ripe inside and the sun was warm. They were carried several feet—and sometimes ants then carried them farther—which was an advantage only for those that were not eaten. The pods of some plants reach such a state of tension when their seeds are ripe that they seem literally to explode at the slightest touch—like the touch-me-not balsam. And there is a plant in Gombe that splits open, with a loud crack, at the first drop of rain, sending out seeds in all directions. I used to collect these pods and take them to my son, when he was little, and arrange a show for him.

Seeds come in all shapes and sizes. Most are quite small, but not so the coconut. This giant can be carried for miles across the ocean and, in this way, has enabled coconut palms to colonize almost every tropical island.

Sex Education

Plants reproduce both sexually and asexually. Every gardener knows how a cutting, given by a friend, can grow roots and survive. This is how my second husband, Derek Bryceson, and I built up our garden in Dar es Salaam. Some plants, such as the blackberry, form adventitious roots when the tip of a stem arches over and touches the ground. At this place a new plant will grow. Then there are those that send out special stems that are called runners when they grow *over* the ground, like strawberries, or rhizomes when they grow *under* the ground, like buttercups. When the runner, or rhizome, is far enough away from the parent plant, the tip puts out roots from which new plants can grow.

There is no doubt whatsoever that this kind of asexual, or “vegetative,” reproduction can be an immensely efficient strategy. And when plants are introduced to new environments, it can also be very destructive. The water hyacinth is a free-floating aquatic plant with attractive lavender or pink

flowers. It originated in South America, but has been introduced widely in tropical and subtropical areas of North America, Asia, Africa, Australia, and New Zealand. It reproduces asexually by runner and is one of the fastest-growing known plants—it can double its population in just two weeks. It clogs waterways and lakes. It starves water of oxygen, killing fish, turtles, and other wildlife. It was actually grown on lakes in World War II to fool Japanese pilots into thinking they could land. Governments have spent a great deal of money in their efforts to control the water hyacinth.

However, while reproduction without sex may be efficient, it doesn't allow for genetic diversity and so almost all plants can reproduce sexually as well. We know all about human sex (way too much in some instances). Most of us are familiar with the couplings of dogs (cats are far more discreet and usually do their thing at night). Country people know about farm animals, and naturalists have found out a great deal about the mating behavior of countless wild mammals, birds, and insects. Much of all the above involves courtship, which may be elaborate. And we have come to realize, with all the private life exposed by patience, binoculars, and DNA analysis, how much cheating goes on.

What about plants? We can hardly suppose that plants could *enjoy* sex—but who knows? Maybe one day, a scientist will detect something akin to the endorphins that are produced in humans during pleasurable experiences (including excitement, love, and orgasm) in some part of a plant when being tickled or brushed against its stamens or pistil while it is being pollinated. Nothing in the plant world would really surprise me—but it does seem unlikely. So for now I will stick to the plain and obvious facts.

The bladder wrack, a common seaweed, was well known by us as children. We loved to walk along the beach at low tide when a storm had cast lots of seaweed onto the beach. We would seek out the strands of bladder wrack and stamp on the partially dried bladders, which made a marvelous satisfying popping sound (the same as when you pop the air bubbles of Bubble Wrap). It is at the tip of these bladders that the sperm and eggs are stored. There are male and female bladder wracks, and reproduction takes place only once a year, when both sperm and eggs are released into the water at the same time. Fertilized eggs sink to the bottom of the sea and soon attach themselves to some hard surface.

Flowering plants, of course, have the most complex reproduction. And it is the love of flowers, and the blossoms with their staggering variety of shape, color, and size, that have so bewitched people over the ages. The largest single bloom in the world is that of the “corpse flower” (*Rafflesia arnoldii*) of Sumatra—it may measure a yard across and weigh as much as fifteen pounds. The flowers actually look and smell like rotting flesh, which is why it's commonly known as the corpse flower. The smallest, by contrast, is that of the tiny water weed *Wolffia*, which measures a mere .01 inch across. And, too, there are the perfumes, the sometimes-intoxicating scents produced by flowers, especially those that are put out at night to attract moths and other night pollinators. Even bats.

Flowers are equipped with female and male organs, the pistil and the stamen. The stamen produces the pollen, which must somehow reach the pistil so that the waiting undeveloped seeds can be fertilized. This happens when pollen grains pass through little openings (stigma) at the tip of the pistil and travel down a tube (the style) to the ovum at its base.

The Swedish botanist Carl Linnaeus discussed this in his famous work on the classification of plants. He was dismayed when he learned that one of his articles, translated into English, was banned because it was “lewd and salacious”—“stamen” and “style” had been translated with the words *husband* and *wife*. One plant was thus described as having four husbands, two taller than the other, and another had twenty husbands or so in the same marriage! At any rate, irrespective of the number of husbands, successful pollination results in the development of a seed.

The countless and cunning ways that plants have devised to get the pollen grains with their living sperm from stamens to pistils are absolutely awesome. Some release their pollen in large quantities, sometimes explosively, into air or water with the hope that it will be transported by the currents of air or water to the waiting pistils. As I write this, the pollen from the pine trees in our garden is being carried by the breeze in yellow clouds. The ground, the cars, our clothes—everything is covered with fine yellow dust. Bad luck for those who suffer from allergies.

Other plants have opted to have their pollen transported by a variety of animals, who are lured in their service by enticing fragrances, delicious nectars, and attractive colors. Many kinds of insects serve as pollinators—and so do birds such as hummingbirds, occasionally bats, and even, it has been suggested, small amphibians. Some plants, including many orchids, have very specific needs—only one species of wasp pollinator will do.

Probably the first pollinating insect that springs to mind is the bee. I already described how I loved to watch the bees in the glorious summer days of childhood as they buzzed from flower to flower, probing for nectar and gathering golden pollen on their back legs in what we called the “breadbasket.” This was the bee benefiting from the flower, obtaining the ingredients for making honey and “bee bread” to feed the young back in the hive. But at the same time, as the bees moved from one bloom to the next, pollen was repeatedly brushed off onto the outstretched pistils. So the flowers were achieving their goal as well.

Not all insects are attracted by glorious scent or alluring nectar—certain plants cater to the preference of those that prefer a “fragrance” most horrid to our senses. The titan arum, which stands about six feet tall, and the corpse flower (*Rafflesia arnoldii*) of Sumatra, which, as mentioned, has the biggest single bloom in the world, both emit a stench that is irresistible to those flies and beetles that eat or lay their eggs on rotting flesh. I well remember when a titan arum was in bloom at the Royal Botanic Gardens, Kew, and lines of people gathered for the dubious thrill of experiencing its vile smell.

Defense Strategies

The other day I watched a cow feeding in a field. She was chewing her way through grass and a whole lot of herbs. There was clearly nothing the plants could do about it. Or was there? There were a few clumps of ragwort in the field, and I noticed how the cow avoided them. She clearly knew, somehow or other (from a bad experience or instinctive reaction to the toxins in its scent), that this plant was poisonous.

Plants are unable to run away or fly, so unless they develop some kind of defense, such as poison, they are liable to become someone’s breakfast, lunch, or dinner. In fact, plants have developed a whole host of ways to protect themselves. Some simply taste nasty, and some of the nasty ones are actually as poisonous as the ragwort is to cows. Deadly nightshade, so often mentioned in the old storybooks, is even more poisonous to us than is the ragwort—children can die from eating as few as three berries—but many birds eat it without any ill effect.

Unfortunately for the ragwort, the caterpillars of the cinnabar moth have become resistant to the poison and live on the leaves. This is, of course, what happens when we spray pesticide on farms and gardens—some insects become resistant, so other forms of poison must be concocted. In nature there is usually a balance so that if an insect predator proliferates unduly, its plant food will diminish to the point where the insect numbers cannot be sustained. And when the predators are then reduced, the

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