

THE SECRET OF THE SPRING

by

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The Secret of the Spring

I gritted my teeth and grimaced in terror as I stepped off into space at the top of the cliff. Barely a meter away, I crashed into the great hickory that grew there, claspng the rough trunk over-tight and banging my cheek. Relieved to find that I was not falling, I loosened my hold and began to descend. The passing bark uprooted my shirt and skinned my tummy, so I leaned back a bit. That change of angle pitted the doubly reinforced and riveted seam at the crotch of my jeans against the grainy cords of bark, giving my genitals a delicious drubbing as I slid down the ancient tree. It wasn't hard to control angle and rate for maximum effect, and I found myself wishing the tree were taller. Unfortunately, I lost control as the increasing girth exceeded my reach, and I covered the last twenty feet or so in virtual free-fall. Fortunately, I landed on my bottom, which was more than ample even then, on this, my first visit to The Spring more than forty years ago.

Father had preceded me in sliding down the tree and watched my performance with knowing glee. He told me that this had been the preferred mode of access to The Spring for generations, although his grandfather had certainly provided the ultimate alternative. We picked our way through a rubble of head-sized stones that littered the ground and approached a pair of room-sized boulders a short distance away. We rounded the nearer one, and voilà!

There, at the base of a towering limestone bluff in Southern Illinois, about forty miles from Kentucky, in the foothills of the Ozark Mountains, lies a fine, sweet spring, renowned since Dan-

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iel Boone's time and before for its purity and fine taste. It must have acquired a name sometime along the way, but it has been lost to time, and the valley is now known only as "Beauman's Bottoms." It is a place of nearly supernal, ineffable natural beauty, the very finest scenery that temperate climate, virgin oak-hickory climax forest and interesting geology can provide. The bluff is lined with many horizontal, rounded furrows of coral formations that give it the look of a noble brow beset by worry. The image is furthered by the gouge in the stone where The Spring lies, about the size and shape of a Volkswagen Beetle, which resembles the facial depression for an eye. From a distance, the area of the bluff framed by the two large boulders gives one the impression of one side of an immense human head buried to the cheekbones. Close up, it is rough and covered with rounded, frilly patches of ash-green lichens here and there covering the many graffiti and giving the "face" an even more venerable air. It is in the middle of the Shawnee National Forest, and in spring the display of mosses and ferns is the most diverse and concentrated to be found anywhere in the world. Indeed, our family name for this glorious valley was "Ferndale." Once, with the help of my trusty two-lens pocket magnifier (a birthday present from my father, it has been the most treasured possession of my life) I was able to identify more than two hundred species of moss in a circle the radius of my outstretched body. It is easy to see why my great-grandfather felt he had to own this magnificent little corner of creation.

A Quèbecois from Trois Rivières, Doric-François l'Beaumière was a short, dark, wiry man with a fierce, black beard, piercing eyes, and a fiery, dramatic temperament—a sure exponent of the "banty rooster syndrome." He eventually married an Irish Amazon, a towering woman with flaming red hair and a temperament to match his own, but he ruled the roost like a martinet. He came south in the early 1800s, bided for a time in what became Evansville, and eventually settled on 750 acres of fine hilltop land between the Wabash and Mississippi rivers. After he fell in love with and acquired this separate parcel of bottom land, he decided that he had to share it. He hired laborers to clear brush and lay trails through the forest; he built latrines and little footbridges;

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he influenced the surveyors for the Illinois Central Railroad to bring the line close, and then built a proper train platform to accommodate proper ladies and gentlemen; and finally, he threw a party. It was such a success that it became a regular event, an annual springtime affair which was avidly anticipated by people for hundreds of miles in every direction. They came by train from as far away as Memphis and St. Louis, and they partied for a full week. At the end of each day special trains would take everybody home or to hotels in Paducah or Cairo, and then bring them back the next morning. There people would disembark, the men in spats and bowlers, the women in bustles and great feathered hats, to spend the day communing with glorious Nature, courting in leafy glades and mossy grottoes, competing in various games, or just lying about, eating and drinking. Eventually these springtime fêtes grew into major events with musicians, games of chance, even a little midway with jugglers and magicians. They became social landmarks for decades—for generations. Truly, both sets of my grandparents and two of my four sets of great-grandparents met their spouses and engraved their initials on the bluff at these parties, including old Doric, himself.

Today, virtually all of his efforts have been erased by time. Except for a few graffiti mostly obliterated by lichens, the only sign of civilization is The Spring, itself. Nestled in an oval recess at the base of the bluff, a pool the size of a bathtub is retained by unmortared bricks on two sides. Water drips from above and wells up from below so that there is a continuous trickle between the bricks, forming a modest little creek that meanders down the hill. I remember well my first sip. It is impossible to drink without kneeling right in front of it, *in* the overflow, so I was resigned to wet knees from the start. It was September after a hot, dry summer, and we were hot and thirsty. But near the damp stone it was cool and peaceful. A spider web was stretched over the far corner, and as I bent down to drink, my eyes met those of a small leopard frog floating nearby. We regarded each other quietly for a moment, and then it was gone. I could see a little sediment on the bottom, but the water was very clear. I looked to Father for reassurance, he nodded, and I put my lips to the surface. It was wonderful. Cool, of

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course, and thirst-quenching, but also quite sweet. I understood why it had been famous.

When I got on my feet again and stepped back, I stumbled over some of those head-sized stones and fell into the creek. It wasn't very deep and I managed not to get too wet, but I did make a considerable ruckus flailing about in the greenery. And what greenery! Peppermint! Waves of aroma flooded over me, and I forgot all about the water. I sat on a rock and pulled handfuls to my face, crushing leaves and stems with my fingers and sniffing like an addict. Father guffawed, and then pointed to another plant with an inquiring expression. I gave back a blank look, and he said, "Watercress!" I had heard of it but had never seen or tasted any, so I took a nibble. It was quite peppery, and I compared it with the mint. Then I was struck by something strange: there were no other plants present. Everything was dry and brown everywhere except where there was water, and one would expect to find great diversity there, but no, there was not a single "weed" of any kind. The peppermint and the watercress had the competition utterly at bay and the creek entirely to themselves. Why? It took another forty years for the answer to emerge, but I think I finally understand. The explanation introduces a branch of science so new that it doesn't even have a name.

Let's call it "semiochemistry." Semiochemicals are substances that elicit a major change in growth or behavior at extremely low concentrations. The word isn't in the newest edition of the O.E.D., but I presume the root is the Latin word for "symptom." Whatever, the critical distinction is the vanishingly small amounts involved. Semiochemicals are not drugs or poisons or irritants or reagents or anything to do with ordinary chemistry, but substances such as insect pheromones, that seem to operate almost one molecule at a time. It has been estimated, through careful experiments with gas diffusion rates, that a male *Cecropia* moth is able to home in on a female a mile away after encountering a scant three molecules of her scent! That implies that each molecule is detected individually. Such sensitivity is beyond amazing; it is stupefying to a conventional chemist.

But, aha! not to a biochemist. We know about receptors, now. Receptors are large protein molecules that have more than one "busi-

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ness end." Usually they span a cell membrane, with one end on the inside and the other end sticking out on the outside. A good example can be found in taste buds. If and when the one special molecule that fits exactly in just the right place comes along and is "received," its very presence there causes the huge receptor to change in some way—change its shape or its chemistry so that other molecules in the vicinity are affected, thus initiating a chain or cascade of reactions. And if that cascade ends up at a specially sensitized nerve cell, it is possible that a nerve impulse could be produced from a single molecule.

I was introduced to this new field through a popular book called *The Secret Garden* by David Bodanis, an Oxford don who a few years earlier gave us *The Secret House*, another fascinating little volume. He deals in matters of the very small and insignificant. *The Secret House* is essentially a book of photographs and discussion about microscopic things around the house—tiny parasites that live in our eyelash follicles, micro-organisms, textiles, dust and dirt, and those tiny dust mites that number in the millions in everybody's beds, etc., but also other "invisible" but not microscopic effects such as infrared and sonic images. But between 1986 and 1992 Bodanis got interested in semiochemistry, and *The Secret Garden* is a layman's introduction to the amazing world of plant-plant, plant-animal, and animal-animal communication at the most basic, molecular level.

It's analogous to (and homologous with) the standard story of Darwinian competition and the success of the so-called "arms race" between evolving plants and animals that has produced the astonishing biological diversity and exotic pharmacopoeia to be found in nature, which we are just beginning to appreciate. The only difference is the scale. Some more semiochemical examples:

- (a) As a caterpillar attacks a shrub, a few molecules of its saliva circulate in the plant's system, which reacts to produce a few molecules of ethylene gas, which may be detected by a passing wasp, causing it to go hunting for the caterpillar in order to parasitize it with an egg.
- (b) Down in the soil, whole cities of compatible bacteria and fungi assemble around plant root hairs and cooperate in produc-

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ing vapors which repel invading roots from neighboring competitors.

- (c) When a beetle attacks a spruce tree in the Pacific Northwest, the tree sends out gaseous warnings to other trees in the vicinity so that they can begin to produce chemical defenses even before being attacked. And they do. And it helps.
- (d) When mats of blue-green algae of the same species but not the same clone grow into one another, they both stop growth in that direction and maintain a very narrow and precise ribbon of no man's land between them.

These are not ordinary examples of chemical communication and defense, like ants following a scent trail or the repellent properties of marigolds used to border gardens. Those involve "major" biological secretions composed of relatively high concentrations of chemicals that any of us could smell and any chemist could analyze. These semiochemicals are so subtle and diaphanous that they were not even imagined ten years ago. In the case of the caterpillar and the wasp, it's not the whole shrub that mobilizes to manufacture ethylene; it's just the nearest few leaves. The wasp truly gets only a handful of molecules as a behavioral switch. In the soil cities, the battles of the root hairs occur over distances that are barely visible—on the order of one hundred microns—and involve fewer than one hundred molecules of nitric oxide or cyanide. Both the spruce trees and the algal mats have their efforts continually removed and diluted by wind and sea. These are examples of the exquisite sensitivity of biochemical receptors.

I think it's likely that the peppermint and the watercress cooperate in the production of semiochemicals from their roots that interact synergistically to repel just about everything that tries to move in. We planted some of the mint in our garden at home, and it did invade and crowd out other plants. I know nothing of watercress's growth habit, but its genus is *Nasturtium*, part of the mustard family, which is known to be invasive.

Regardless of whether my conjecture about peppermint and watercress is ever confirmed, I am delighted finally to have some kind of explanation. In addition, I am doubly delighted to find an even deeper connection between two pet subjects of mine, evolution

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and chaos theory: semiochemistry is just another example of ordinary Darwinism, at a lower fractal level. The unimaginable complexity of life on Earth continues all the way down to individual molecules and atoms.

I will close with an account from my own field—the microbiology and chemistry of water supplies and water treatment—that seems to me to be the ultimate example of bio-geo-semiochemistry.

In the last ten years something new and fundamental has been added to textbooks of General Bacteriology. It's surprising to consider that there could be anything really fundamental left to discover these days, but it's true. Since the beginning of true bacteriology with Koch, Lister, Pasteur, et al., the life cycle of a bacterial culture has been a "lag" phase after the initial inoculation, followed by a logarithmic growth phase, followed by a long, slow decline into senescence, and finally, all are dead. Apparently, nobody ever tested a culture that was two or three years old.

But a culture tube with rich, plentiful food and perfect temperature, and no room to grow and no way to get rid of wastes, is highly artificial and unlike the real world. Drinking water in particular is extremely limited in nutrients, and the bacteria that inhabit drinking-water systems grow quite slowly. Bottled water is the perfect test subject, and when that industry "caught on" researchers began to notice something new. There is usually an active chlorine or ozone residual in the water when the bottle is sealed, and the water has usually been very thoroughly treated before then, but still there are almost always some survivors. While on the shelf, they grow until there is no more food, and then they continue to grow until there's not enough cytoplasm to permit another division, and then they go dormant. Most die, but not all, and the culture survives in a few individuals. After a few months, the survivors rouse themselves and begin to grow again, using the remains of their sisters as nutrients. This cycle of growth, decline, dormancy and growth can continue indefinitely, with the long-term growth curve resembling a halting sine wave. Samples taken at different times may show a plate count of a few hundred per mL, or a few tens of thousands per mL, or nothing at all, and the number, whatever it is, has no health significance at all, and very little meaning of any kind.

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The drinking water distribution system is another place where bacterial dormancy has been shown. I suppose a lot of people think disinfection kills everything, and drinking water is sterile, but no, there is a thriving community down there in the mains. Most dissolved or suspended materials in water get absorbed onto surfaces, and that's true of bacteria as well. They form intricate consortia of various species in gluey mats called biofilms, where they grow until shredded by turbulence. They produce acidic wastes which initiate corrosion cells on the pipes, causing ugly tubercles of rust, scale, sediment, and grunge to grow and accumulate. In the nooks and crannies dwells a veritable zoo of microscopic protozoa, hydras, and rotifers, plus very macroscopic crustaceans, insects, amphipods and copepods. A few years ago I saw a presentation at a conference in which somebody tied a pair of panty hose to a fire hydrant and let it run full blast all afternoon. After six hours they had a bulging monstrosity which, when slit open, filled seven bushel baskets with a dark, glistening, moving, wriggling, scuttling, overflowing horde of tiny monsters, and the entire audience of professors and professional engineers and chemists chorused as one, "Eeeuuwww!" It was a wonderful moment for a producer of water filters. But I digress . . . my point was that all water mains everywhere are covered with bacteria which continually "seed" the passing drinking water with little chunks of biofilm, and it is mostly these that are responsible for whatever plate count is determined when samples of drinking water are taken for bacteriological analysis. The strange thing is, hardly any of them grow. Researchers have been working for decades, but the *best* that can be done is only about one percent recovery, and the *usual* result is lucky to detect two or three out of a thousand that are known to be present and alive. The other ninety-nine-plus percent are simply said to be "non-culturable." Now we are beginning to understand that the bacteria go dormant and revive again according to each species' characteristic schedule, regardless of the nutrient level in the system. There is an orderly progression, or succession, of the various species present, each one achieving numerical dominance for a while and then declining as another approaches its turn at hegemony.

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All this is background to my example of the ultimate semiochemical system, and that is the bacteriology of the deep subterranean strata. We used to think that the bacteria in water from newly drilled deep wells were just surface contamination from the drill bit, but recently, very careful work near Ada, Oklahoma and elsewhere has shown otherwise. It is now established that deep sedimentary rock harbors organisms that have been there since the strata were laid down hundreds of thousands or millions of years ago. They are still alive and dormant, waiting to be revived. Very careful experiments have provided estimates that they can be roused by exposing them to as little as one molecule of sugar and two molecules of oxygen per organism. It is satisfying to note that that is precisely what biochemistry would predict, if one would dare to consider such a prospect. It may be stretching things a bit to call essential nutrients "semiochemicals," but to my mind, springing to life after a million years of dormancy is the ultimate "behavioral modification," and a single molecule the ultimate material limitation.

The real Secret of The Spring is its call to examine the little things. Mies van der Rohe taught that "God dwells in the details," and they are a delight. The glorious complexity of creation is there for us to appreciate; just don't neglect the little things. They are sometimes the most fascinating, and it seems that there are no limits.

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