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A Case for Wonder

In science education, nothing is more important than developing the capacity for amazement

It's an early May morning and the air is cool and still and filled with lambent light. I am out in a shrubby field, counting birds with three students from my field biology class. We're working our way through a small patch of brambles and wild rose, more concerned about the thorns ripping at our legs than the northern cardinal singing from a nearby black locust, when a song sparrow jumps up directly below my feet and skitters off into deep cover. There's an unmistakable whirr of wings that comes when an incubating or brooding bird flushes, so I know that we have stumbled upon an active nest. I kneel carefully, part a concealing canopy of vegetation, and discover a small cup of dried, amber-colored grass. Lying in the cup are a single egg and two newly hatched young, still wet and perhaps only an hour old. I reach into the nest and remove the egg and one of the young, to show the students. One of them, Mary, is worried: "Won't the mother bird abandon her nest if someone touches her nestling?" No, I explain, that's an old wives' (or husbands') tale, and the female will return after we leave. I've handled hundreds of nestling sparrows and have never known the parents to desert their young. And so we spend a few minutes looking at the delicate, pale blue-green egg, with its intricate pattern of reddish-brown blotches, and talking about the nestling, which is blind and almost naked, its only feathers a mohawk-like crown of down along the top of its head.

The nestling, which on its first day of life is little more than a belly and a beak, weighs about two grams—the rough equivalent of four raisins—but when it fledges in nine or ten days it will weigh ten times as much. I tell my students that nestling songbirds have the fastest growth rate of any vertebrate and then ask them to think about their own growth and how long it took them to double their weight after birth: five months, more or less. I say nothing about quantitative models of growth, about logistic curves, instantaneous rates of change, inflection points, or asymptotes—leave all of that for the classroom or another less numinous morning. Instead I simply ask them to marvel at what these tiny creatures can do: grow so quickly and survive the first ten days of life when they are essentially helpless and there are so many things out there that can kill them—starvation, drenching rain, biting flies, and a host of predators, from mice to snakes and crows. After we finish our small discussion I quote (a bit self-consciously) Gerard Manley Hopkins—"My heart in hiding / Stirred for a bird,—the achieve of, the mastery of the thing!"—then gently set the young bird and egg back in the nest.

We continue through the field, the morning a bit more beautiful, the brilliant air a bit more tinged with wonder.

I was hired to teach at the College of Brockport in 1993, and since then I have done what the job announcement asked of me: taught courses on conservation biology and terrestrial vertebrate biology, and established a research program involving undergraduate and master's-level students. I have published more than forty papers in peer-reviewed journals, received many hundreds of thousands of dollars in grants and contracts, served on more academic committees than I care to remember, sent twenty-five master's students and countless undergraduates on to careers of their own, and written three books of creative nonfiction exploring our relationship to the natural world. It has been a hectic twenty-three years and sometimes there has been little opportunity to think deeply about what I am doing, why I do it, and most importantly, what it is that I want to teach my students.

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Just what is it that environmental science students should learn?

Well, there are the obvious things: sufficient background knowledge in their environmental science major, which encompasses ecology, chemistry, geology, statistics, and a smattering of the social sciences; a technical skill set that prepares them to compete successfully for employment or further educational opportunities; effective written and oral communication skills; and the ability to think critically about science and environmental issues.

All of these objectives are important, but beyond them there is one even more vital: the capacity for wonder. And wonder is a response to the world—to life!—that sustains intellectual creativity and nourishes our hearts and souls. Karl Barth once described theology as "necessarily the logic of wonders," and the same "logic" should suffuse education. *If* we can cultivate the capacity for wonder in ourselves, and *if* we can foster it in others, then we might step into a more compelling and magical world. Inhabiting such a place would grant us a particular kind of grace, in which the familiar would never grow old, the unfamiliar would burn with sudden brilliance, and our lessons would never be finished.

In other words, to fully comprehend and appreciate something as "common" as a nestling song sparrow is to participate in the essence of an educational (or scientific or artistic) process. That naked, helpless song sparrow, just now emerged from the egg: an outcome of five hundred million years or more of vertebrate evolution cupped in my hand, the seemingly endless spiral of time and blood and sex resulting in *this* young bird, which will grow more quickly than any other vertebrate and in two weeks (more or less) take to the air.

I sometimes believe that I would consider my career as a teacher successful if I consistently offered each of my students at least one opportunity to fully and directly confront wonder, and in doing so *know* and *feel* it in an intensely fundamental and personal—even if imperfect—way. Such an experience would fuel their intellectual curiosity and help them understand how lovely and important it is to cultivate their capacity for wonder. Directly confronting wonder and incorporating it into their hearts might even make my environmental science students more inclined to embrace classes that they typically find intimidating such as organic chemistry and statistics—for there is beauty in these subjects, if only they were given the space in which to see it. More opportunity for wonder would allow them, as young scientists, to more fully and competently encounter life in all of its brilliance, magnificence, and beauty, as well as its brutality and terror.

Take for example the phenomenon that I once observed in the Snowy Mountains of Australia—the way in which foraging ants would announce their discovery of a pipit nest, the first thin trickle tracking toward the nestlings, a trickle that quickly became an inevitable stream, the stream that I wanted to stop but could not, the stream that sometimes disturbed my thoughts for days, as I had been bitten by those same ants and so could understand the pain and imagine something of what those young birds' deaths would have been like. The only consolation in my understanding was my amazement that the Australian pipits would go on, in the face of it all, in a type of collective transcendence that offered some hope to me, and to the larger world.

Encounters with wonder would remind my students of how they might have been as a child, even in these many-fingered digital times—more inclined to awe, less jaded, more connected by sensory and visceral contact to the physical world. Rachel Carson understood how open children are to direct experience, how critical this capacity is to their education and well-being—and how this ability tends to diminish with age. In *The Sense of Wonder* Carson observed,

> *A child's world is fresh and new and beautiful, full of wonder and excitement. It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is dimmed and even lost before we reach adulthood. If I had influence with the good fairy who is supposed to preside over the christening of all children I should ask that her gift to each child in the world be a sense of wonder so indestructible that it would last throughout life, as an unfailing antidote against the boredom and disenchantment of later years, the sterile preoccupation with things that are artificial, the alienation from the sources of our strength.*

Yes. If only we could retain and cultivate this sense of wonder, if only we could encounter the world in the way that I've seen when I band birds with fourth- or fifth-grade students, and let them hold a chipping sparrow or black-capped chickadee: the look of delight that comes to them when they cup the small bird in their hand and feel its heat, feel the thrum of its fear and pounding of its heart against their palm, or when they look into the dark iridescence of the bird's eye and see—what?—a reflection of themselves or some sheer otherness, an intimation of a greater world, a world that rises up when they open their hand and the bird climbs into the air and is gone. I've taught a few of these same students ten years later, and it makes perfect sense that they recall, with some excitement, the details of their bird-banding experience—for the sensory intensity of their contact, their wonder at the "mastery of the thing," had marked them in some small but indelible way.

But when I look at my junior- and senior-level college students during a lecture, or coax them into a discussion about what

to me are the most astounding marvels—say the ability of a lungless salamander to survive for a year without eating, or how the body temperature of a hibernating arctic ground squirrel can fall to below freezing during hibernation—I rarely glimpse obvious traces of the excitement that I feel when I confront these phenomena. Instead I see my students scribbling hurried notes ("Will this be on the test?") or glancing at the clock on the wall or struggling to stay awake and focused. There's less of this ennui when students are out in the field—more engagement and excitement, perhaps driven in part by the sheer pleasure of being outside and part by relief from the relentless stream of information that pours forth from lectures, collaborative learning exercises, assigned reading, and the like, not to mention the requisite exams and lab reports.

But perhaps I am being deceived by what feels like the natural reticence of many who are drawn to science, their shyness in the face of deep emotion, the inability to express what we feel in the face of the world's complexity and beauty—tendencies that are further reinforced by our urge to quantify, standardize, and formulate, and an educational system that now emphasizes measurable student learning outcomes and appears to value information more than knowledge, and knowledge more than wisdom. For example, the New York State teaching standards on the Living Environment curriculum, standards that guide secondary-level instruction in the biological sciences, says nothing about cultivating in students an emotional response to life's great pageant. Wonder and a sense of the aesthetic are never mentioned since they are not amenable to measurement.

It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is dimmed and even lost before we reach adulthood.

But how might we craft a curriculum of wonder and beauty? In *The Sense of Wonder*, Rachel Carson argues,

> *For the child, and for the parent seeking to guide him, it is not half so important to* know *as to* feel. *If facts are the seeds that later produce knowledge and wisdom, then the emotions and the impressions of the senses are the fertile soil in which the seeds must grow. The years of early childhood are the time to prepare the soil. Once the emotions have been aroused—a sense of the beautiful, the excitement of the new and the unknown, a feeling of sympathy, pity, admiration or love—then we wish for knowledge about our emotional response. Once found, it has lasting meaning. It is more important to pave the way for the child to want to know than to put him on a diet of facts he is not ready to assimilate.*

Carson is undoubtedly right, in that emotional affinity breeds a desire for knowledge, and facts devoid of an experiential context mean little. And yet. I believe that facts—the details of this world—are integral to our understanding of it, and a stimulus to wonder. Andrew Hipp, systematic botanist and curator of the Morton Arboretum, writes that "Natural history—like fiction or poetry—is truth by way of the particular." In an analogous way I would say that wonder—like natural history—is amazement by way of the particular. I have encountered the relationship between wonder and the particular in so many situations, from the discovery of a nestling sparrow in a shrubby New York field to the minute alpine willow species clinging to life on some wind- and sun-blasted alpine tundra, their flowering stems only two inches high, yet related to the seventy-foot-tall weeping willow growing in my New York backyard. Or take my encounter with the Cottonball Marsh pupfish, *Cyprinodon salinus milleri*, on the floor of Death Valley: amid a chaotic wasteland of slabs, cups, and pustules of gypsum and sodium sulfate salt, beneath a blinding light, enveloped by punishing heat, in a country too saline to nourish even pickleweed and saltgrass, there are tiny fish no more than one-and-one-half inches long, going about their business in a killing ground of salt and heat. It is stunning that these fish can exist in an environment that has been described as perhaps "the most extreme fish habitat in North America in terms of temperature and salinity." Perhaps it is sufficient to encounter them in their element, but it helps me to know that these tiny fish most likely evolved from an ancestral freshwater population some seven to nine million years ago, on the Mesa del Norte of Mexico, south of the Rio Grande. It helps me to know that these astounding creatures and their kin can tolerate salinities upwards of seventy-one parts per thousand and water temperatures of 107°F, and that they have high levels of heat shock proteins in their gills that probably help them tolerate the wide fluctuations in salinity that characterize their home waters. On and on these details flow—on and on, rising like the very atmosphere that envelops Cottonball Marsh and its pupfish, the extraordinary distance and depth of the Great Basin, the way

in which this place (in the words of one biologist I know), "lays your soul bare," and likewise, the way in which these tiny fish and the facts that describe their existence, their presence in the world, lays my soul bare.

I REALIZE, though, that I have few clear ideas about how to "craft a curriculum of wonder." I have no new or vaguely radical pedagogy to propose, no concrete recommendations destined for *The Journal of College Science Teaching*. Mostly what I have is one admonition for my students: *pay attention*. In other words: Stop talking. Stop glancing at your iPhones and computer screens. Stop multitasking and thinking about where you would rather be. Instead, pay attention to the sensuous details of the world—the sinuous rise and fall of a Pleistocene esker, covered ten thousand years after the last glacial retreat by a blanket of shagbark hickory and sugar maples, white oaks and American beech, and the ways in which slope and aspect and sorted fluvial sediments, along with human and nonhuman history, have affected the vegetation along the esker. Pay attention to how the size and arrangement of the premolars distinguish a smoky shrew from a masked shrew, or to the side-to-side sway of a red-backed salamander across the forest floor, "a motion and a spirit" that can be traced back across hundreds of millions of years of evolution, to a time when its ancestors swam through Paleozoic seas.

Recently, after reading David Haskell's *The Forest Unseen*, in which he describes a year spent watching a one-square meter plot of old growth Tennessee forest, I attempted a similar but severely truncated version of his project in my field biology course. I asked students to stake out a one-square-meter patch of deciduous forest habitat and focus their attention on it for one hour, extending their observations from a few inches into the soil and leaf litter to the forest canopy. I left the instructions for the assignment deliberately vague (fool), and wanted nothing more from them than some detailed descriptions, a few "how" and "why" questions related to their observations, and one larger idea about a pattern or process occurring in their plot that they might later pursue via the scientific literature. In designing the assignment, I mostly wanted to create a space in which wonder might happen. A few went off into the forest on their own, and were quiet. They watched intently and later produced reports that were rich in detail and questions. But many were as restless as a six-year-old in time-out; they placed their squares close to one another, chattered back and forth, surreptitiously glanced at their phones, fidgeted, and repeatedly checked the time (no doubt wondering when their hour of enforced inactivity would end). These students' reports tended toward the vague, uninspired, and disengaged; they seemed as far away from wonder as Seattle is from Istanbul.

In the aftermath of my small experiment I was left disheartened and reminded of what I had already understood: that it takes years to cultivate a sense of wonder, that our educational system all too often shies away from engaging with wonder and with the question of how to instill this capacity in our children, and so nourish it in adults. But I will persist with the one-square-meter assignment and try it again in another class, with a more extensive set of rules: absolutely no "devices," plots at least thirty yards from one another, no watches, just a fifteen-centimeter ruler, hand lens, and notebook. And I will seek out other ways of encouraging curiosity in my students, through direct encounter with the world.

Just before beginning a unit on environmental physiology in my ornithology class I might take my students outside on a bitterly cold February day, when a Canadian gale is blowing hard out of the northwest. I'll have them watch mallards and ring-billed gulls for an hour, as the birds ride the freezing, wind-whipped waters along the canal near my college. Afterward, when the memory of the cutting wind and aching cold are still fresh in my students' minds and bones, when hypothermia is more than a strictly hypothetical concept—then I will have them delve into radiant heat exchange, thermal budgets, the insulating efficiency of feathers, and graphs depicting the relationship between ambient temperature, metabolic rate, and survival.

And I will keep thinking, explicitly, about how to foster in my students their desire to interact emotionally with the details of the world—not just because this capacity will make them better scientists and bring pleasure to their lives, but for a myriad of other reasons, two of which seem most crucial to me. The first of these is that a sense of wonder—cultivated by learning how to ask questions, paying attention to detail, and being still—serves as an antidote to the poisonous hubris of certitude. For "the practice of wonder" should at a minimum teach us that the world and our understanding of it are uncertain. The arrogance, bluster, and blind ideology that have become such a large part of our public/political discourse, promulgated across the cultural landscape via Facebook, Fox News, Twitter, Yik Yak, and a host of other "platforms," are poorly served by wonder. When Doug Peacock studied grizzly bears in the Yellowstone ecosystem he refused to take a gun with him because he wanted to learn humility in the face of an animal that could kill and eat him; as David Gessner writes, "Humility, Peacock came to believe, was the proper emotional backdrop for reason." In a similar way I believe that wonder is the proper emotional backdrop for an understanding tempered by the sheer beauty, mystery, and unpredictability of the natural world, a world exemplified by alpha predators, such as the grizzly bear, although equally so by a Cottonball Marsh pupfish.

The second reason involves the way in which wonder might help us deal with the pain and suffering that we all encounter

in our lives, at some times and in some places—especially in our own mortality. In September of 1963, when she was much weakened by the breast cancer that would kill her eight months later, Rachel Carson and her close friend Dorothy Freeman spent a lovely morning by the Maine sea, watching migrating monarch butterflies feed on milkweed as they made their way south. Later that day Carson wrote Freeman a "postscript" about their experience:

> *But most of all I shall remember the Monarchs, that unhurried westward drift of one small winged form after another, each drawn by some invisible force. We talked a little about their migration, their life history. Did they return? We thought not; for most, at least, this was the closing journey of their lives.*
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> *But it occurred to me this afternoon, remembering, that it had been a happy spectacle, that we had felt no sadness when we spoke of the fact that there would be no return. And rightly—for when any living thing has come to the end of its life cycle we accept that end as natural.*
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> *For the Monarch that cycle is measured in a known span of months. For ourselves, the measure is something else, the span of which we cannot know. But the thought is the same: when that intangible cycle has run its course it is a natural and no unhappy thing that a life has come to its end.*
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> *That is what those brightly fluttering bits of life taught me this morning. I found a deep happiness in it—so, I hope, may you.*

Near the end of her life Rachel Carson took some solace in the migration of monarch butterflies and the astonishment that they instilled in her, a response cultivated by a lifetime of right practice. Like Carson's experience with "those brightly fluttering bits of life," there was something important about the way in which my students and I encountered that brood of nestling song sparrows. But whatever occurred in that shrubby field—the way in which such an experience might impact my students and their response to the world—I am thankful that it remains completely beyond the reach of quantitative assessment, something that never will be encapsulated in any "student learning outcome":

"The environmental science student will demonstrate a passionate love for the natural world, as symbolized by a tiny bird."

"The environmental science student, when presented with a nestling song sparrow, will be consumed by awe."

"At the conclusion of their undergraduate education, the environmental science student will effectively articulate his or her ineffable appreciation for the beauty, stunning complexity, and tenacity of life, as evidenced by a nestling song sparrow."

"The departmental benchmark for successfully achieving Student Learning Outcome #7 is that 70 percent of the students will score 70 percent or better on the instruments designed to examine their ability to express wonder."

On and on and on and on.

We cannot quantify or "assess" wonder, and yet it is wonder that sustains intellectual and artistic creativity, nourishes the most active minds, and gives rise to the best professionals, no matter what their area of expertise. This wonder should be cultivated by textbooks and lectures, lab experiments and field studies, discussions and papers, creative performances and artistic works, internships and independent studies. In my field it should come from developing a rich appreciation for evolution and ecology, and biological form and function, but it is best found when you do something direct and physical, such as holding a tiny nestling in your hand on a beautiful May morning. Then you can marvel at its wholeness and how it grows into life despite its vulnerability, before setting it down, ever so gently, in its nest and continuing on into the lovely and widening day. And if this wonder finds a path into your mind and heart, which experience has made less solid and resistant, and so flourishes there—well, you are on your way toward getting an education and learning something vital about the life of a sparrow, and the ways of the world. And in this awakening it is possible to inhabit a world suffused with light and colonized by beauty, a world in which so many things burn brightly.

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Citizen

I am in full support
of whoever invented fields of sunflowers
tilted together to face it, to take it in.

I cast my ballot for their sturdy stalks
and fat seeds. I pull the lever
for the straight sunflower ticket.

I tuck my voting receipt
in the change pocket of my jeans
and when I get home

I plant it.

—Jim Daniels