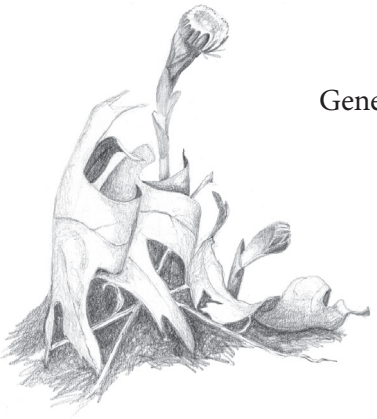
In Context

A Publication of **The Nature Institute**



#49

Spring 2023

Dear Readers,

When we were preparing the first issue of this publication, we were searching for a name. In the end we decided on *In Context*. The name seemed appropriate 25 years ago and it still feels right today. The word "context" is in one respect vague because it's so general. It can mean almost anything and everything that surrounds and interacts with what we have placed in the center of our attention. When we focus on something — a particular animal or plant, a new development in science, a book of interest — we may at first isolate it from the world of which it is a part in order to begin to get to know it. We become familiar with how this plant grows and develops, or we wrestle with the ideas that a scientist presents. The danger lurking in the background of such endeavors is that we neglect to attend to how a phenomenon is itself an expression of a larger world. We need to look to its context — to the world that lets it exist and that it, in turn, contributes to. That intention lies at the basis our enduring appeal to view things "in context."

This leads to what we could call a relational science. It is always about weaving through a variety a phenomena, which at first may seem unrelated, and seeing whether connections appear. Goethe spoke of a "zarte empirie" — a gentle or delicate empiricism. The approach is empirical because it is always about giving our careful attention to the wealth of concrete phenomena. It is about experience. And the way we form ideas should be gentle; we don't want to force our ideas upon the world. In an active listening attitude, we want to be receptive to the meanings that show themselves in the relations we study. This leads us into open-ended inquiry in which our understanding can — and needs to — continually grow.

In this 49th issue of *In Context* you will find a variety of contributions that are rooted in this spirit. We hope you find them illuminating.

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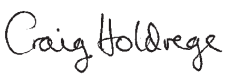
Craig Holdrege



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Preface to a Thirteen-Year Project

Stephen L. Talbott

This is the preface to Steve's recently completed book, Organisms and Their Evolution: Agency and Meaning in the Drama of Life (*previously titled* Evolution As It Was Meant To Be — And The Living Organisms That Tell Its Story). *All chapters are available on The Nature Institute's adjunct website, bwo.life/bk.*

I see a crow, perched atop a shagbark hickory tree about fifty meters in front of me. It seems oddly unperturbed on its branchlet as it surfs the tumultuous waves of a stiff wind. The winds, of course, are its own element, just as the twisting currents of a swift stream belong to the trout. The crow, I reflect, is its own sort of master of the wide domain it surveys — a domain whose whole aspect is unfamiliar to me. As I walk, I try to see myself through its unhuman eyes, a small, insignificant figure approaching far below, passing beneath, and then slowly receding into the distance.

I was once taught to see myself this way when in the presence of a bird on high — I, an intruder moving for a few moments through another's native landscape. It was a modest little exercise in becoming detached from one's own point of view. I suppose it's rather easy for us today. We are, after all, heirs of Copernicus, whose one giant leap for mankind sprang from his then-novel capacity to project himself, as an observer, onto the surface of the sun. From that viewpoint he could imagine his own, troubled earth moving serenely through space.

But Copernicus had only to project himself through what was in the process of becoming, for us, "empty space." How much more difficult to insert oneself into the "mind" of a crow! Who is it that looks down at me, and from what strange, inner world does it gaze? What would I *really* be seeing if I could see with crow-vision, so penetrating in its crow-ness, yet so alien to me? I have to admit that there is vastly more of myself projected to the top of that tree than there is of the crow. When the lives of distantly related beings are at issue, isn't getting outside one's own viewpoint all but impossible?

My primary aim in this book is to enable the reader to see organisms — and especially animals, which are my main examples — with new eyes. In place of a systematic survey, I present what might almost be approached as a series of re-visioning exercises whose diverse focal points, so I hope, can merge for the reader into a single, coherent landscape. It will be a landscape viewed, so I also hope, from unexpected angles.

The oddity lies in the fact that I rely rather heavily on topics drawn from molecular biology, a discipline that gives us no real landscape at all — certainly not one based on the kind of direct, sensible experience the founders of the Scientific Revolution craved. The biologist's picture of atoms and particles is synthesized from theoretical constructs and

outdated mental pictures that, especially in the physics of the last hundred years, have been thoroughly subverted. So how we should actually *picture* what I will refer to as the "microworld" is a genuine mystery today.

The problem is that biologists have been content to stick with nineteenth-century images of the solid little "particles" that were debunked in physics long ago. And so they imagine a cell full of little materialized "molecular machines," however tiny. Where physicists have acknowledged many wide-open questions at the foundation of their discipline, biologists have doubled down on a rather crude materialism.

But the biologists' problem is a problem for this book as well. How can I focus as much as I do on a field of research (molecular biology) that is more or less a blank slate so far as an experience-based (empirical) science is concerned? Am I not just lending further support to a kind of biological fantasy world?

I am inclined to plead guilty to this charge. Of course, I do at times try to warn the reader against misconceptions — for example, in Chapter 15 ("Puzzles of the Microworld") and Chapter 21 ("Inheritance, Genetics, and the Particulate View of Life"). But there are also at least three strong, positive justifications for looking carefully at how biologists appeal to molecular-level research as a bottom-up foundation for understanding organisms. These all have to do with the fact that molecular biology presents to one's imagination a kind of blank slate. Looking at what researchers have projected onto this blank slate can tell us a great deal about the character and pathology of biological thought today.

To begin with, we see a seemingly unquenchable thirst for unambiguous (and therefore unbiological) cause-and-effect explanation. These explanations tend to be of an antiquated, billiard-ball sort involving particles that, as physicists have long known, simply aren't there — certainly not in the way they are being imagined within biology. In this way we come to those ubiquitous and hopelessly misconceived "molecular machines" that are supposed to perform the fundamental living work of organisms.

The fact that biology as a whole has been thought to be securely grounded in molecular-level explanation tells us a great deal about the distortions of this particular science. It tells us more, that is, about the minds projecting their preconceptions upon the unknown, mysterious molecular background than about organisms as such.

In the second place, because so much of molecular biology is based on non-empirical, unsupportable, and metaphysical (materialist) assumptions, the supposed explanations issuing from molecular biology never add up. When we look at these explanations, we easily recognize the confusion at work in them. (See, for example, Chapter 8 ("The Mystery of an Unexpected Coherence") and Chapter 9 ("A Mess of Causes".)

Recognizing the confusion can, in the third place, point us in the direction of a more adequate understanding — one that starts with the observable organism rather than a fantastic, non-observable realm littered with metaphysical "projectiles." I gesture toward the grounding principles of such a fuller understanding in Chapter 13 ("All Science Must Be Rooted in Experience"), Chapter 24 ("How the World Lends Itself to Our Knowing"), and Chapter 25 ("Some Principles of Biological Understanding").

I have, throughout the writing of this book, been accompanied by a discomfiting awareness of the difficulty of the task I have set myself. This is presumably due mainly to my own limitations. Seeing things anew — as opposed to collecting more and more data and trying to assemble it into unambiguous demonstrations of truth — is not something I find easy, nor is it something we are generally encouraged to strive for today. The following thoughts, borrowed from others, have, for me, emphasized the great distance from routine claims of truth to genuine profundity:

• The first of these thoughts is an overall conclusion drawn from a study of meaning entitled *Poetic Diction*, written in 1928 by the philologist and student of the evolution of consciousness, Owen Barfield. It expresses a truth also forced upon me directly by many less-than-satisfying efforts at communication. (The phrasing is my own:)

> *If a conversation takes place primarily as a logical contest or as a battle of "proofs," rather than as an effort to clarify, shift, and deepen meanings, it is likely to be shallow.*

In my run-up to writing this book — and throughout the writing — I have had to suppress my own deeply rooted, almost congenital instincts toward doing intellectual battle. I now know that victory in this particular struggle with myself will never be fully won.

• Then there is my vague remembrance of a remark I somehow associated with the late physicist, Georg Maier. It ran more or less like this:

> *If you think you have reached a point where you can cleanly explain a profound truth, you do not yet understand it.*

After the first appearance of this preface, my colleague, Henrike Holdrege, gave me an actual quotation from Maier, which serves just as well: "*the knowing of a phenomenon (appearance) is not at all completed by a successful explanation.*"

• Finally — again from Barfield, and this time as a direct quote wrapped up with a striking metaphor — there is this:

> "*If you take your view of the world seriously, to air it is tiring. Moreover, in any ordinary conversation you*

can only do so very superficially, and your own heard superficiality wounds you. The opinions, whether firm or tentative, of a man over fifty who has thought for himself about the nature of man and the universe will have acquired a certain depth and weight that make them ill adapted for point-blank encounter. Submarines rarely engage one another in battle." (Barfield 1965, p. 74).

If you want to have a fruitful conversation with someone, the two of you must meet upon some sort of common ground. For if you see things in such fundamentally different ways that every assertion from one side is met by a refusal to accept it on the other side, then there is not much reason to talk. If, on the other hand, the two of you are so close in thought and assumption that you mean the same thing with your words and can work with precisely the same set of facts, then the role of conversation is also limited. All you need to do is to order the facts in such a way as to prove your case to the other person. Nothing really new will arise, because your proof was already implicit in your mutually accepted understanding of things.

But there is a potentially productive middle ground where enough is shared to make conversation possible, and enough is not shared to raise the hope of genuinely new insight. In this case the challenge is to hear the other person's words and facts with new ears. We can most easily open ourselves to this possibility if we have managed somehow to get outside our culture's "common sense," much as we today are able to challenge, or even laugh at, the received and unquestioned wisdom of previous historical eras. Managing to see our own culture in such a foreign light, however, can be an almost impossible task. But even a small effort in that direction can be life-changing — like being let out of a prison you hadn't realized you were in.

I do not expect my efforts here to be adequate. But I do hope they may be of some use to those sympathetic readers seeking a new vantage point upon biology — one that, even if at first it presents an unfamiliar and perplexing landscape, at least does not require us to deny the living experience of all creatures, including ourselves.

Sources

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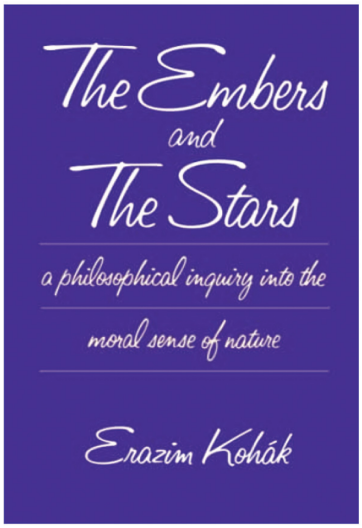
Recalling What We Have Hidden

A contemplation of Erazim Kohák's book

The Embers and the Stars: A Philosophical Inquiry Into the Moral Sense of Nature

Ryan Shea

In my dining room hangs a print purchased several years ago for me by my wife. It is titled "Against Forgetting." At first glance, it looks like a simple black and white photo of a cross-section of a tree, showing the growth rings. Closer inspection reveals that this is only half the story. The other half is a photograph of a human thumbprint, which almost perfectly mirrors the tree rings, matching them line for line. The image serves as an icon. Fingerprints and tree rings are beheld together. The holding together is accomplished with a single activity that is both seeing and remembering. I see the print with my eyes and an aspect of that seeing is *re*-membering humans and trees together as members of a unified whole. It is an icon "Against Forgetting."



Samuel Johnson once wrote that "people need to be reminded more often than they need to be instructed." Erazim Kohák's 1987 book, *The Embers and the Stars: A Philosophical Inquiry Into the Moral Sense of Nature*, (University of Chicago Press) takes up the work of reminding. Kohák (1933-2020) was a philosopher who was rigorously trained in the German phenomenological tradition focusing especially on the work of

Edmund Husserl. This is a philosophical book. It is a book of deep reflection that engages with the thoughts of philosophers and scientists. The goal, however, is far from abstract argument for its own sake. He summarizes the task of his book by saying "I have not sought to 'prove a point' but to evoke and share a vision. Thus my primary tool has been the metaphor, not the argument, and the product of my labors is not a doctrine but an invitation to look and to see. With Husserl, I have sought not to instruct but to point out, to recall what we have forgotten."

Kohák sought to incarnate this goal both as a professor of philosophy and as a modern-day Thoreau. During the day hours of the week, he would teach at Boston University, but on nights, weekends, and school breaks he would return to his New Hampshire homestead. Here he lived all year round without electricity in a house he had built in the middle of a clearing that he had cleared with his own axe. The titular "embers and stars" that guide his thinking are only visible to him in the New Hampshire darkness and solitude. The blare of civilized noise and the glare of civilized lights leave us deaf and blind to what shows itself in nature. Kohák went to the woods to achieve clarity of vision and to perform his work of "recalling what we have thus hidden from ourselves." What does Kohák think we have hidden and forgotten? How has it blocked our vision? And how might we remember?

Modern natural science strives above all else to be objective. The scientific spirit is that wherein all hints of subjectivity have been expunged. For this reason, to be anthropomorphic, that is, to attribute human attributes to natural beings, is the unforgivable sin and must be scrupulously avoided. The trouble is that human beings are subjects. Everything we experience is experienced by us as subjects. The ideal of strict objectivity requires that we forget this obvious truth. The first kind of forgetfulness is a self-forgetfulness. In this purposeful ignoring, this willful ignorance, we also forget everything that pertains to humans as subjects. Kohák gives the following list of what we lose when we forget ourselves: "value, meaning, beauty, goodness, truth, holiness."

The amnesia does not stop at the self. Our everyday experience of the natural world is not of the dead world described by physics and chemistry, devoid of all value, meaning, beauty, goodness, truth, and holiness. As a matter of daily fact, we do not encounter our own pets as mere complex mechanisms, or our local Audubon nature preserve as so many board feet of lumber. As I sit and watch a sparrow at my bird feeder, I am struck by what Kohák calls its "integrity," which is "not merely [its] utility but an intrinsic, absolute value ingressing in the order of time." It is good that the sparrow is. Its existence is good as an absolute value, separate not only from any human utility, but also from the role it plays in its ecosystem. Kohák laments that when we speak of "nature" we frequently are not referring to that living reality encountered in our experience, but to the "highly sophisticated theoretical nature-construct" of the sciences, which we then mistake for reality. Our forgetfulness has spread from the self to nature and in doing so has created a problem, maybe a paradox, perhaps a contradiction.

By pursuing objectivity, the natural sciences have forgotten not only the human subject, but also the natural object. In seeking to perfect our knowledge, we have accidentally denied the existence of the knower (the scientist-as-subject) and so radically transformed the known object that it bears little resemblance to the real world we were seeking knowledge of in the first place. The "nature" on the chalkboard in a physics classroom is not what confronts us when we step out our front door. To know the former is not the same thing as to know the latter. The physicist would, no doubt, point out that Kohák is being frightfully naive and childish in preferring prescientific experience to scientific knowledge. Kohák would happily agree but say that his is "a second-order naïveté, a willed, conscious reaffirmation of the reality of meaningful lived experience, motivated by the chastened admission of the futility of cunningly devised fables." He is naive in its original sense of "native, natural" as opposed to "alienated, artificial." Now it becomes clear why we might need to recall what we have forgotten in order to be able to see.

For Kohák, we must seek to understand "any and all reality *from within*" rather than "explaining it superficially from without." That is, we must understand a living entity "in terms of its meaningful being rather than in terms of categories arbitrarily imposed upon it from without." The starting point is with our own primal experience, before it is siphoned through the abstractions of physics, chemistry, and biology. Kohák says that what we first encounter, if we are not blinded by our technological civilization or stupefied by our scientific theories, is a world of meaningful being.

Walk out into a forest and close your eyes. Then open them. What do you see? You do not see simply green, red, brown, and blue colors. Nor do you see merely various complex shapes. Nor do you see simply a forest, or a pine forest, or a deciduous forest. You encounter everything as tied up within the whole complex narrative of your life. For example, you are out in the woods right now in order to clear your mind for an article you are writing, or because your doctor told you to in order to get your blood pressure under control, or because you are a biologist specializing in the mating rituals of red squirrels and you are coming to collect data, or because you work for the parks service and you are clearing off the paths after a powerful

wind storm. All our experiences are situated within a web of significance.

The trouble is that those meanings are often entirely human-centered (head clearing, physical health, job) rather than an authentic meaning-into the text of nature. We often read things according to our own favorite terminology, rather than working to come to terms with the other. This tendency to make everything exclusively about ourselves is, no doubt, part of the motivation for the ideal of objectivity in science. Yet, if you find that a student in ninth grade is systematically misreading texts by projecting his own interpretations and making all the books be significant only in relationship to himself, the solution is not to outright deny that the books contain any intrinsic meaning whatsoever. You do not tell him to avoid looking for meaning but show him how to find what the book itself is saying. The solution is to train him in the difficult art of interpretation. Kohák is asking that we devote at least as much thought and discipline to learning to read the intrinsic sense of a forested landscape as we do to learning how to read Shakespeare. The solution to both problems is not to deny, and thus willfully forget, meaning and sense simply because they are difficult to apprehend. The solution is to acknowledge the limits of our current understanding so that we might thereby strive to transcend our limits.

So too with the fraught relationship between humans and nature. We do not solve the practical problem of ecological catastrophe, or the theoretical problem of shallow anthropomorphic projection, by denying our humanity. We cannot hide from ourselves and should not try. Speaking of his Thoreau-like life in the woods, Kohák says: "I have come to belong in this world, not because I have become less human but because this world is far more human than I once realized. When humans surrender the arrogance of domination, they can reclaim the confidence of their humanity. Nature, freed from the constraint of mechanical nature-constructs, can accept the human as also a part of its moral order."

The recalling, the calling-together, of humans and nature must not mean the reduction of the human being to the abstracted theoretical constructs of nature proffered by the sciences, but rather the realization that they both participate in meaning, that is, in deep interconnection at their core. To see well is not to connect things. They are always already connected. To see well is to remember that they are already connected.

In moving in the opposite direction of objectification Kohák's first step is to help us to see-together humans and nature. Over half of the book is concerned with healing this rift between culture and the wild. His penetrating insights in this area are worth the price of the book and the cost of a careful reading. Yet, Kohak does not stop here. He speaks of a deeper "moral sense of nature" and writes: "The ageless boulders of the long-abandoned dam, the maple and the great birch by twilight, the chipmunk in the busyness of his days and his dying … have value in eternity, as witnesses to the audacious miracle of being rather than nothing…. The moral sense of life cannot be wholly contained in the order of time. It must be anchored in the eternity of the good, the true, the beautiful, the holy."

Kohák recognizes that we are here getting into deep water and that the term "eternity" does not seem to fit in well with our usual ways of thinking about nature and the environment. And yet there is the sparrow at my bird feeder, with its intrinsic "integrity" and "absolute value." For its value to be absolute, it must not be purely reducible to its temporal life any more than it is purely reducible to its material constitution. Here we encounter nature in its depth and height. And it is for this reason that "to destroy heedlessly, to pluck and discard, to have and leave unused, is an act of profound disrespect to the eternal worth of nature. For nature in its integrity is not simply a reservoir of raw materials."

Some may find the reference to eternity to be obvious, others may find it strange, and still others may find it simply confusing. But before accepting it wholeheartedly, or rejecting it out of hand, remember that Kohák's goal in the whole book is "not to argue but to see and to evoke a vision" and he is always "pleading with the reader to pause and ponder rather than to argue and agree." His book provides an excellent opportunity for deep meditation and reflection. If you are like me, then you will find the work of philosophical recollection required in the act of reading allows the world to start to show back up in its depth and profundity.

The mark of a good thinker is generosity. They are not systematic in the sense of building a crystalline filing system in which everything has its own pigeon-holed place. But, rather, the generous thinker is one that joyfully welcomes any and all phenomena, does not reject, cramp, or conveniently forget and misplace those that do not fit. Kohák's book will not explain the world. Indeed, it will not explain anything at all. For to explain is to make the object to be explained small and orderly enough to fit into its apportioned box. "There are things which it is so beside the point to explain," he writes. "It is much more important to cherish and give thanks for the lights that enrich the night. Explaining, making, those are the priorities of the day which conceal the world around us. In the dusk of a forest clearing, other things matter — to respect first, then to understand, only then, perhaps, to explain." Rather than explanations and theories, Kohák can provide the reader with a practice of recollection, generosity, and appreciative wonder for the gift of the natural world. His book might then become for you an icon "Against Forgetting."

Events

▪ In December 2022, Henrike and Craig taught the first two weeks of a two-module course, "Seeing Nature Whole — A Goethean Approach" in Florianopolos, Brazil. In his article, "**Generative Knowing in Education**," on page 19 of this issue, Craig discusses the kind of phenomenological and artistic exercises used during the course and why they are employed. (The second module in Brazil is scheduled for December 2023.)

▪ Our hands-on winter workshop in 2023, "**The Wisdom of Animals — Exploring their Dynamic Forms and Behavior**," took place over the last weekend in February. Participants in this short course studied how everything within an animal is interconnected and expresses a deep wisdom.

▪ Jon McAlice spent a week in Switzerland this past February, mentoring 40 Waldorf school educators on self-directed learning through the grades, and on how to develop and assess school curricula. His consulting work also took him to San Francisco the same month to facilitate a conference on "**The Experience of Meaning in Education**."

▪ Through the online European teacher training website **Lehrerseminar für Waldorfpädagogik**, Craig gave an intensive workshop in February for high school science teachers — from Estonia, Lithuania, Latvia, and Bulgaria — about the content and approach to teaching biology in the 11th and 12th Waldorf grades.

▪ Over this past winter and spring, John Gouldthorpe and Henrike Holdrege gave an online seminar, "**Working Through Our Color Experience**," for 12 current and graduated students in our Foundation Program.

▪ At the **15th International Training Week** for Waldorf educators in Kassel, Germany (March 31–April 6, 2023), Craig taught a 5-day course on "Evolution as a Developmental Process" to participants from 8 different countries, He also gave a keynote address for the conference on the topic of "Intelligence in Nature — The Challenge of Forming Living Ideas."

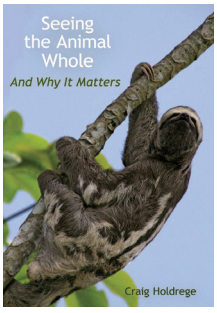
▪ Following up on the success of our drawing course offered last fall, artist Ella Lapointe began teaching a spring session of "**Drawing into Nature**" on April 18. Held at the institute, the class runs Tuesdays from 4:30pm to 6:00pm until June 13 (except on May 23). To counter our tendency to see mainly what we already "know," we use the act of drawing as a means of pouring our attention into the actual concrete appearances of the world.

Other events, as of this writing, planned for spring and summer 2023 include:

▪ A workshop, "**Plant Observation and the Living World,**" facilitated by Craig Holdrege, Henrike Holdrege, and Jon McAlice (April 21–23). We will use the humble plant as a potent teacher to help the human mind become ever more flexible, dynamic, and context-sensitive.

▪ A talk at the institute on April 26 by Jon McAlice will address "**Experience, Imagination & the Nature of Meaning**." The 7pm event is free and open to all.

▪ The weekend of May 6–7, Ryan Shea and Craig Holdrege will present **"Seeing and Language: Creative Reading and Writing as a Way to Experience Meaning in Nature."** In this workshop, we explore the ways in which a creative language practice can amplify and deepen our immediate experiences and foster new capacities of perceiving.



▪ Craig will host a Q&A on June 16 with international students enrolled in an online course called *Goethe and the Language of Holistic Science.* The focus of the session is Craig's most recent book, ***Seeing the Animal Whole — And Why it Matters*** (Lindisfarne Books, 2021).

▪ Participants enrolled in cohort IV of our **Foundation Program in Goethean science** will meet for two weeks at the institute this coming June for the intensive residential phase of the course, culminating in completion of the program, which they began 15 months earlier.

▪ As part of a two-week professional development program from the **Center for Anthroposophy**, Henrike Holdrege and Craig Holdrege will offer the week-long course "Living in Transformations — Geometry and Plant Study" (July 2–7) for educators, parents, and administrators. Participants will take two complementary and mutually illuminating pathways to help attune themselves to dynamic processes in the world.

Staff News

We're pleased to announce that **Ryan Shea** has officially joined our staff as a part-time researcher and educator. Ryan brings eight years experience as a teacher at Providence College, where he gave courses in philosophy of science, environmental philosophy, and nature writing. He completed our Foundation Program in 2022. His interests weave together ancient philosophical biology (especially Aristotle), the scientific revolution, phenomenology, German idealism, and Goethean qualitative science. That is, when he's not busy being a caregiver to his two young children. Welcome Ryan.

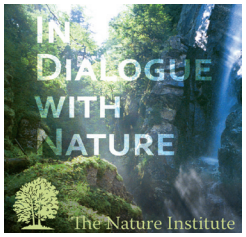
Steve Talbott Transitions to Emeritus Status

Steve Talbott joined the work of The Nature Institute 25 years ago, soon after its founding in 1995. As a writer and editor, Steve was instrumental in bringing our efforts to a broad international audience through *In Context* and through our website. We began publishing *In Context* in 1999, and Steve was its editor for 44 issues; it now reaches people in 63 countries. Our website was launched in 2004 and Steve was the webmaster until 2020. This technical work was always going on in the background as Steve researched, wrote, and participated in many spirited conversations during our weekly research meetings. In the first decade, Steve engaged mainly with topics related to technology. He published 126 issues of *NetFuture: Technology and Human Responsibility* (netfuture.org) between 1998 and 2013. Around 2009, the focus of Steve's work shifted to the study of genetics, epigenetics, and evolution. This culminated in the 25 chapters of his recently completed online book, *Organisms and their Evolution — Agency and Meaning in the Drama of Life* (see the Preface to the book on page 3, or go to bwo.life/bk for the full text). Steve has been immensely productive.

Now, in 2023, he is an emeritus researcher at the institute. This means he is free to pursue — or not! — any topics he wants to. He has no day-to-day obligations except for those he sets for himself. As I know Steve, he will never stop working. And what I mean by "working" is his life pursuit to understand *meaning* in the world more deeply and to wrestle with the riddle of humanity's place in the larger context of life on earth.

We celebrate (quietly; Steve is not big on celebrations) his 25 years of work for The Nature Institute. The institute would not be what it is today without his manifold contributions. We wish him much breathing room, energizing walks, continued dialogue, and the lovely freedom from deadlines that an emeritus researcher can enjoy. CH

Recent Podcast Episodes



You can find our podcast on the institute's website (https://www.natureinstitute.org/podcast/in-dialogue-with-nature) or wherever you access podcasts.

- Our most recent podcast is comprised of two parts. First, we share a recording of Craig Holdrege reading his essay, "**Where Do Organisms End?**" (which first appeared in our third issue of *In Context*). Following this, our podcast host, John Gouldthorpe engages Craig in a conversation about the reading and its intent: to challenge our habitual way of making sense of living beings through their physical characteristics, and instead by way of their relationships.

- In Jon McAlice's talk "**Appreciating Barry Lopez**," recorded at the institute at the end of 2022, we hear about the biography and works of award-winning writer Barry Lopez, whose life was defined by a profound connection to the more-than-human world. Lopez died in 2020, bequeathing a trove of writings that invite us all to understand and enjoy nature as he did — as alive and responsive.

And a NEW VIDEO

Last September, Henrike Holdrege gave a lecture and slideshow at the institute on **"Gestures in the Work of Artist Ernst Barlach**." We've created a video of Henrike's one-of-a-kind presentation that features some of the remarkable work produced by Ernst Barlach (1870–1938), a German sculptor, visual artist, and playwright. You can view the video at natureinstitute.org/videos.

Spring Matching Grant

One of our generous supporters has offered a $5000 matching grant for donations made to The Nature Institute this spring. This allows us to potentially raise as much as $10,000 this season to support our education programs and provide scholarships to our intensive courses. Such grassroots support also shows that our work has a large and dedicated following. You can give to the institute by check or credit card using the envelope inserted in this issue, or give by credit card at our website (natureinstitute.org/friend).

Thank you for your caring support.

From Our Mailbox

Dear Craig,

I wanted to share that I found the workshop immensely fruitful and I'm still recounting the concepts we learned with friends and family. Particularly salient were the illustrations of how human bones change over time, driving home the concept of living bones, and the adaptability/responsiveness of all animal bodies to our environment and behaviors. Also, the activity of placing our own bodies into the shape of a lion's crouch, followed by looking at the bones of the legs of different animals to identify the different placements of toes, heels, and knees. This was very effective.
— Leslie Ruckman

Dear Henrike,

I wanted to let you know how very much I appreciated your inspiring presentation of Barlach's work! I loved it so much. I do wish I could have been there in person, but I am honored and inspired to have seen it in this form. I have watched it over the last 3 days, and it is one of the most inspiring art experiences I have ever had. It is how you wove it together with his pieces and with his writing, speaking of his creation process, like life itself. A great gift; thank you.
— Helen Walker

Publications

- **The Biodynamic Federation/Demeter International** asked Craig to contribute a chapter to a new training manual for biodynamic farmers and agriculturalists. The focus of the manual is on presenting experiential exercises that encourage a more profound and lively experience of the biodynamic curriculum and a deeper connection with nature and its formative forces. (The online manual was not yet complete as of this writing.)

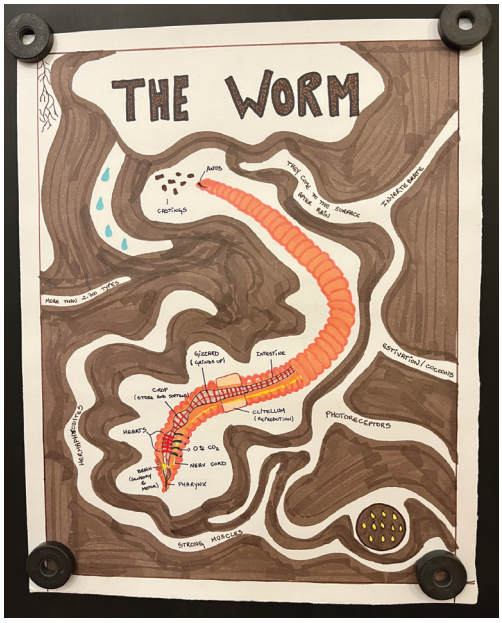
- At the close of 2022, institute senior researcher Steve Talbott published the final online installment of chapters in his book project that aims "*to recapture the drama of life in the place where it actually occurs — in organisms themselves — and to lay bare as clearly as possible the failure of reigning evolutionary theory to explain the special qualities of that drama.*" After more than a decade in development, his 25-chapter book, ***Organisms and their Evolution — Agency and Meaning in the Drama of Life*** is now a highly original resource and thought-provoking publication. You can read individual chapters and download the whole book, free-of-charge, at our adjunct website, *bwo.life/bk*.

A Remarkable Transformation: Urban Composting

Aline Carvalho

Aline Carvalho completed the institute's 15-month Foundation Program in Goethean Science last summer. For her independent project during the course, she chose to experiment with a technique of indoor composting that would work easily and inexpensively for urban dwellers without access to a yard. She presented her successful results — rich, healthy compost produced in simple buckets by a thriving worm population — at the end of the program. Having created this portable system, Aline was able to demonstrate composting in several public schools around Boston and Cambridge, where she lives.

Here is a recap of her presentation.



Observing and learning from nature fascinates me and composting is one of the processes I admire most. It's amazing to see up-close the transformation of organic matter into soil. From my observations and studies, I've come to realize that earthworms may be one of the most important organisms on our planet. They are directly connected to the cycle of organic matter, in addition to assisting in soil oxygenation — all of which is critical to healthy plant life. So before explaining the technical process of composting, I'd like to inspire an appreciation of earthworms with some remarkable facts. Some of these details also explain why there are best practices for managing a compost bin:

- Earthworms breathe through their skin.
- They don't have eyes, but they can feel light and dark.
- They have five hearts.
- They are relatively stronger than a horse; an earth worm can lift 50 times the weight of their own body.
- They can dig more than 16 feet deep.
- They have population control, reproducing according to the amount of food they receive daily.
- They are hermaphrodites.
- They lay eggs.

The most recommended worm for composting is the red wiggler worm. I tried using worms I found in the garden but they died in captivity or escaped, so I bought red wiggler worms from a pet shop. They'd been stored in a refrigerator and appeared whitish to almost ashy; within a week in the compost, however, they changed to a deep red and doubled in size!

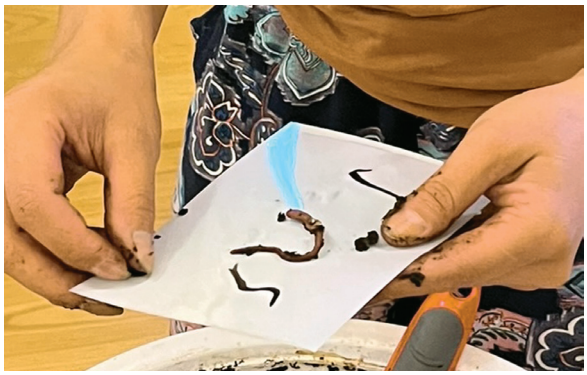
To start my urban composting project, I created a do-it-yourself compost bin that was space-saving and inexpensive. Nowadays it is possible to buy many compost bins online, but I find these are usually costly and large. Instead, I repurposed three five-gallon industrial paint buckets (water-based). Because the natural environment of earthworms is dark, the buckets should be opaque so you can replicate their habitat as much as possible.

My composting system consists of these buckets stacked, with the top and middle buckets having small holes drilled in the bottom to allow for air flow. This is also true for the top lid, where I drilled holes with the smallest drill bit I could find (to prevent worms from escaping). If these tools are not available, it's possible to hammer a heated nail into the plastic to make small holes. (The middle bucket does not have a lid since it is covered instead by the first bucket stacked above it.)

Beginning from the top down, Bucket 1 is where the process starts. This is where you put your worms, some wet organic matter (food scraps) and dry organic matter (leaves, plain cardboard, roll tubes, newspaper, twigs, saw dust). I started with just five worms initially. After several months of composting, my worm population grew to more than a hundred. Every time you add food scraps, it is important to add dry organic matter and then stir. Mixing the dry and wet organic materials will help control water in the process and stirring increases oxygen.

After about three months, I had completely filled Bucket 1 with wet and dry organic matter. At this point, my mixture needed to rest to allow the full decomposition to happen, resulting in soil. So my empty Bucket 2, in the middle, then became the top bucket for food scraps and dry matter, while Bucket 1 moved to the middle of the stack. A handful of worms from the first bucket acts as your "starter" for the next bucket of scraps.

Bucket 3 is reserved for slurry collection — the liquid resulting from organic matter decomposition. While this collection is optional, the benefit of collecting the slurry is that it makes an excellent biofertilizer when diluted with nine parts water. The liquid has no unpleasant odor, unless a worm falls into it and dies. To prevent this from happening, you can put a clay pot upside down in the bucket, which allows a worm to climb onto that pot and avoid drowning in the liquid. (The smaller the holes in the bottom of Bucket 2, the less likely earthworms will fall into Bucket 3.)



Some of the red worms that drive the compost cycle

The time for full decomposition varies depending on the amount of materials added, but I found that usually it takes three months to fill the first bucket, and three months (undisturbed) for organic decomposition, so you'll have the first soil ready for use about six months after starting. You can place the soil and worms directly on the earth or in the garden; if you want to use the soil indoors for planting, filter out the worms by passing the mixture through a screen.

You can locate this composting system anywhere that is protected from rain and direct sunlight. I keep mine in a basement. During the winter, I noticed that earthworms' metabolism slows down, so I had to be more attentive that the humidity and temperature were not too low.

The benefits of composting are not just for gardeners. In addition to being able to observe a remarkable transformation, by composting you also significantly reduce the environmental impact of man-made waste. Approximately 51% of the waste that is generated in US homes could be composted. After starting my compost I reduced the quantity of trash bags (in a house with two people) from one bag of trash a week to one bag of trash every two or three weeks. The results are immediate.

Some Trouble-Shooting Tips

- **Worms escape from the container**
  This is often caused by too much sun, or a toxic element, such as citrus, for example. To remedy, change the location, remove the 'element', and leave the container uncovered for a few hours to observe.
- **Worms on the lid and walls of the buckets**
  Excessive water is usually the cause of worms migrating away from the organic matter. Add sawdust, hay, or straw to reduce the proportion of water.
- **Flies**
  Uncovered food scraps, and excessive water or citrus can attract flies. Add sawdust, hay or straw, remove the citrus if present, and capture the flies using a mixture of ½ cup of apple cider vinegar, 2 tablespoons of sugar, and 2 tablespoons dish soap.
- **Smelly compost**
  A strong odor can be caused by a lack of oxygen, too much water, or the wrong food scraps. To treat it, turn the compost regularly, add dry materials and/or remove the offensive food scraps.

What Scraps Go in the Compost Bin?

You want about 70% of your food scraps to be fresh plant material: fruit and vegetable peels and cores, seeds, coffee grinds, egg shells, tea leaves and bags, grass, fallen leaves, flowers, nuts, bread, cooked food (without any meat, fish, dairy, or hot spice), herbs, onion, and garlic. All these scraps have water in their composition and so are the "wet" matter for your compost.

The remaining 30% could be cardboard, roll tubes, newspapers (not magazines), twigs, saw dust, hay, and straw. These materials have no water and are the "dry" matter in the decomposition process.

Do not add any of these to your compost: Oil, fish, meat and bones, processed foods, animal litter, dairy products, salt, lemon and lime, spices, and diseased plants.

Thank You!

We are privileged to thank all who have made donations or contributed goods or services to The Nature Institute between October 1, 2022 and April 30, 2023.

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Being Hydra

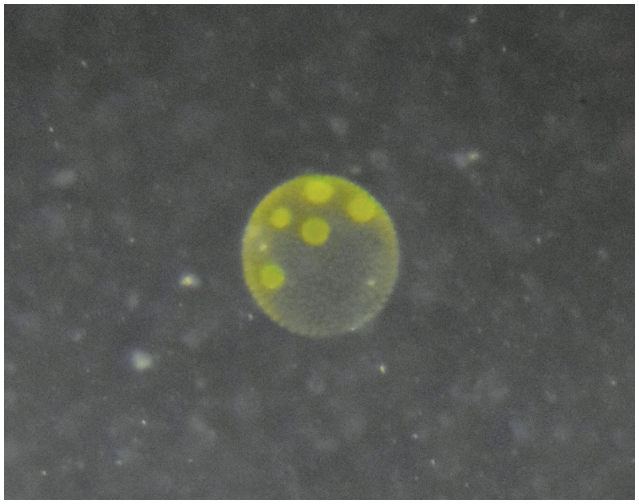
"At the same time plant and animal, and neither animal nor plant"

Jon McAlice

In the late 1600s, when Antoine van Leeuwenhoek first focused his self-made microscope on samples of water taken from the ponds, the rain barrels, and the roadside ditches of his native Delft, he discovered a previously unknown world. This is the world of little things, expressions of life too small to be noticed in the context of how we normally experience the world. When we look into the water flowing through a streambed or filling a pond or wetland, there are things that we can see — the rocks at the bottom, the shape of a fish holding itself stationary in the current, the yellow underside of a box turtle's neck as it disappears into the depths. We can also see the forms of eddies and vortices in the water itself, wave patterns and turbulence. We can see the green of aquatic plants and, at the right time of year, the colors of their blossoms on the surface. Shapes and shifting forms speak to us of movement. We can listen to the burbling of the water. These impressions belong to the macroscopic world of freshwater. We become aware of them as belonging to the world we live in. We can perceive them without the help of instruments.

What van Leeuwenhoek discovered is that within this readily perceptible world is another world: the microscopic world. Since his first descriptions of the "animalcules" living everywhere around us, our understanding of the microscopic world and its significance for the health and well-being of all life, including that of our planet, has grown enormously. Life would not exist on earth without these invisible organisms. Van Leeuwenhoek's discoveries opened a new field for natural scientific research. Water especially showed itself as an environment where life came to expression with a magical blend of simplicity, richness, and immediacy.

The observational boundary between the macroscopic and the microscopic is not a hard boundary. It is fluid. Consider water again. We can dip a glass into the water of a pond and hold it up to the sunlight. There is evidently something in the water. We can see flecks, sometimes small green bodies. If we watch closely, they appear to be moving around. But what are they? How are they shaped? How do they go about their lives? How do they relate to other



(All photographs by Jon McAlice.)

Magnified volvox

aspects of the watery world? These are questions that can only be answered with the help of a microscope. Without its help, we can discover that they are, but not *how* they are.

Two organisms that live on this boundary between the macroscopic and the microscopic have captured the attention and appreciation of researchers continuously since van Leeuwenhoek first mentioned them in his letters to the Royal Society in London at the beginning of the 18th century. Both are what we might term boundary organisms. Volvox is a colonial alga with cellular differentiation; hydra are freshwater polyps (Phylum Cnidaria) with remarkable regenerative capacities. Volvox is considered to be a plant, yet displays a sensory and a vegetative pole, a distinction found in animals. Hydra is an animal, with regenerative capacities once thought only possible in plants. Further complicating the issue is that the most common species of hydra (and the first observed closely), *Hydra veridissima*, is pale green suggesting a plantlike quality.

Both volvox and hydra are found in freshwater ponds and wetlands. I have found both organisms in water samples taken from a wetland lying just north of The Nature Institute. This wetland is fed by a seasonal stream and empties into the Agawamuck Creek which flows through our local Hawthorne Valley. My sampling point is just to the south of a small road that divides the

wetland into two distinct parts. The downstream section is smaller and contains a beaver dam, upstream of the road the wetland stretches back into a wooded valley. The larger upstream section is about 30 acres. I sample on the downstream side, just below and off to the side of a culvert connecting the two sections. The flow of water through the culvert has been relatively stable throughout the fall and winter. Once the stream passes through the culvert and enters the body of standing water it forms a gentle eddy curling back on itself upstream. It is a point where the water is constantly being refreshed, yet which remains relatively still. A small clump of brown, broken stalks of last season's phragmites stands along the downstream edge of the eddy. This is where I take samples.

I began sampling in early November, a time of year in which volvox are believed to be absent. Yet in samples taken regularly through December and January at water temperatures as low as 4°C**,** volvox have been present, as have hydra. They appear in all stages of development giving no indication that they go into a state of dormancy in the winter months. I have regularly brought water samples directly from the wetland and examined them under the microscope before they have warmed. I find myself constantly surprised by how much activity is taking place in the cold water. It is alive with tiny creatures merrily living.

In what follows, I will focus on one of these two organisms, the hydra.

Although van Leeuwenhoek mentioned hydras in 1702, the Swiss naturalist Abraham Trembley was the first to describe them in detail. Trembley discovered them in 1740 when he was working as a tutor to the two young sons of a Dutch nobleman, Count William Bentinck. His interest in natural history led him to sampling the water in the ponds and ditches around the Count's estates. He and the boys gathered samples and placed them in glass jars on shelves in one of the estate's greenhouses. He writes about his first glimpse of a hydra in his *Memoirs on the Natural History of a Type of Fresh Water Polyp with Arms Shaped Like Horns*:[1]

> Having noticed various small animals on the plants that I had taken from a ditch, I put some of these plants into a large jar filled with water, placed it on the sill of a window, and then set about examining the creatures it contained. Soon I discovered a great many of them, all quite common indeed, but most of them unfamiliar to me. The novel spectacle presented me by these little animals excited my curiosity. As I scanned this jar teeming with creatures, I noticed a polyp[2] fastened to the stem of an aquatic plant. At first I paid it little heed, for I was following the livelier little creatures which naturally attracted my attention more than an immobile object. The casual observer, especially one completely unfamiliar with such physically similar animals as marine polyps, could scarcely avoid taking the freshwater polyp for a plant. I have said that the polyp I had noticed was motionless. The point is not that it was unable to move, but at that time I knew nothing about whether it could move or not. (Trembley, p. 5)

Hydra with radial tentacles

Trembley first thought the hydra to be parasitic plants. Their shape, their coloring, and their lack of motion appeared plantlike. At first glance, a casual observer would have little trouble agreeing with Trembley's assessment. *Hydra veridissima*, the green hydra that Trembley first observed, appears as a pale, lovely green stalk stretching out into the surrounding water topped by threadlike tentacles that may exceed the length of the stalk quite markedly. Its greenness extends out into the tentacles, although these become increasingly translucent the thinner they become. When I observe more closely and over time, however, it begins to show me other facets of how it is in the world. The movement of the tentacles first appears to be brought about by ambient motion in the surrounding water. Yet they do not all drift in the same direction but reach out radially, at times perpendicular to the stalk. Each tentacle can move individually. Truly surprising is that when the hydra is disturbed, it immediately contracts; the tentacles all but disappear, the stalk becomes a small green blob close to the surface to which it is attached. I have observed this often yet at times not been able to determine exactly what brought it about. What does the hydra perceive in its surroundings that calls forth this sudden response?

It was events such as these that first captured Trembley's attention. He noticed that the tentacles appeared to move on their own and then he saw the hydra contract.

> One day I jogged ever so slightly the vessel holding the polyps in order to see how the ensuing movement of the water would affect their arms. I was completely unprepared for the result. I expected to see their arms and even their bodies merely shaken and dragged along with the motion of the water. Instead, I saw the polyps contract so suddenly and forcefully that their bodies looked like mere particles of green matter and their arms disappeared from sight altogether. I was caught by surprise. (Trembley, p. 6)

And he continues: "This surprise served to excite my curiosity and make me doubly attentive." He began to question whether he had been too quick in judging them to be plants. What he observed "roused sharply in [his] mind the image of an animal" (Trembley, p.,6).

Trembley now found himself in a state of what we might call today *productive discomfort*. Was hydra a plant or was it an animal? He became increasingly attentive. He noticed that the hydra in one glass appeared to congregate on the side of the glass receiving the most light. What he did next changed the course of scientific inquiry. He reached out and turned the glass halfway round. Would the hydra move back into the light?

> The day after turning the jar I found the poorly lit side on which I had left many polyps was almost devoid of them. The polyps were on their way to the best-lit side … After seeing the same thing a number of times, I became convinced that the polyps had a distinct propensity for the best-lit area of the jar. I did not venture to decide whether this propensity was directly related to the light or whether some other factor attracted them to the best-lit side. (Trembley, p. 7)

The modest simplicity of this last statement belies its significance. From the very beginning Trembley's experimental interactions with living hydras arose from questions that awakened in him as he observed them. He did not conduct experiments to prove or disprove theories. In fact, he explicitly warned against jumping to conclusions based on insufficient observation:

> When facts are lacking in such research, it is more appropriate to suspend judgment rather than to make decisions which almost always are based on the presumption that Nature is as limited as the faculties of those who study her. (Trembley, pp. 69 –70)

The only way to truly know the hydra was to know the hydra fully in all the expressions of its specific way of being. Trembley proceeded carefully.

His discovery of the movement of hydra toward the well-lit side of a jar was followed by the observation that the number of tentacles differed from hydra to hydra and that the length of the tentacles differed on a single hydra. Despite his growing inner certainty that a hydra was an animal, these observations caused him once more to wonder. What could decide the question one way or the other? At the time it was widely accepted that plants had regenerative capacities not to be found in animals.

Hydra budding

> At this point I speculated anew that perhaps these organisms were plants, and fortunately I did not reject this idea. I say fortunately because, although it was the less natural idea, it made me think of cutting up polyps. I conjectured that if a polyp were cut in two and if each of the severed parts lived and became a complete polyp, it would be clear that these organisms were plants. Since I was much more inclined to think of them as animals, however, I did not set much store by this experiment; I expected to see the cleaved polyps die. (Trembley, pp. 7–8)

They didn't. Over the course of the next ten days each of the two parts grew back the part that was missing: the original "foot" grew a new "head"; the original "head" a new "foot." The results of this experiment did not, however, lead Trembley to conclude that hydras were plants. He realized that what he was observing was an organism expressing the

characteristics of an animal with regenerative capacities found among plants. At one point in his *Memoirs* he refers to them as plant-animals.

I have never felt inclined to repeat Trembley's sectioning experiments. Others have, however. When word first began to circulate in the scientific communities of Paris and London of Trembley's discovery, sectioning hydras became quite the rage. They were sectioned and observed in laboratories, drawing rooms and the literary salons of Paris. Trembley's polyps took the continent by storm. This was in part due to his generosity. Once having observed the regenerative capacity of the polyps he reached out and shared his observations with other naturalists. And not only his observations. He devised special containers that would allow him to also share his polyps, sending them on horseback, by coach, and by boat to various acquaintances in Europe and England. Trembley's generosity was so unself-serving that others ended up publishing his experiments before he could. But that didn't matter. Alexander Trembley's name became inseparable from the tiny creature that, no matter how you cut it, would grow again and be whole.

Hydras have a relatively simple bodily organization. It consists of a long tube with a foot and a head. The head is comprised of a dome-like swelling at the center of which is the mouth, and a ring of tentacles. The body consists of two layers of epithelial cells — the ectoderm and the endoderm. They are separated from one another by an extra-cellular matrix. A network of nerve cells extends through the ectoderm. The inner layer forms a digestive cavity that extends from the mouth to the foot or basal disk. The mouth is the only opening. On the outer surface of the tentacles, and to some extent the body of the hydra, are cnidocytes or nematocytes. These are stinging cells. Four different types are found in most hydra, the largest of which contains a spine that is ejected with enough force to pierce the shell of a small crustacean and a thread that injects toxins powerful enough to paralyze it.

Both the layers of cells in the body column as well as a third population of cells, termed interstitial cells (since they are located in spaces between the epithelial cells) are actively dividing stem cells. They retain this embryonic characteristic throughout the life of the organism (Martinez 2012, pp. 479-487). The stem cells are undifferentiated, multipotent cells. Depending on their origin, they give rise to the differentiated cells of various parts of the hydra's body. Ectodermal and endodermal stem cells give rise to the differentiated cells of the tentacles, the basal disc and their interiors. The interstitial cells differentiate into nerve cells, stinging cells, secretory cells and gametes. Hydras thus do not have clearly distinct somatic and germ cells. New cells are constantly being formed in the center of the organism's body then moving outward towards the more differentiated distal ends. The differentiated cells are sloughed off and constantly replaced. The entire hydra, with exception of the tentacles and the basal disk, is in the ongoing process of becoming hydra. Its body is a veritable fountain of new life.

Most animal organisms have life cycles that include clear stages of birth, growth, development, maturation, reproduction, aging, and death. Hydras go about things somewhat differently. Although sexual reproduction is possible under certain conditions, hydras usually reproduce by budding. (The following is based on observations of *Hydra veridissima*.) A bud will appear on the side of the hydra's body between 1/3 and 1/2 of the way up. It begins as a small bump that in relatively short time grows out into something resembling the tip of a new shoot. The tip swells and begins to dome out. The base of the dome begins to show signs of a radial starlike differentiation. I have observed between five and eight such growth points appearing. Others have reported more. These growth points begin to extend as the tentacles are formed. At this point the digestive tract of the bud is still connected with that of the parent. This connection remains intact until after the budding hydra begins to capture its own prey. Once the digestive tracts separate, it is a short time until the newly formed hydra lets go of the parent, which, depending on the conditions, may already have brought forth one or two new buds. Even the term "bring forth" does not seem to appropriately describe the budding process. Bringing forth has a connotation of intent: Hydra bring forth. This is not the impression one gains when observing the process. The budding appears to be but one aspect of a hydra's continuous process of becoming. I have observed a bud forming on a young hydra only 48 hours after it had separated.

Thus birth, growth, development, maturation, and reproduction come to expression in hydra not as distinct stages in a life cycle but rather as a continuously flowing stream of generation, differentiation, and activity. Hydra becoming hydra. What about aging and death?

In 1998, Daniel Martinez, a hydra researcher at Pomona College in California, published the results of his four-year observation of three cohorts of hydra living in a lab environment (Martinez 1998 pp. 217–225). Very few hydras died over the course of this study and, when he published his results, the cohorts were still going strong. His paper gave new weight to the notion, first voiced at the beginning of the 20th century, that a hydra is immortal in the sense that although individual cells are lost and replaced, the organism as a whole shows no signs of senescence or aging. Hydras retain throughout their lives the vitality and generative capacities usually found in embryonic development and young organisms. They remain forever

young. Death may come from without through adverse environmental conditions or predators but it is not part of hydra's life-cycle in the way we usually think of it. Hydras live and go on living.

None of this is immediately apparent when we observe a hydra through a magnifying glass or under a microscope. What appears is a fragile, flexible organism whose way of being is as flowing and omni-directional as its surroundings. The terms "foot" and "head" are to some extent misnomers, since they call to mind notions of up and down. There is no up nor down in the world of the hydra. One end of the hydra holds fast. The other extends out into its environment. It is not uncommon to find a hydra "holding fast" to the underside of the water surface with the body and tentacles extending out below. The tentacles can extend so far that they become almost invisible in the surrounding water. Yet even the distinction between holding on and extending out is not absolute. When moving from one location to another in still water, hydras travel by means of slow somersaults. The foot and the tentacles each take on the function of holding on, one after the other. I have also watched a hydra lie down among the debris at the bottom of water and raise its foot up while extending its tentacles out among the weeds, holding on with its body.

Trembley opened his *Memoirs* with the remark that "[t]he little creature whose natural history I am about to present has revealed facts to me which are so unusual and so contrary to the ideas generally held on the nature of animals" (Trembley, p. 1). The more time one spends with these "little creatures" the more apt this remark appears. There is an uncommon fluidity in being a hydra. The simple tubular body structure with the radial symmetry of the mouth and tentacles can appear in one moment to be compact and globular then grow to be an oval body with short tentacles. A moment later it appears to be little more than a thin, flexible stalk with fine filaments reaching out into the water around it. If a tiny shrimp brushes up against one of the tentacles the stinging cells incapacitate it, and it is drawn back into the mouth and slowly digested as it is moved down towards the foot. As one watches, the form constantly shifts. At the cellular level, the constant generation of young cells gives rise to an ongoing regeneration of the organism's entire body. It is a bit like watching the shape of an eddy in a flowing stream. As long as the flow continues, the eddy is visible.

Abraham Trembley's scientific work was shaped by his research with hydra. He too was fascinated and somewhat mystified by this "little creature" and what it had to tell us about the natural world. Thoughts on the doing of science appear throughout the four volumes of his study of hydra. At the end, he returned once more to the problem of attempting to classify organisms based on general rules.

> [I]f one were to cling scrupulously to the quite generally accepted ideas on the nature of plants and animals, it would follow that a polyp, in view of its various properties, is at the same time plant and animal, and neither animal nor plant. (Trembley, p. 1&2)

Trembley embodied an approach to understanding nature that rests on the premise that what the natural world has to teach us goes far beyond the ideational frameworks we construct to explain it. Each organism has something to teach us about the whole of which they — and we — are a part. In Trembley's words:

> Nature must be explained by Nature and not by our own views. These are too limited to envision so grand a Design in all its immensity. The beauty of Nature certainly shines forth all the more when what we know about it is not mixed with our fancies. Seen clearly, Nature inspires ideas within us more worthy of the infinite wisdom of its Author and thereby more suitable for shaping our spirits and our hearts. This thought is what we should keep before us in all our researches. (Trembley, pp. 187–188)

Notes

1. The quotes from Abraham Trembley's Memoirs are taken from Sylvia and Howard Lehnhoff's translation, which was published in 1986 following over 30 years of research. It is the first complete translation of Trembley's Memoirs in English.

2. When Trembley first began to observe hydras he called them simply "little creatures." After repeating Trembley's experiments, the French naturalist Rene Reaumur named them polyps. Trembley mentions the term "*Hydre*" in his Memoirs referring to the many-headed creature he created through grafting experiments. It called to mind the mythical Greek Hydra. Linnaeus gave it the scientific genus name *Hydra* in 1758.

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Generative Knowing in Education
An Example

Craig Holdrege

In December 2022, Henrike Holdrege and I taught the first two-week module of our course, "Seeing Nature Whole — A Goethean Approach," in Florianopolis, Brazil. (The second two-week module will occur in December 2023.) There were 18 participants, whose professions included education, farming, art, therapy, engineering, veterinary medicine, nutrition science, and organizational consulting. This diverse group of individuals brought enthusiasm and sincere interest to the work. What follows is not so much a course report as an attempt to show a way of working. For that reason, I am writing the narrative in the present tense.

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Each day we engage in three different kinds of activities: projective geometry, clay modeling, and plant study. At the outset it is not at all clear to participants how these activities relate to each other. Even though at the beginning of the course we say that we are not going to apply geometry to plants, there tends to be an underlying assumption that we will do just that. Why else would we offer geometry in a course? People know that scientists apply mathematics to model or explain natural phenomena. But that is not our intent in the course. We ask participants to be patient and to engage, and we hope they will see how the different activities enhance one another.

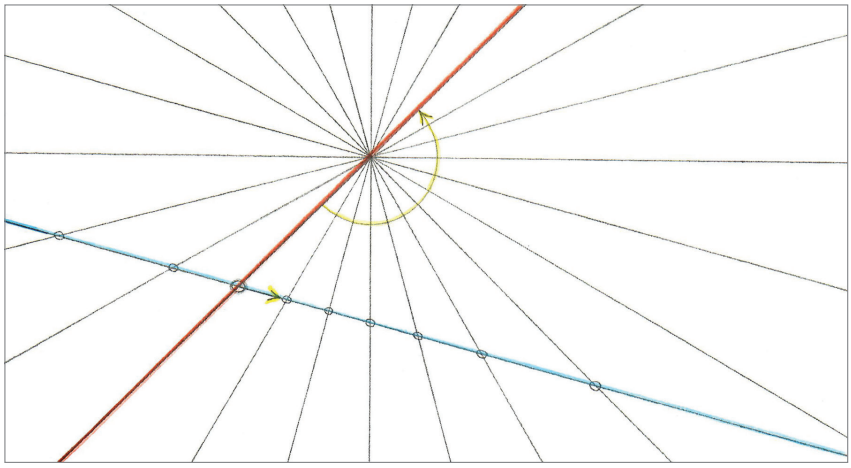
In all these areas — and at the heart of our efforts — we want to work experientially: We pay close attention to what we perceive, to the process of getting to know something, to how insights arise, and to the quality of questions and insights. We actively and consciously delve into a field of phenomena, consider them from a variety of perspectives, and attend to the relations and connections that show themselves.

The work in projective geometry lies at one pole of human experience — the experience of concentrated thinking and of ideas that challenge our normal habits of thought. In a way we are asking participants to practice a kind of mental gymnastics that is disciplined, brings thinking into movement, and asks of them to move into unfamiliar territory that opens up new possibilities of conception.

At the other pole, we immerse ourselves in the vibrant and diverse plant life, which we study in the courtyard of the conference center where the course is held and also in the nearby Restinga habitat. This is a shrubby woodland that stretches along the dunes close to the coast in this part of Brazil. We meet in perception a plethora of forms, colors, textures, and scents. The plant world reveals countless wonders. We encounter the riddles of life, growth, development, and death that plants present us with.

A third activity is clay modelling. Starting with clumps or small pieces of clay, we make geometrical forms; we sculpt forms with only planar, convex, or concave surfaces; we shape clay figures in which the different kinds of surfaces come to appearance; we create a series of forms that reflect a transformation. In these activities we are quietly present as embodied beings giving shape to material substance.

I can only hint at how these different activities support and illuminate each other during two weeks of concentrated collaborative effort. In projective geometry, we take a number of different thought paths. These are anchored through drawings that each person does and through exact picturing of geometric forms. The work leads to the central idea of the infinitely distant. This is at first a disturbing notion. Why? Because it necessitates that we leave behind concrete mental pictures. It is easy to comprehend that two lines have a crossing point, even if we have to imagine that crossing to be very far away. What about two parallel lines? In Euclidean geometry they are an exception to the rule and have no point in common. It was one of the key conceptual breakthroughs in projective geometry to conceive, for example, that parallel lines have a point in common in the infinite. (See the box, on the next page, for one entryway into conceiving of a common point at infinity.)



We draw the orange line and then the blue line with which it intersects. In our imagination, we rotate the orange line in a continuous movement counterclockwise by 180 degrees (yellow arc). It does not challenge our imagination to picture this continuous movement of the line rotating in a point.

Now consider the intersection of the rotating orange line with the blue line. The point of intersection moves to the right and returns from the left to the starting point! For finite picturing, there is a gap. When the intersection moves out to the right, there comes a moment at which the rotating orange line and the blue line are parallel. Here we cannot picture an intersection.

At the next moment, the intersection returns from the left, and we can comfortably picture again. For projective geometry, every line is a whole and has one point at infinity. (See Henrike Holdrege (2019) for a variety of pathways that together lead to an understanding of the infinitely distant.)

Instead of saying that parallel lines are an exception, projective geometry challenges us to conceive of a point we cannot picture. It says, "two parallel lines have a point at infinity in common." For projective geometry, the points move continuously in one direction along the line through the infinite and return from the other back again. This too is a continuous movement.

The infinite in this conception is not an "ever-farther-and-farther-out-there" that you never reach. (This common view of "infinite" the philosopher Hegel called the "bad infinite.") The infinite that projective geometry helps us to conceive of brings continuity to the whole of the line, plane, and to space when dealing with three dimensions. The wholeness in projective geometry is gained by including the infinite, that special and enigmatic "place" that we cannot picture. The understanding of it grows during many hours of work by considering a variety of geometrical phenomena, all of which first show their coherence when the infinitely distant is taken into account.

This new view has significant implications. First, wholeness includes a remarkable feature (the infinitely distant) that is not picturable but that is conceivable in clear rigorous thought. For example, in our typical (Euclidean) understanding, a triangle is a circumscribed figure that I can consider in isolation. There is the figure and the surrounding emptiness of the plane. In projective geometry we learn to consider the triangle as a three-sided figure (a trilateral) formed by three lines that extend through the infinite. In this way the trilateral configures the whole of the plane. The finite trilateral is one section of the plane and the sur-

rounding sections change when the shape of the trilateral changes. More generally, any figure in the plane, or body in three-dimensional space, is not isolated. It is related to the whole of the plane or of space. There is no such thing as an isolated thing.

While we are doing this work in geometry, at other times of the day we are modeling in clay and observing plants. We mold a clump of clay into a sphere and afterwards build up a sphere out of little pieces of clay. We add more little pieces and make the sphere into a cube. On another day we sculpt a tetrahedron. Before doing this work, we picture circles, spheres, cubes, and tetrahedrons in our imagination. We let them grow and shrink. We relate them to each other, for example, a sphere inside a cube such that the sides of the cube are tangent planes of the sphere.

When forming these bodies in clay, we have an idea that is at work in the movement of our hands. We can notice when the bodies come close to being right, and we notice imperfections. We notice them because the inner guide — the intuitive knowing of sphere, cube, and octahedron — informs our looking. Our seeing involves not only our eyes; we are seeing the outer bodies through our inner knowing. All this points to the very inner nature of geometrical forms, and at the same time to the wonder that we can give body to these forms through our own bodies.

We meet plants in the sense world. One focus can be attending to leaves — their shapes, colors, sizes, and textures. We encounter a remarkable variety of leaves—also within one plant. We look closely at them and picture their characteristics in our imaginations. In this inner re-creating, we conjure forth and move through the characteristics perceived and we present them vividly to our mind's eye. Such image-forming engages both will (the power of doing) and feeling (receptivity to qualities). I could also say the activity of inner picturing is one in which memory, thinking, willing, and feeling are all at work.

After we take in some of the great variety that the plant world offers us, we ask: What is a leaf? In a given plant species we may discern a certain pattern in the way the leaves are shaped. We might say: the leaves of a given species are usually between three and six inches long, generally planar with a longer or shorter stalk, and have an overall lancelet shape, often with pointed lobes and toothed margins. This is an abstract way of formulating what the leaves have in common (what Henri Bortoft calls "the least common denominator"). What it misses is that the specific leaf shapes are not exactly predetermined and that no leaf is exactly like another. The leaves come into being. The plant creates manifold leaves and there is no end to the possible shapes. We need to move from the idea of pattern to that of living formative tendency if we want to approach the reality of leaves. We approach the capacity of the plant to bring forth a multitude of forms and that capacity itself is no specific thing. We approach the generative life that is at work in every leaf, as we approach the infinitely distant in geometry.

In working with clay, we ourselves are giving form to a malleable substance. After starting with geometrical forms, we move into the realm of convex and concave surfaces, and the many ways they can come into relation to each other. Our goal is not to imitate plant forms; we want to give expression to the formative elements of surfaces, edges

that arise between surfaces, and bodies that have different kinds of surfaces. In creating these we are agents shaping with those elements of form. Participants notice how the work in clay helps them in plant study to become receptive to the undulating form of a leaf, the full form of a swelling bud, or the unfolding of a flower. The forms become expressions of activity rather than static appearances viewed from without.

Another activity that helps us to approach the nature of formative potency entails observing and considering plants with the guiding question: Where and how do I perceive growth and decay in plants? Or to phrase it a bit differently: Where and how do I perceive coming into appearance and fading away, wilting and dying? We spend time looking at plants from this point of view. We perceive, for example, rounded forms (buds) at the center of a rosette of leaves; we see flowers that are only partially unfolded. The not-yet-fully-developed parts are tender in consistency, and of a different coloration than developed parts. We see drooping leaves and flowers, and ones that in their crinkled, dry, and skeletal form are scarcely visible remnants of living leaves and flowers. We participate in the different appearances of the plant, and consider them in relation to one another, both in the present and over time.

When we do this, growing, transforming, unfolding, and decaying reveal themselves to us as activities of the plant that we apprehend in momentary snapshots. We don't perceive growth as a sensory process happening continuously before our eyes. The moments are expressions of the plant as ongoing, unseen activity. The generative life itself never becomes visible in a thing-like way. Or I could also say: It is always potentially perceivable and becomes perceivable if we have the ability to see the momentary manifesting activity. This generative power is at work in all that comes to appearance and becomes visible to the mind's eye in the process of engaging with leaves, flowers, stems, and roots.

We enter in this way the realm that Goethe was pointing to with his idea of the archetypal plant ("Urpflanze"). Toward the end of his life Goethe looks back at what he considered to be the *discovery* of the archetypal plant. He speaks of "catching sight of it," of beholding in a "sensuous form" the "supersensible plant archetype" (Goethe 1989, p. 169). The archetype is not some abstract scheme; it is not an invention. It is the plant as generative activity that we can begin to glimpse when, to paraphrase Goethe, our perceiving becomes a thinking and our thinking a seeing (Goethe 1995, p. 39). Thinking here is not a mode of distanced consideration. It is a willful and receptive activity of being-with the phenomena.

Imagine that we are engaging with the plant in this way, and beforehand in the mornings doing the work in projective geometry I described above. The course participants are experiencing both in geometry and plant study that we approach thresholds in understanding. We are moving from what is concretely picturable to qualities that are not visible, yet clearly at work in the phenomena we are considering. This is exhilarating and challenging. By working in the two polar directions of intense sensory immersion and concentrated inner weaving of thoughts, we are stretching our capacities. In both directions the concrete picturable leads into glimpses of non-pictorial qualities — generative life in the plant and the infinitely distant in geometry. There is a delicate intimation that the two realms are related.

I mentioned above that when we take into account the infinitely distant in projective geometry, we no longer think of figures in the plane or space in the same way. Each figure is part of the configuration of the whole of plane or space, including the infinitely distant. In our picture of the world as one of tangible things, we have no trouble discerning boundaries between things — this chair is separate from that cup and from that person sitting on the chair. We are habituated to apprehending things as separate from each other, and then we may seek to understand how they may be connected. Projective geometry gives us one way of conceiving connectedness as fundamental — what we previously thought of in terms of separation, we discern as distinctions and differentiations within an integrated whole.

Plants lead us beyond "separateness thinking" in another way. One starting point is to consider that the plant does not create its body out of nothing. It needs what we typically call the environment. It needs light,

warmth, air, water, and minerals to create and maintain the substances of its body. We often say that the plant develops out of a seed. This is true. But it is also true to say: The environment becomes the plant through the seed. We need to hold these two thoughts together to approach the reality of the plant. The plant as a separate thing is an artifact of separateness thinking. There is a plant-generating potency dormant "in" the seed and there is a plant-generating potency in the environment. When these become active, plants develop. Each plant is a particular realization of potency in the world, one focused point-like in the seed, the other a peripheral world of possibilities that we call environment.

In one way this plant-environment reality is easy to see and comprehend: A seed may germinate only after it has gone through a period of cold in the winter. The leaves of a plant growing in the shade will be different from those of one growing in full sunlight. The way roots develop are highly dependent on the character of the soil, but also on the above-ground conditions. The size of a plant and the degree to which it forms fewer or more leaves, roots, branches, flowers, fruits, and seeds are dependent on the environment in which it is growing. We can also say: In the way it grows, the plant expresses qualities of that elemental environment.

A riddle arises when we consider further. The specific form tendency of leaves in a species or genus — the differences between ash, maple, oak, or birch leaves — cannot be fully understood by considering the relation to sunlight, precipitation or some other "environmental factor." This is also the case with the distinct formative tendencies of flowers in different plant genera and families. No doubt one finds, for example, many fascinating confluences of flower form and insect pollinators that show the connectedness of these two realms of life. But it remains a riddle that a flower type has three, four, five, six, or eight petals. In what we consider to be one environment there are manifold types of plants — different formative tendencies. The way they express themselves is dependent on the potentials within the specific ecological environment (in which other plants are also involved). But what about the formative tendencies as such? What about the manifold ways of being a plant? Out of what formative environment, out of what generative world are they comprehensible?

Such questions don't lend themselves to clear-cut answers; and if you attempt to give one, you notice that something dies. In a sense these questions are an expression of our having touched deeper and larger riddles of life. They are aspects of generative knowing — an enlivening opening, an awakening into the not-yet-known that also gives us a sense of the immense creativity at work in the world. It was the experience of these openings and riddles that, I think, led a couple of the participants at the end of this particular course to remark: "How could you possibly do plant study without also studying projective geometry?"

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"When facts are lacking in such research, it is more appropriate to suspend judgment rather than to make decisions which almost always are based on the presumption that Nature is as limited as the faculties of those who study her." — Abraham Trembley, 1710–1784