



# In Context

Number 37 Spring 2017

The Newsletter of The Nature Institute

---

Letter to Our Readers 2

## NOTES AND REVIEWS

Children and Nature / *George K. Russell* 3

## NEWS FROM THE INSTITUTE

2017 Farmers Course 8

Our New Fellowship Program 9

Mathematics Alive! 10

Out and About 10

A New Colleague 11

New Online Resources 11

New Publications 12

A Challenge Grant 12

Thank You! 13

## FEATURE ARTICLES

What Is Life? / *Stephen L. Talbott* 14

Why Does a Zebra Have Stripes? / *Craig Holdrege* 17

#37



## The Nature Institute

### STAFF

Linda Bolluyt  
Colleen Cordes  
Bruno Follador  
Craig Holdrege  
Henrike Holdrege  
Seth Jordan  
Veronica Madey  
Stephen L. Talbott

### ADJUNCT RESEARCHERS/FACULTY

Jon McAlice  
Marisha Plotnik  
Vladislav Rozentuller  
Nathaniel Williams  
Johannes Wirz

### BOARD OF DIRECTORS

John Barnes  
Siral Crane  
Douglas Feick  
Craig Holdrege  
Henrike Holdrege  
Marisha Plotnik  
Jan Kees Saltet  
Signe Schaefer  
Jeffrey Sexton  
Douglas Sloan  
Nathaniel Williams

### BOARD OF ADVISORS

Will Brinton  
Gertrude Reif Hughes  
Wes Jackson  
Andrew Kimbrell  
Fred Kirschenmann  
Johannes Kühl  
George Russell  
Langdon Winner  
Arthur Zajonc

### *In Context*

Copyright 2017 The Nature Institute.

EDITOR: Stephen L. Talbott

LAYOUT: Mary Giddens

Copies of *In Context* are free while the supply lasts. All issues are posted on the Institute website. Our *NetFuture* newsletter is available at: <http://netfuture.org>.

The Nature Institute  
20 May Hill Road  
Ghent, New York 12075  
Tel.: 518-672-0116  
Fax: 518-672-4270  
Email: [info@natureinstitute.org](mailto:info@natureinstitute.org)  
Web: <http://natureinstitute.org>

The Nature Institute, Inc., is a non-profit organization recognized as tax-exempt by the IRS under section 501(c)(3).

Dear Friends,

Ours has been called an “age of abstraction.” We learn, early in our education, to *ab-stract* (“pull out”) from every rich, phenomenal context particular parts or aspects—especially those parts or aspects that lend themselves to mathematical treatment. The almost inevitable temptation is then to allow our abstractions to stand in the place of the original phenomena, which then may be easily forgotten. And so, atoms and molecules substitute for mountains and rainbows, wavelengths substitute for color, and genes substitute for organisms. It is not surprising that distorted understandings and policies result when we ignore a many-sided reality in favor of one-dimensional abstractions serving the purposes of mathematical theory and technological manipulation.

In this issue of *In Context*, we present three articles that deal in one way or another with the limitations of abstraction and how to overcome them. To begin with, George Russell asks how we can restore to children an essential and healthy relation to the natural world—this at a time when, for many children, their primary exposure to nature is mediated by that most severe tool of abstraction, the electronic screen. As a veteran of forty-eight years of biology teaching at the university level, George has watched as the students passing through his classroom have brought with them the effects of ever-increasing screen time—and ever less awareness of the simplest features of the natural world. The experience has prompted him to think long and hard about how to reintroduce children and young people to nature in our own time. Here he shares some of the fruits of that thinking with us.

A primary invitation to abstraction in biology lies in the strong compulsion to ask of every feature of every organism, “What is its survival value?” The assumption is that if only we can identify the “survival strategy” represented by the feature, we have adequately explained it. Any further understanding—for example, seeing the feature as an expression of the distinctive way of being of a particular kind of organism—is not something biologists are trained to seek. In this issue Craig looks at the puzzle of the zebra’s stripes, and finds that the search for a survival strategy is not particularly straightforward. And perhaps, in any case, the more important place to start is with the pleasure of acquainting ourselves in the fullest possible way with the phenomena immediately before us. We may find that these speak to us in their own right.

Finally, in “What Is Life—Let’s Take Living Things on Their Own Terms!”, Steve looks at the frequent and hotly debated question whether all biology can be understood as ultimately “nothing but” physics. The question, he thinks, is strangely formulated. It might be more promising to ask whether we can ultimately understand physics only with the help of biology. Through our intimate connection with our own bodies and their expressive potentials, we have an “insider’s knowledge” of material phenomena that we can scarcely hope for in relation to an “inanimate” world that is more mystery to us than anything else.

We hope that this issue of *In Context* will inspire every reader to take a further step past abstraction and into a rewarding engagement with the natural world that is our home.

Craig Holdrege

Steve Talbott

## Children and Nature

GEORGE K. RUSSELL



*The fact that children are spending less and less time in nature – and some not at all – is not only a tragedy for individual children, but for the future of our species. For this contact is so important for psychological and spiritual development. When I think of my childhood I remember spring bulbs pushing up pale shoots through the dead leaves, spiders in the garden carrying tiny babies on their backs, the scent of violets and honeysuckle, and the sound of the wind rustling the leaves as I perched for hours in the branches of my beech tree. It was that magic of childhood that shaped the passion that drives me to spend my life fighting to save and protect the last wild places on the planet.*

– Jane Goodall, Ph.D., D.B.E., U.N. Messenger of Peace

IN MY MANY YEARS OF TEACHING, I regularly met young people whose chief interest was the study of cellular and molecular processes, but who had little acquaintance with living nature and little or no inclination to study the life sciences in a more holistic manner. There were always exceptions, and our departmental course offerings in ecology, vertebrate zoology, and animal behavior regularly attracted students with interests in field-based studies and the biology of whole organisms. And I was always heartened to find an occasional student who had spent many years of childhood outside in nature or one who had once tended vegetable gardens and hatched butterflies. But my long experience with students concentrating in biology, as well as a wide variety of non-majors, was that many if not most had little meaningful experience of the natural world. I am

seriously troubled by what I have come to see as a deep gulf between the interests and inclinations of so many young people and the living world.

A Kaiser Foundation (2010) survey found that the average American school child (ages eight to eighteen) spends almost eight hours on a screen (hand-held, TV, video, etc.) every day. Today's statistics are surely higher. And more recent studies, although anecdotal, suggest that many young people cannot identify or characterize even a few common wild flowers, song birds or local mammals. Given these findings, it is no surprise that young people have little time for quiet immersion in a natural setting, no time to play in nature, no time to experience the ocean tides or the vicissitudes of the weather or the comings and goings of wild animals. One study goes so far as to state that many youngsters

spend as little as seven minutes each day attending to even the simplest of natural phenomena. I have known students who spend virtually no time at all in such activity and appear to be largely estranged from nature.

Direct personal encounter with nature, and the associated feelings of wonder and delight, form the basic ethos for protection of the natural environment. We will honor and protect what we have come to love and admire, and such feelings have their source in personal experience. But what of those for whom there is little or no connection with nature? Can we expect them to participate with enthusiasm in the search for solutions to the vast array of environmental challenges facing us? And are we losing sight of the notion that each person has the possibility of finding in the many wonders of nature an opportunity for self-renewal and inspiration?

My aim is to awaken in readers the wish to assist others, young and not so young, by showing them what lies outside their front door or in a nearby park or woodland. I hope that true nature experience will begin to replace what can be seen as an increasingly addictive dependency on text messages, emails, videos, and a torrent of unreal, virtual images. A great deal depends upon whether we can wean young people from their devices and begin to address the widespread malaise of indifference to nature.

We can implore young students to act ethically with respect to nature, but those who are indifferent to nature or lack compassion and a sense of caring cannot and will not do so. Current facts about toxic substances in air and water, about the loss of habitat for endangered species, and about global warming do not suffice. Thus the focus of attention turns to the source of an authentic relation to nature.

A foundation stone for our inquiry is Richard Louv's work over the last decade: his seminal book, *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder*; two subsequent books; and the nationwide movement he has inaugurated and inspired—the Children and Nature Network. Louv asserts that profound nature experience is a “spiritual necessity” for the growing child, but that the youngster who plays outdoors, like the Florida panther and the whooping crane, has become a kind of endangered species—the “last child in the woods.” A fourth-grader in San Diego put the matter succinctly: “I like to play indoors better 'cause that's where all the electrical outlets are.” Richard Louv quotes the naturalist, Robert Michael Pyle, who asks poignantly: “What is the extinction of a condor to a child who has never seen a wren?” and Louv looks to the future with concern, asking, “Where will the next generation of stewards come from?” The movement to which he has contributed so much is often referred to, appropriately, as “No Child Left Inside.” Since *Last Child in the Woods* Louv has

authored two more books, *Nature Principles* and *Vitamin N*. Each book, especially *Vitamin N*, provides numerous suggestions for ways to help children and their families make meaningful connections with nature, and I urge all parents and teachers to consult the Children and Nature Network (<http://childrenandnature.org>) for edification and inspiration, and, above all, to gain assurance that there are hundreds if not thousands of grassroots groups in this country helping young people to experience and work with the living environment.

Personal experience lies at the very heart of the matter. Individuals who are fortunate enough as children to have had profound connections with all that nature offers—plants, animals, wild places, natural rhythms, the sky and weather, and much else—will have a firm foundation that can extend throughout their lives. My own approach in teaching, whenever possible, was to introduce an admixture of natural history into my several courses, including definite assignments in the close observation of living nature in whatever ways I could arrange. We were not able to visit the rainforests of Amazonia or Yosemite National Park, but we made ample use of local habitats, the university campus itself, and what the ecologist David Ehrenfeld has termed the “rainforests of home.” Whatever successes I had as a teacher convinced me that students will take a deep interest in a study of the living world, both inside and beyond the classroom, if they are guided to an authentic encounter with living plants and animals, natural settings and the enchantments of life itself.

## The Unnatural Pull of Technology

Educators and parents are acutely aware of the vast inroads of technology in the schools, and countless millions of dollars are spent each year to introduce computer programs, simulations, on-line courses, and a wide variety of other means into the educational process. There is a pressing need to assess how this trend relates to the theme of children and their relation to the world of nature.

Lowell Monke was a Computer Sciences teacher in the public school system of Des Moines, Iowa, for some years and subsequently taught prospective teachers as a member of the Department of Education at Wittenberg University in Ohio. His long experience as a teacher showed him both the value and the challenges of an increasingly computer-bound age. Monke has been a singular voice in showing that, for every positive argument put forward in favor of computers in schools, there is a hidden, unrecognized loss. He argues that the digital screen cannot begin to simulate the direct experience of nature that Richard Louv reminds us is so essential for the proper growth and development of



the child. “Children come to know a tree,” Monke writes, “by peeling its bark, climbing its branches, sitting under its shade, jumping into its piled-up leaves. Just as important, these firsthand experiences are enveloped by feelings and associations—muscles being used, sun warming the skin, blossoms scenting the air. The computer cannot even approximate any of this.” Perhaps his most telling assertion is that “there is a qualitative difference between learning *about* something, which requires only information, and learning *from* something, which requires that the learner enter into a rich and complex relationship with the subject at hand.” Computers in education, appropriately used, are here to stay, but young people, above all, need to sink their hands into things that are real and actual.

David Sobel, recently retired from Antioch New England University, has made numerous and substantial contributions on the theme of “place-based education.” His study, *Beyond Ecophobia: Reclaiming the Heart of Nature Education*, is widely cited and admired. Other books and articles of his carry similar themes. In an essay “Look, Don’t Touch” he reminds us that childhood experience in nature is all-important in establishing lasting bonds between individuals and the natural world. He writes that John Muir, E. O. Wilson, Aldo Leopold and Rachel Carson all had “down-and-dirty experiences in childhood” through which they formed lifelong bonds with the earth and its creatures. Sobel tells us that “nature programs should invite children to make mud pies, climb trees, catch frogs, paint their faces with charcoal, get their hands dirty and their feet wet.” Too much emphasis on concepts and the mechanical principles of nature, especially in the early years, does little to establish the sort of deep communion with nature to which he alludes.

“Between the ages of six and twelve, learning about nature is less important than simply getting children out into nature.” A recent book by Sobel and several collaborators, *Nature Preschools and Forest Kindergartens: The Handbook for Outdoor Learning*, highlights an effort, originating in Europe, to bring children into nature at very early ages, and several schools in this country, especially the Forest Kindergarten at the Saratoga Waldorf School, have achieved remarkable success.

The most powerful voice of all is surely that of Rachel Carson. She is best known for her seminal work, *Silent Spring*, a book that helped to launch the environmental movement in the early 1970s. But she is also the author of “The Sense of Wonder,” a lyrical essay she wrote a few years before her death in 1964. It has been widely acclaimed as one of the great American nature essays and it deserves full attention from everyone concerned for the future of the natural environment and the future of our children.

Carson spent her summer vacations at a cabin retreat along the coast of southeastern Maine where she found repose and the inner strength to confront powerful voices not wanting to hear her message about toxic chemicals and the poisoning of the natural environment. In “The Sense of Wonder” she helps the reader recapture something of lost childhood and to reflect on the sense of wonder that each child brings into life as a kind of birthright. Readers of this essay will be profoundly affected, I think, and I trust that each will come to value even more the power of nature to awaken our hearts to the beauties and wonders of nature. Rachel Carson has alerted us to what we are doing to the natural environment; she has also shown us how in nature we can find sustenance for the human spirit. She wrote:

---

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 disenchantments of later years, the sterile preoccupation with things artificial, the alienation from the sources of our strength.

## Play and Gardening

One of the most troubling aspects of our theme is that children seem to have forgotten how to play. Stephanie Hanes, a regular contributor to the *Christian Science Monitor*, writes in "Toddlers to Tweens" that for many if not most American children "free play" no longer exists. Youngsters are programmed and scheduled, tested and retested, given little or no recess time at school, and pressured to get ready for higher levels of education. They have little or no experience of the joys of wandering, the vagaries of fantasizing, or the simple pleasures of made-up games, unscheduled days, and the carefree delights of summer. Hanes writes that "children's play is threatened, and kids—from toddlers to tweens—should be relearning to play. Roughhousing and fantasy feed development." The matter of children's play is a serious concern for parents, teachers, and child psychologists throughout this country. Many current books, popular magazines, and academic studies attest to this concern, and readers will likely be able to suggest titles of their own. I offer Gary Paul Nabhan and Stephen Trimble's *The Geography of Childhood: Why Children Need Wild Places*; Susan Linn's *The Case for Make Believe: Saving Play in a Commercialized World*; Scott Sampson's *How to Raise a Wild Child*; and the highly relevant publications of the Alliance for Childhood.

Along a similar vein, Carolyn Jab's in her essay, "The Privilege of Gardening with Children," speaks to the matter of children and the soil. Young people who cannot recognize various types of wild flowers, songbirds or species of ornamental trees and shrubs will not have planted seeds or harvested vegetables or picked apples. Jab's offers helpful, practical suggestions for how parents can guide youngsters in planting and caring for a garden. Most importantly, she informs us that "children have a deep and abiding interest in growing, perhaps because they are doing it themselves. They remind us, if we let them, that the point of gardening is not a perfect platoon of well-disciplined plants. Rather, it is the

privilege of witnessing a miracle as simple, profound and unpredictable as growth itself."

Most of my direct acquaintance with primary and secondary education is through Waldorf schools, and I am aware that many have made gardening and, where possible, the care of animals an important part of the curriculum. Waldorf schools in Harlemlville and Garden City, New York; Kimberlton, Pennsylvania; Holyoke, Massachusetts; and the Summerfield Waldorf School in California have each instituted exceptional programs in gardening, and there are others, equally important, that could be cited. I urge readers to examine the website description of the Summerfield curriculum, where it is evident that most young students working their way through the twelve years of this program will likely emerge as individuals deeply connected to and concerned for the well-being of the land and committed to its preservation (<http://summerfieldws.org/the-farm>). Children who spin wool, collect cow-pies, and build compost piles in the lower school; plant and harvest vegetables, care for farm animals, and work with natural materials in middle school; and undertake projects in sustainability in high school will surely be different from young people educated in the ordinary way. (I am aware that there are important projects going on in various public schools around the country and I have no wish to belittle these efforts, but only to point out the value of what I have learned from Waldorf education.)

## A Natural Imagination

There are further considerations. Douglas Sloan, Emeritus Professor of Education at Teachers College, Columbia University, writes that children "simply being in nature is not enough. If nature is to nourish children, and they in turn are to protect and nourish it as adults, imaginative capacities for feeling and perception must be brought to birth in childhood." As a child I read a great deal and a favorite book was *The Curious Lobster* by Richard W. Hatch. The curious lobster's thoughtful musings and his adventures with Mr. Badger and Mr. Bear have lived with me ever since childhood. The book has no environmental message, and it makes no plea for conservation or animal protection. It deals only with the life of Mr. Lobster, a fictional character I came to love, and to this day I am unable to order lobster meals in restaurants. I wonder how many other books of childhood have helped to shape my attitude and a sense of respect and compassion for animal life?

My parents grew up in very different parts of the country—my mother in the Bronx, my father in rural North Dakota—but both were exposed to the nature essays of John Burroughs. These short essays highlight and celebrate simple happenings in nature and implicitly invite readers to explore

---

and make observations of their own. It is an educated guess that Anna Botsford Comstock's classic volume, the *Handbook of Nature Education*, and Thornton Burgess' *Bird Book for Children* may have influenced my parents' early lives.

Sara St. Antoine, herself an author of many splendid books for children, notes a decline over the last two decades in children's books dealing with the simple representation of natural places or animal life:

We didn't have a lot of books about environmental problems when I was a kid. The stories that really nurtured my connection to nature were simply ones where a landscape and its inhabitants came alive. I wanted to experience vicariously the wind on the prairie, the waves on the seas. I wanted to see what badgers or lions looked like up close and contemplate their daily routines, their wild spirits. On some level, I'm not even sure these had to be real ecosystems and real species.

St. Antoine's book suggestions for young adults include such works as *An Owl on Every Post* by Sanora Post, *The Red Pony* by John Steinbeck, *Winterdance* by Gary Paulsen, and the *Lord of the Rings* by J. R. R. Tolkien. Early readers are directed to *Grasshopper on the Road* by Arnold Lobel, *Henry and Mudge* and *the Starry Night* by Cynthia Rylant, and *Mouse and Mole: Fine Feathered Friends* by Herbert Yee. By her standard these books are as much a part of the corpus of environmental literature as any books directly treating environmental issues. (My own list includes all of Beatrix Potter, the several books about Babar and Celeste, and two of my favorites, Freddy the Pig and Uncle Wiggily. Recommended for older readers are Farley Mowat's *Never Cry Wolf*, Jane Goodall's *Reason for Hope: A Spiritual Journey*, and J. Allen Boone's *Kinship with All Life*.)

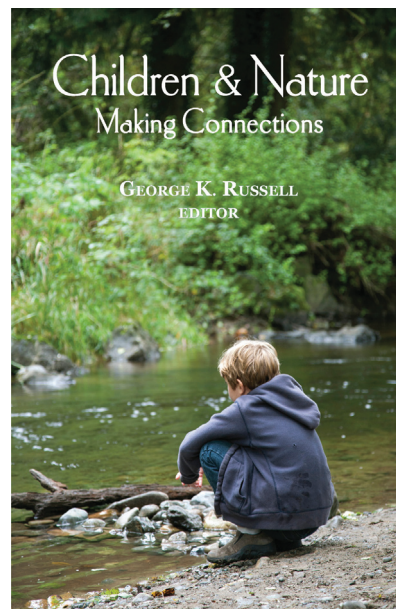
I leave the final words for Rachel Carson. When asked by parents how they can teach youngsters about the natural world when they themselves know so very little about it, her answer was the following:

If a child is to keep alive his inborn sense of wonder without any such gift from the fairies, he needs the companionship of at least one adult who can share it, rediscovering with him the joy, excitement and mystery of the world we live in. Parents often have a sense of inadequacy when confronted on the one hand with the eager, sensitive mind of a child and on the other with a world of complex physical nature, inhabited by a life so various and unfamiliar that it seems hopeless to reduce it to order and knowledge. In a mood of self-defeat, they exclaim, "How can I possibly teach my child about nature—why, I don't even know one bird from another." I sincerely believe that 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 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 the object of 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.

Rachel Carson tells us that "those who dwell among the beauties and mysteries of the earth are never alone or weary of life." But what of those who have little or no contact with the natural world and for whom the beauties and mysteries of the earth have long since disappeared? And what of those youngsters whose lives revolve around cyberspace and technological devices and virtual images to the exclusion of anything resembling genuine nature experience? Do we not owe it to our young people to follow Rachel Carson's lead with all the determination and strength of will we can possibly bring to bear?

---



George Russell is an emeritus professor of biology with forty-eight years of teaching experience at Adelphi University on Long Island, New York. A founding co-editor of *Orion* magazine, he edited the book, *Children and Nature: Making Connections* (Myrin 2014). It contains contributions by Richard Louv, Scott Russell Sanders, David Sobel, and nine others. George also serves on the board of the *Evolving Science Association*, a collaborative effort of the Myrin Institute and The Nature Institute.

## 2017 Farmers Course

Numerous times I have seen a bumper sticker that reads: “No Farms, No Food.” Yes, but we need to recognize farms as more than places where food is produced. The translation of the word “farmer” in my native Portuguese is “agri-culturalist.”

In this light, there could be other bumper stickers that say: “No Farms, No Culture”; “No Farms, No Landscapes”; “No Farms, No Communities”; “No Farmers, No to the Possibility of the Health of the Earth and Ourselves.” As Rudolf Steiner pointed out in his 1924 lectures, *The Spiritual Foundations for the Renewal of Agriculture*, there is practically no field of human endeavor that does not relate to agriculture in some way. Seen from whatever perspective you choose, agriculture touches on every single aspect of human life.

When farmers come to The Nature Institute, their presence fills the space with a special mood. The character of their handshake, the quality of their pace, the special feel of their humor and deep thought-fullness—these bring a unique quality to their conversation and participation in our courses.

Each February since 2009, The Nature Institute has offered a week-long course for farmers, gardeners, apprentices, and others who love the land. These intensives focus on honing observational skills and on developing capacities of flexible thinking and discernment. Together with participants we pursue a qualitative, phenomenological method as a contemplative practice. In these courses we explore topics that pertain directly to nature and agriculture: plant growth, metamorphosis, and ecology; the cycle of the year

and astronomy; the whole-organism biology of animals; domestication in plants and animals; the qualities of the four elements (earth, water, air, and fire); evolution and human responsibility.

This past February twenty-two farmers and apprentices came to our Winter Course from local farms as well as Virginia, Vermont, Pennsylvania, Peru, and Canada. The theme this year was “Developing a Qualitative Understanding of Nature: Animals, Humanity and Evolution.” Along with Craig, Henrike, and Bruno they explored:

- Exercises in flexible thinking through geometry
- Mineral, plant, and animal: different ways of being-in-the world
- Wild and domesticated animals
- Animalness and humanness in evolution
- Hands-on activities related to morning sessions
- Observing farm animals (at neighboring Hawthorne Valley Farm)
- Astronomy: daily and yearly rhythms of sun, moon, and stars

Last, but not least—thanks to our new Program Coordinator, Seth Jordan—for the first time this year we started each day with group singing. This brought a delightful quality to the whole week, especially as our voices grew together with time.

BF







### *Some Comments from Farmers Course Participants*

“I appreciated that you did not just present information that can be found on the Internet or in a book ... but guided us into a new way of thinking.” (Apprentice)

“I enjoyed the holistic approach to learning, where activity and observation are included in the process.” (Apprentice)

“Every aspect of the course was woven into the other. Learning about how we as humans see and think of the world was magnified. We were reminded of our responsibility on Earth; of our freedom.” (Apprentice)

“The animal and manuring elements of the course were insightful and expansive in the context of my agricultural conceptions, and have already proven valuable in understanding practical reality of both domestic and wild animals and our role as ‘husbands’ of the natural world.” (Farmer)

## Our New Fellowship Program

As winter draws to a close, we are looking forward to the springtime arrival of six participants in our new Fellowship Program. This year’s fellows hail from all over the world: India, Argentina, Scotland, and France.

The purpose of the program is to give individuals the opportunity to deepen their understanding and practice of holistic phenomenological science. Fellows are given room and board as well as space at the Institute to do their work. They will also be given guidance and support, in the form of educational seminars and regular meetings with Institute staff, as they pursue their own research projects.

This year’s projects will focus on plants, soil fertility, and nutrition; the study of landscape; and the dynamic morphology of fish. Fellows will be at The Nature Institute beginning in mid-May and, depending on the individual, will continue through the summer for terms of varying length.

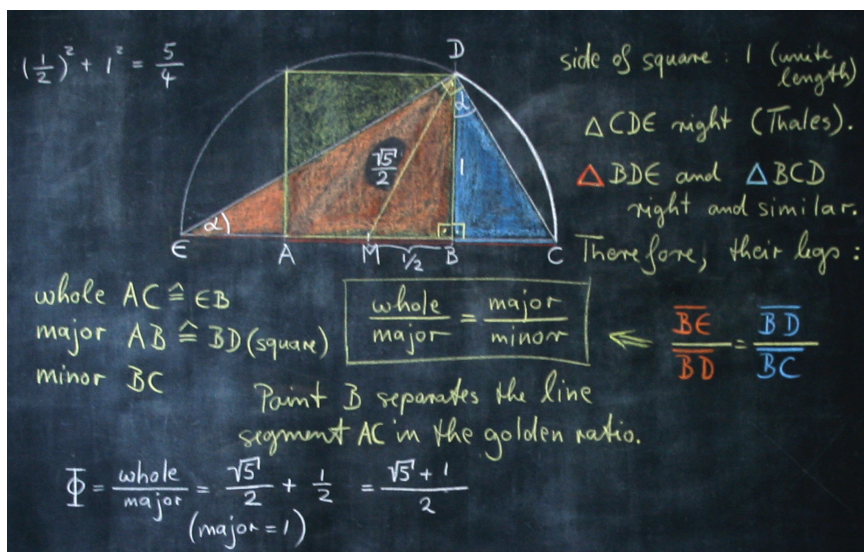
## Mathematics Alive!

From March 17–19, for the seventh time, The Nature Institute offered *Mathematics Alive!*, a weekend workshop for middle school teachers. Henrike Holdrege, together with Marisha Plotnik, who teaches math in middle and high school at the Rudolf Steiner School in Manhattan, New York, led a group of eleven teachers from schools in Maine, Washington D.C., Pennsylvania, Vermont, Massachusetts, and New York. This year's topic was "Pentagon, Pentagram, and the Golden Mean." Here are some comments from course participants' evaluations:

"I am planning to re-vamp my entire seventh grade math skills plan, thanks to your gentle, profound guidance." — "My experience is that this collegial work is very supportive and nourishing. Since this work is a process, it never gets old or finished. I appreciated the balance of moving, making (geometric) constructions, and algebra. What I have learned and re-experienced here will inform my teaching and, with my colleagues, help our school's math program. Because you bring math topics in experiential as well as cognitive ways, I look forward to any topic." — "I am planning to use all of this (well, much of it) with an eighth grade skills class as a 'capstone' experience to end their year." — "I admire the fruit of different perspectives coupled with the respect for different approaches. Working with the (geometric) forms enables me to enhance my traditional training that focused more on number and formula. I greatly appreciate the many angles from which we viewed the topic."

Over the years, *Mathematics Alive!* has covered a wide range of topics, including Euclidian geometry embedded in form drawing and movement; various proofs for the theorem of Pythagoras; negative numbers and their arithmetic; introducing algebra and discovering algebraic rules; solving linear equations based on the child's previous experiences in arithmetic; the platonic solids; and irrational numbers. All these topics are part of most schools' math curriculum. In the foreground of our work are these questions: Can the student at the onset of puberty be supported in her or his healthy development by practicing and engaging in math? Can doing math further the human capacity for discernment between true and false? Can math be more than drill and a mere set of rules that require the student to learn them by heart and to apply them? Can math, rather, be present in the classroom in its greater fullness?

Before a teacher can bring greater fullness of math into a classroom, obviously, that fullness has to live in the teacher.



Often our own schooling and higher education in math did not provide that fullness. Therefore, we as adults engage in learning, sharing, and working together during the weekends of *Mathematics Alive!* at The Nature Institute in order to bring the topics to life in our own experience. HH

## Out and About

- When this issue of *In Context* arrives, Craig and Henrike will have returned from their month-long stay in Australia. During April they gave a variety of talks, workshops and classes in Sydney, Tocal, Mullumbimby, and Perth. In the latter two cities, they gave classes for teachers during week-long conferences. Henrike taught math for middle school teachers and also projective geometry. Craig's classes were concerned with evolution.
- In July, Craig and Henrike will be teaching the second part of the two-year program on "Seeing Nature Whole" in Florianopolis, Brazil. The two-week session will focus on color and light, animals, and evolution. The same twenty-five participants who attend last year's session will be coming again to complete the program.
- At the end of November, Bruno gave two workshops at an Ecological Farmers of Ontario (Canada) gathering. He spoke on "Developing Dynamic Ways of Working with Farm-Scale Composting" and on "Practices and Insights of Biodynamic Agriculture." The conference took place in Kingston, Ontario. Afterward, the farmers' organization wrote in their review of the conference, "Follador's presentation was far more than a practical guide to managing compost—it was a kind of sustained reflection on humus infused with poetry, cultural analysis, and an abiding love of the subject."

- In December, Bruno gave one of the keynotes at the third National Mexican Biodynamic Conference, in Coatepec, Veracruz. He spoke about “Soil, Culture, and Human Responsibility.” He also gave a three-day workshop on biodynamic composting practices.
- In January, Bruno gave one of the keynotes at the Utah Farm Conference, held in Cedar City. He spoke on “Soil, Culture, and Human Responsibility” and gave a workshop on “Practices and Insights of Biodynamic Composting.”
- In early February, Bruno gave an invited lecture at the Annual International Conference of the Biodynamic Movement. He spoke on “Experiential Sketches on Fertilizing and Composting” and gave a three-day workshop on “Developing Dynamic Ways of Seeing and Working with Farm-Scale Composting.” The conference took place at the Goetheanum in Dornach, Switzerland.

## A New Colleague

Seth Jordan joined us this past November as our part-time Program Coordinator. He is very enthusiastic about supporting our work in Goethean science, as well as exploring how our approach can inform a new impulse in the social sciences.

Seth graduated with a degree in Philosophy from Connecticut College in 2003. In his senior year, he took a seminar on evolution where he learned that nature is a complex, murderous machine—“red in tooth and claw”—but, he adds, “this didn’t seem like it was really the whole picture.” Since that time, his main work has been in educating and organizing. In 2008, he co-founded “Think OutWord,” a peer-led program for young adults exploring possibilities for social change. In the following years, Seth spent much of his time organizing and teaching workshops in the U.S. as well as in Europe and Asia. In 2014, he settled back down in our area as a teacher at Free Columbia.

One of Seth’s first tasks at The Nature Institute has been to manage the daunting organizational and logistical tasks associated with the establishment of our first Fellowship Program. (See separate news item.) The program would have been impossible without his efforts. We are very happy to welcome Seth onto our staff.

## New Online Resources

***Educating for Sustainability.*** The Nature Institute is happy to offer a major new online resource that we have created to serve holistic and phenomenological sustainability education. Over the past year we have identified our relevant writings and materials, written a brief synopsis for each, and

then organized them as a guide according to subject matter and also education level (early childhood through postsecondary education).

In addition, we also provide a bibliography of publications by other authors, and links to other organizations offering important resources in sustainability education. Special thanks to our colleague Colleen Cordes for her tireless work on this project.

Please use the resource for your own study and for your work in the classroom. And please share it with anyone who you think might be interested! You can find it on our website at <http://natureinstitute.org/sustain>.

***A YouTube Video.*** At this winter’s week-long Farmers Course, Craig gave an evening talk on the life and work of Franz Marc, the great expressionist painter who worked with tremendous devotion to portray animals as they themselves “see the world and feel their being.”

Craig shared numerous slides of Marc’s work—beginning with his early drawings and paintings (including some fascinating photographs of his work as a young teacher of anatomical drawing), and then tracing his further evolution as an artist, and ending with his powerfully vibrant expressionist works.

We recorded Craig’s presentation and slideshow and have made it available on YouTube and on our website at <http://natureinstitute.org/txt/ch/marc.htm>.



Franz Marc, Foxes, 1913

---

## New Publications

**Craig Holdrege:** Not long after this newsletter appears, Craig's new monograph on frogs will be published. Appearing in our Nature Institute Perspectives series, the booklet is entitled *Do Frogs Come From Tadpoles? Rethinking Origins in Development and Evolution*. It is published by the Evolving Science Association, a joint venture of the Myrin Institute and The Nature Institute, and, when available, can be purchased from the bookstore on our website.

In this study Craig has brought together and re-worked the three articles on the frog from *In Context* #33, 34, and 35. He shows how the agency of beings is a central force in development and evolution, in contrast to current thinking which treats living beings as effects of mechanisms. He presents key issues of development and evolution through the lens of amphibian ontogeny (development of an individual organism) and phylogeny (evolutionary development of species over time). The result is a concrete example that can be used by educators to introduce a holistic way of viewing evolution.

In describing his undertaking, Craig writes:

In my portrayal of frog and amphibian evolution I have tried to present a picture of evolution as a creative process. In so doing I have consciously avoided a trend of thought and research that is often dominant in the study of the fossil record and evolution. That is the search for ancestors and origins in the fossil record.

The booklet is furnished with many illustrations.

**Stephen L. Talbott:** A lengthy article by Steve entitled "Evolution and the Purposes of Life" was published in March in *The New Atlantis*, an influential journal devoted to discussions of science, technology, and society. The piece is the initial, and more preparatory, half of a two-part effort to sketch the basic principles of a radical reconceptualization of evolution theory. The decisive element in this reconceptualization is the insistence upon taking organisms seriously as purposive agents in the evolutionary process—this, as opposed to assuming that the "mechanism" of natural selection is the key factor in evolutionary change.

As these words are being written, the Winter 2017 issue of *The New Atlantis* is at the printer and not yet available. We hope to have some news about the reception of the article (which we expect may be a bit stormy!) in the next *In Context*. Meanwhile, you will find a link to the full text of the article at <http://BiologyWorthyofLife.org>.

Also, last autumn the Norwegian publisher, Paradigmeskifte Forlag, released a book consisting of several articles by Steve—"Getting Over the Code Delusion," "The Unbearable Wholeness of Being," "What Do Organisms

Mean?" and "Evolution and the Illusion of Randomness," along with several others. A number of these were previously published in *The New Atlantis*. The book, translated into Norwegian by a good friend of The Nature Institute, Trond Skaftnesmo, is entitled *Å gjenoppdage organismen—fra molekyl til evolusjon*, which translates to "Rediscovering the Organism—From Molecule to Evolution."

And, finally, a translation into Spanish of Steve's Nature Institute Perspectives booklet, *In the Belly of the Beast*, is currently in the works. It is being undertaken by the Colombian scholar, Mauricio Loza.

**Bruno Follador:** Bruno's article, "The Creature That Has Never Been," which was originally published in the spring 2015 issue of *Biodynamic Journal*, has now been reprinted in *Lilipoh Magazine* vol. 85, no. 21 (fall, 2017). The revised title is "The Creature That Has Never Been: Shifting Our Approach to Livestock—From Machine to Being." And now, in its fall/winter issue, the *Biodynamic Journal* has reprinted Bruno's article from *In Context* #34 (fall, 2015), "Portraying Soils and Compost: Color, Form, and Pattern." Both articles are also available on our website.

### A Challenge Grant: *Sustaining the Work!*

A Nature Institute supporter has generously offered to donate up to \$5,000 as a matching gift to support our work. This issue of *In Context* gives you a window into our intentions and activities.

Whether it is in adult education programs or in publications, we strive to foster an awareness of the deeper nature of nature. This awareness can grow as we become more attentive to concrete appearances and to our own active participation in the world. Can we—instead of fostering division and abstraction—let the connectedness and richness of the world come to ever fuller expression through human activity? That is a striving that motivates our efforts.

Thanks to this challenge grant, every dollar you donate to The Nature Institute by June 30 will be matched, up to \$5,000. You can make a gift by check or credit card using the enclosed envelope, or by credit card through our website (<http://natureinstitute.org/friend>).

*Thank You!*

# Thank You!

We would like to thank the Edwards Mother Earth Foundation for its challenge grant in support of our Living Soils initiative, those of you who helped us meet the challenge, and everyone else who contributed goods or services between October 1, 2016 and March 31, 2017.

PLEDGES	Howard Cort in memory of Lois Lund Cort	Philip Incao & Jennifer Thomson in memory of Fentress Gardner	Fred & Masako Metreaud Nancy Metz in memory of Stanley & Virginia Metz	Ann Scharff Elizabeth Scherer Lucy Schneider Steffen & Rachel Schneider Jeff Sexton & Connie Cameron
Nancy Kay Anderson	Barbara Coughlin & John Fallon	Ina Jaehnig Van James in memory of Peter Glasby	Daphna H. Mitchell Rick Mitchell Karl-Peter & Mechthild Möller	David Shufelt Meinhard Simon David & Christine Sloan
Janet Barker	Royse Crall	Whitney Jastram in memory of Lydia H. Jastram	Kornelia Möller & Gerd Kroonen	Douglas & Fern Sloan Patricia Smith
Betty Brennehan	Siral & David Crane	Nelle Johansen	Wilhelm Möller & Elke Buhler	Sam & Elizabeth Smith Lourdes N. Smyth
Michael Hall in honor of Robin Wall Kimmerer	Eugene Creany	Eileen Jones	Gregory Moore	Jerome & Rebecca Soloway
Judith Haney	Harriett Crosby	Kevin Jones	Pam & Rob Moore in memory of Eva Gardner	Claus Sproll Ann Stahl in memory of William Ward
Michael & Patricia Holdrege	Jim Cummings	Thomas Jordan	Frank Mulder	Betty Staley Alice Stamm
Susan Starr	Lisa Damian	Gloria Kemp	Joyce Muraoka	Stuart & Laura Summer Linda Sussman
Trish Streeten	Annelies Davidson	Tiger Keogh	Astrid Murre	Elizabeth Sustick Candyce Sweda
Jo Valens & Michael Thomas	Jim Davis & Brooke Heagerty	Bruce Kirchoff	Ben Nash	Christian Sweningsen Chris Tekverk & Deborah Enright
Mark Vecchio	Lucian Davis	Fred Kirschenmann & Carolyn Raffensperger	Carol Niffenegger	Thorwald Thiersch John Trevillion
Elisabeth Wiley in honor of The Nature Institute	Pamela & Terry DeGeyter	Ann Kleinschmidt & Lee Coates	Lin Notzelman	Roberto & Donna Marie Trostli Konrad & Theres Urech
DONORS & VOLUNTEERS	Karole Delaney	Arthur Kleinstein	Robert Oelhaf	Mario & Donna Verna Greg & Frances Vig
Anonymous	Susan Delattre	Manfred & Lieselotte Klett	Jeffrey Onans	Conrad & Claudia Vispo
John & Monica Alexandra	Kathleen DeRosa-Lazare	Rita & Gary Kobran	Frederick Otto	Jeremy Wadsack Andree Ward
Carol Alpert	Jean-David & Karen Derreumaux	Johannes Kühn	Traute Page & Eric Meyer	Chip Weems Christian Wessling
Monica Amstutz & Robert Bower	Frank & Cheryl Doble	Kerstin Kup	Tim & Maggie Paholak	Ian Whyte Gisela Wielki
David Anderson	Charlie Doheny & Cate Decker	Alicia Landman-Reiner	Renate Pank	Sherry Wildfeuer Thomas Wilkinson
Anthroposophical Society in Australia	Sandragail Dunn	Klaus & Shirley Langpohl	Joseph & Emilie Papas	Nathaniel & Andrea Williams Christian Wittern
Elizabeth & Arthur Auer	Charles Duquette	Elan Leibner	Thomas Patsenka in memory of Betty Ann Patsenka	Lyt Wood Waltraude Woods
David Auerbach	Gregory & Nanci Dvorsky	Art Levit	Susan Peterson	Vanya & Christina Yoors
Brigida Baldszun	Mark Ebersole	Nancy & Ted Lewis	James Pewtherer & Jan Baudendistel	Arthur & Heide Zajonc Cathy Zises
John & Diane Barnes	Hanna Edelglass in memory of Stephen Edelglass	Christof Lindenau	Grace Ann Peysson	ORGANIZATIONS
Olga & Felix Bauer-de Wit	Jeffrey Endelman	Andrew Linnell	Martin & Janene Ping	Commonplace Fund of RSF Social Finance
Sylvia Bausman	Judith Erb	Martin Lockley	Marisha Plotnik & Thor Radysh	Edwards Mother Earth Foundation
Carol Beauvais	Lee Ann Ernandes	Peter Lolocono	Mary Lee Plumb-Mentjes & Conrad Mentjes	Kalliopeia Foundation
Ursula & Klaus-Georg Becher	Frank Fawcett	Elizabeth & Alan Lombardi	Gina Qualliotine & Richard Green	The Kathy Yoselson Fierce Determination Fund of The Community Foundation
Gerhard Bedding	Douglas Feick	Penelope Lord	Richard Green	The Michael Foundation
Christina Beneman	Virginia Flynn	Merrily Lovell	Lisa Ravetto	RSF Social Finance
Jeanne Bergen	Nick & Gisela Franceschelli	Peter Luborsky	Anna & Brian Ree	Rudolf Steiner Charitable Trust Advised Fund of RSF Social Finance
Olivia Bissell	Karl Fredrickson & Renate Kurth	Rich Lumma	Renate Reiss	Rudolf Steiner Fonds
Glenda Bissex in honor of our Mother Earth	Bruce & Karen Frishkoff	Miriam MacGillis	Cecilia Ribakoff	Salvia Foundation
John Bloom & Joan Caldarera	Nicole Furnee & Thomas Chulak	Ben & Veronica Madey	Ruth Riegel	Software AG Foundation
Rose Bohmann	Mike Galbraith	Julius & Gertrude Madey in memory of Roland Keimling	Mark Riegner	T. Backer Fund, Inc.
Benjamin Bokich	Mark & Adrienne Gardner	Debra Magadini	Roger & Dory Rindge	
Linda & David Bolluyt	Mary Giddens	Are & Karin Mann	Geoffrey Robb	
Bari Borsky	Andrew & Sara Gilligan in memory of Richard Meister	Irene Mantel & Tim Hoffman	Christina Root & Donald Jamison	
Christina Bould	Cat Gilliam	Barbara Martin	Margaret Rosenthaler	
Steve Brannon	Gary Gomer	Michael Mason	Roland Rothenbucher	
Ted Braude	Michael Gore	Lawrence & Robin Mathews	Neil Ruggles	
John Breasted	John Gouldthorpe	Kathleen Mayer in memory of Priscilla Coe	George & Leonore Russell	
Will Brinton	Glynn & Anthony Graham	Patrice & David Maynard	Denise Sacks	
Eileen Bristol	Eileen Gunning	Mark McAlister	Stephen Sagarin & Janis Martinson Sagarin	
Walter Burkart	Joan Dye Gussow	Lance & Kathleen McKee	D. Joy Salatino	
George Burnett-Stuart	Karin Haldeman	Alan McKersie	Elisa Saltet	
Bill & Ruth Bywater	Joseph & Diane Haley	Mac & Ellen Mead	Jan Kees & Polly Saltet	
Dorothy Carney	Paula Hall	Rick Medrick in memory of Paul Sneed	Robin Sand	
Maureen Carolin	Patrick Harris	Eleanor Melcer in memory of Donald Melcer	Caitlin Sargent	
Kim Cascone & Kathleen Cascone	Gunther & Vivian Hauk	Mary Elizabeth Merritt & Raymond Crowley	Anne & Joe Savage	
Betsy Cashen	Graham Hawks		Liza Trent Savory	
James Cavender	Ingrid Hayes		Rosemary Scavullo	
Wade Cavin	Marsha & Ed Hill		Signe & Christopher Schaefer	
Lynn Charlton	Charles Hine			
Simon Charter	JoAnn & Mark Holbrook			
Jeffrey Cogshall	Barbara Holdrege & Eric Dahl			
Wendy Bobseine Conway	Craig & Henrike Holdrege			
	Tom Holdrege & Peggy Reis			
	Waldo Hotz			
	Jamie Hutchinson			



# What Is Life?

*(Let's Take Living Things on  
Their Own Terms)*

STEPHEN L. TALBOTT

**T**HERE IS ONE PROVINCE OF REALITY, one domain of the material world, where we humans have gained a knowledge unexcelled in its sophistication, its fine detail, and its almost infinite nuance of meaning. It is a domain that, perhaps more than any other, shapes our lives and influences our happiness day in and day out. And knowledge of events within this domain comes naturally: nearly all humans achieve a level of expertise dwarfing the scientific researcher's mastery of material phenomena in all other disciplines.

The phenomena I am referring to are those coming to expression in the human face. I have specifically in mind, not the power of producing those expressions, but rather of objectively reading them. For, of course, we do read them objectively. Our lives and society would be impossible if we could not navigate the universe of facial gestures with a largely shared understanding. *This means that.*

And the skill could hardly be more refined, even in the very young. Infants take an interest in and learn to read gestures—to the point of reacting differently to speakers of different languages. “Before they speak—before they even crawl—infants can distinguish between two languages they've never heard before just by looking at the face of a speaker.”<sup>1</sup>

In understanding the physical contours and movements of a face, we do not interpret isolated and discrete signs. The play of gestures upon a face is an integrated, multi-themed drama, and at any instant the barest detectable change—the slightest movement of the corner of a lip or brow, the hint of color in the cheek, a sparkle in the eyes—might signal a sudden dark turn in the overall narrative, or a gracious lightening of what would otherwise be a hurtful thrust.

Think of the different ways and different contexts in which a word may be said. Leaving aside the question of language itself, the minutest feature of the physical expres-

sion can convey whole worlds of meaning. And here, in such physical features, we are indeed dealing with *meaning*—a meaning borne upon a material dynamic of force and substance, but not explicable as if the meaning arose from, or were *caused by*, that dynamic.

Suppose, for example, that someone says to you, “Shame!” Depending on the physical modulation of sound, or the slightest shift of facial expression, or the altered gesture of the body as a whole—not to mention the larger context or the history of your relation to the speaker—the meaning could vary from that of severe and judgmental reproach through lighthearted or incidental banter all the way to the positive encouragement of an implicitly granted license.

We are talking, then, about a genuine and shared understanding of a realm of expression that is manifested physically, but explainable only upon a basis very different from anything found in textbooks of physical science. Of course, no one expects a textbook of physics to discuss such matters. But if, as many believe, it is all really “just physics,” we may reasonably wonder: why should the textbooks ignore it? Can we truly understand physics if we exclude an entire and highly distinctive domain of physical phenomena? Or, if it is not all just physics, might not this itself tell us something important about physics—about the character of a physical reality that so naturally lends itself to the intended meanings and expressive powers of living beings?

The usual thought, however, runs in a very different direction.

## Problematic Reductionism

Broach the question “What is life?” in scholarly or scientific conversation, and you will likely find yourself very soon embroiled in a lively debate. The issue will, in the end, almost certainly come down to one or another form of the question, “Can living things ultimately be understood solely

in terms of the fundamental principles governing the inanimate physical universe?”

It is a strange question, assuming as it does that we bring to the table a reasonable grasp of the fundamental principles governing the inanimate physical universe, while also suggesting that any investigation of the phenomena of life in their own animate terms might somehow be misleading, or less than fully grounded. But do we really know that much about the physical reality in which we are immersed? A moment's honest survey may convince us, rather, that we are encompassed by uncertainties.

Why, for example, is there something rather than nothing? What is matter, and what is energy? If, as physicists assure us, the ultimate particles from which the material universe is “built” are in fact not material things in any conventional sense, what do we actually mean by the words “matter,” “physical,” or “substance”? Then again, the only world we know—or, it seems, could know—is discovered within consciousness; what does this imply about the nature of reality? And yet again: can we have a perceptible world at all except by virtue of sensible qualities—and if not, what would this say about a science that claims to be empirically rooted while foreswearing any serious attention to qualities?

To take up this last question for a moment: it seems clear that we have no material world without qualities of sense—warmth and cold; the colors of autumn leaves; the feelings of resistance, pressure, hardness, and texture; the sound of wind, water, and stone upon stone; the sensation of bodily pain. Subtract all qualities of sense experience from the world we theorize about, and there would be no world left. The only way we can have a material anything is by conceiving it in terms of the qualities of experience. Without such qualities, our scientific equations would have no meaning, because they would have nothing to be about.

If the qualities of experience are the irreducible starting point for all scientific understanding, and if, as everyone believes in practice, our understanding truly tells us something about the world, then you might think that a straightforward thought would suggest itself: perhaps it is the nature of the world to *appear in experience*—to exist, in its own essential character, as a *qualitatively appearing world*, a world coming to expression and fullest realization in *consciousness*.

This in turn might lead us to inquire more deeply into the nature of our own experience as knowers, rather than try to eject the knower from science as far as possible. It might even lead us to wonder whether the proper question is not “Can the explanation of living things ultimately be grounded solely in the principles of physical science?” but rather, “Can physical science finally be grounded only in the principles of life and consciously lived experience?”

The question will seem to border on insanity for those who have long accustomed themselves to the idea of a lifeless universe—for those, that is, who can so easily assume an unexplained eruption of diverse, reproducing, sense-making centers of life within an otherwise vast and senseless expanse of dead, supposedly qualityless (and therefore completely unknowable) things. But look at the matter from a different angle: does it not border on the scientifically irresponsible to lose sight of the fundamental uncertainties of our currently ungrounded physics? There are times when our taken-for-granted assumptions are exactly what we need to question if we want to find a fruitful way forward.

## The Pragmatic Glory of Science

If our physical science is ultimately ungrounded, it is by our own choice. We have wanted a science that *works*—a technological science. We have wanted to construct effective machines, and foremost among these are the scientific instruments that, under carefully specified circumstances, undergo predictable changes.

We may claim that the predictable working of such mechanical constructions validates the models in which our



Drawings (here and on p. 14) by Käthe Kollwitz.

knowledge is invested, and this is true enough. But what, exactly, is being validated? The models themselves are merely notional constructions whereby the world, or some portion of it, is re-imagined as a machine—or, at least, this is the researcher's common aim. We certainly do gain by this means a useful knowledge, which is hardly surprising given that the entire effort has been honed for centuries toward this pragmatic end. Such is the standard—legitimate as far as it goes—by which we have chosen to judge the value of our scientific theories.

Nevertheless, it is one thing to articulate bodies of thought aimed at successful instrument construction, and quite another to apprehend phenomena in their own terms. This truth is forced upon us above all in biology, where disciplined familiarity with any particular sort of organism clearly leads to an objective understanding of that organism's distinctive way of being—its recognizable *kind*—despite there being no machine-like determination of its behavior.<sup>2</sup> And we know very well from immediate experience that our ability to read the drama of facial gestures is an entirely different matter from, and is not dependent upon, a causal knowledge of the physical structures, physiological processes, or nerve impulses involved.

As for where we will be led when we begin to take seriously the qualitative character of inanimate physical phenomena, I don't think we currently have much of a clue. A great deal will depend on our recognizing the one-sidedness of current analytical methods, where we never stop and ask ourselves, "What is this?" but instead analyze it into parts merely in order to ask, "How does this part act mechanistically upon that part so as to produce such-and-such a result?" Of course, we don't stop with any of those parts either, but are driven by our method to analyze them into still smaller parts. It becomes an infinite regress.

Along this path we do learn about apparent mechanisms—relationships we can harness in devices of our own making. But we seem unable to cease our analysis long enough to say of any whole or part, "Behold *this*," while actually meaning something by *this*. Every *this* is "explained," not by considering what it is in its own right as a real and qualitative presence in the world, but only by analyzing it into other, equally blank and unconsidered *this*'s. We learn about the utility of things only against a background of deep mystery—mystery upon which we turn our backs in order to enjoy our new-found toys and the triumph of our manipulative powers.

When we do stop to contemplate the phenomena of the world around us, we will have a new kind of science—a qualitative science. It is not surprising that we can, from our current vantage point, say little about what such a science would look like, since the science we have had for several hundred years was founded upon a conscious effort to

leave qualities out of consideration. Presumably we have a lot of learning (and unlearning) to do. But it is hard not to suspect that our understanding of the organism as a living activity may offer us an open door that, if we are willing to step through it, will lead to vast and previously unsuspected physical vistas.

Physicists today continue to bump up against some of the same quandaries about the fundamental nature of things that perplexed the pioneers of quantum mechanics a hundred years ago. One wonders whether current methods have brought us to a dead end of understanding, despite impressive advances in practical knowledge. But this thought now occurs to me: during the mid-twentieth century, biology was tremendously stimulated by a migration of physicists into biology. Could it be that further progress in physics now awaits a return migration?

But if they are to bring anything fresh to physics, biologists will first have to reconcile themselves to the living qualities of their own subject matter. Then they will be well-equipped to inquire whether, in a way we have long refused to explore, we might learn to *read* a landscape—not, surely, as we would a face, but with something like the same attention to expressive gesture.

## What We Know Best

My suggestion, then, is that we should approach the study of life without obsessing about the question of its reducibility to the principles of physical science—this at a time when we have little idea about what sort of physical reality we would be reducing life *to*, and scarcely even know how to ask questions about that reality.

It seems indisputable that organisms are more directly and intimately accessible to us than physical phenomena in general. We are ourselves organisms, and beyond that, we are conscious organisms. It is fair to say that we *possess* our lives and animate bodies in a way we do not possess the non-living world. We have, within the small portion of the world's real estate we call our own, an insider's knowledge.

Living phenomena are, therefore, vividly open to our gaze. The obvious purposiveness of organisms, their striving for life, their drive to reproduce, their cooperation and struggle, their making sense of their world in relation to their own meanings—we can grasp these things far better than we can understand such basic "elements" of the material world as matter and energy, or even the simple fact that material objects *move*. At this point, we cannot honestly disavow even such an unexpected question of physics as, "Might such *moving* somehow be related, at a deep level, to whatever so evidently *strives* in organisms?"

(continued on back cover)





# Why Does a Zebra Have Stripes?

## *(Maybe This Is the Wrong Question)*

CRAIG HOLDREGE

IT IS HARD NOT TO BE IN AWE of nature's creativity as expressed in the striped coat of zebras. The rhythmically sequenced, flowing, black-and-white bands of hair are formed as the zebra develops in the womb. Each of the three different species recognized today— plains zebra (*Equus quagga*), Grevy's zebra (*Equus grevyi*), mountain zebra (*Equus zebra*)— has a characteristic striping pattern. And yet there is considerable variation in the pattern in each species, and also among individuals. I'll focus on the plains zebra.

### A Potent Pattern

When mesmerized by the overall impression of this striped animal, we may fail to perceive consciously what an organic work of art the striping pattern is. We can consider the striping pattern from the perspective of what I will call *biological aesthetics*: we look closely, moving through the details in such a way that their interrelations and connections with different features of the body and the animal's activity begin to show themselves. The descriptions that follow can only point to what needs to be experienced, so please look

at the photos to fill out what the text hints at.

The striping pattern is most complex and refined in the zebra's head, where the senses of sight, hearing, smell, taste, and touch are centered. In the neck and head the animal has greatest freedom of movement—turning down to graze, moving up or from side to side to look and listen.

Between the eyes there are long narrow stripes that end in the dark snout; they broaden at the height of the eyes and narrow to the snout and again at the top of the head. The stripes curve around the eyes and the base of the ears. The side of the head has stripes that are perpendicular to the length of the head and curve to converge with those length-wise stripes to create a wonderfully dynamic pattern.

Overall, there is an interplay between horizontal and vertical striping in the body. Horizontal striping is stronger in the rear of the animal and in its lower legs, while vertical striping dominates in the front part of the torso, neck, and head. In the middle of the body the striping pattern changes abruptly, and yet there is no break. In front of and above

---

Figure 1 (above). Plains zebras in the Moremi Game Reserve, Botswana. (Photo: C. Holdrege.)



Figure 2. Two plains zebras in the Ngorongoro Crater, Tanzania. (Photo: David Dennis; Wikimedia Commons.)

the rear legs, the wide stripes begin on the belly in vertical orientation, then curve toward the horizontal on the rump. As they approach the animal's rear end, each of the black stripes narrows to a tip so that the rear end is more white than black. On the rump the horizontal stripes are broad and become narrower on the legs. The lower part of the legs can also have horizontal stripes, which are very narrow. The horizontal striping at the rear covers the rump and the strong leg and pelvic muscles that thrust the animal forward when it moves.

In contrast, the front legs carry most of the body's weight, and the horizontal leg stripes arch upward into the vertical stripes of the shoulder and neck, continuing into the upright standing hair of the mane. It's worth attending to how

the "flow" of the horizontal leg stripes morphs into the vertical stripes of the shoulders. These two "streams" meet right at the anatomical elbow (which looks like the shoulder) and form a series of upward arching triangular shapes. All this emphasizes the gesture of upward movement.

Each individual animal can be identified by its own unique striping pattern—a whole-body "fingerprint" displayed to the world. When looking closely, you can see the variation in stripes on the flanks of the animals (Figures 3 and 6). A particularly striking example of individual differences can be seen in the photos of the heads of four different zebras in Namibia. Such examples show us that we need to be cognizant of the many variations on a theme that occur.



Figure 3. Plains zebras in the Lake Nakuru National Park, Kenya. (Photo: Daryona; Wikimedia Commons.)



Figure 4. Variation in the stripe pattern in four different individual plains zebras; Etosha National Park, Namibia (Photo: Hans Hillewaert; Wikimedia Commons.)

All in all, the rhythmical striping pattern is a harmonious and dynamic whole in which each band relates to its neighbor. Moreover, in the individual variations we witness a kind of creative playfulness of nature that creates sameness (pattern) which is never the same.

### “Presentation Value”

Twentieth-century Swiss zoologist Adolf Portmann pointed out that in many closely related species there is more generic sameness in the hidden inner organs and greater species specificity in the external visual appearance (Portmann 1967). No one would confuse a zebra and a horse based on outer appearance, and of course, they inhabit different environments. They belong, together with asses, in the genus *Equus* and their internal organs, skeleton, and muscles are remarkably similar. Only a specialist can tell them apart. Similarly, the lion’s skeletal and muscle structure are very

similar to the tiger’s (both are in the genus *Panthera*), but no one would mistake the striped tiger for a lion.

Portmann coined the term “presentation value” (*Darstellungswert*) to point to the significant attention nature has given to external appearances—how animals present themselves to the world through color, shape, pattern, sound, smell, or texture (1967, Chapter XI). Portmann wants us to take the appearances of nature seriously, and not to assume they are simply fortuitous results of organic development that “just happen.” When we do take appearances such as zebra stripes seriously, our awe of nature’s creativity grows and at the same time, as Portmann puts it, we are led to a “vista of the inexpressible.” In other words, we are confronted with the riddle of what nature is expressing through outer patterns such as zebra stripes. We can try to find connections and relations by comparing patterns, say, in different groups of animals, as Portmann did, and more recently biologists such as Wolfgang Schad (2012) and Mark Riegner (1998).

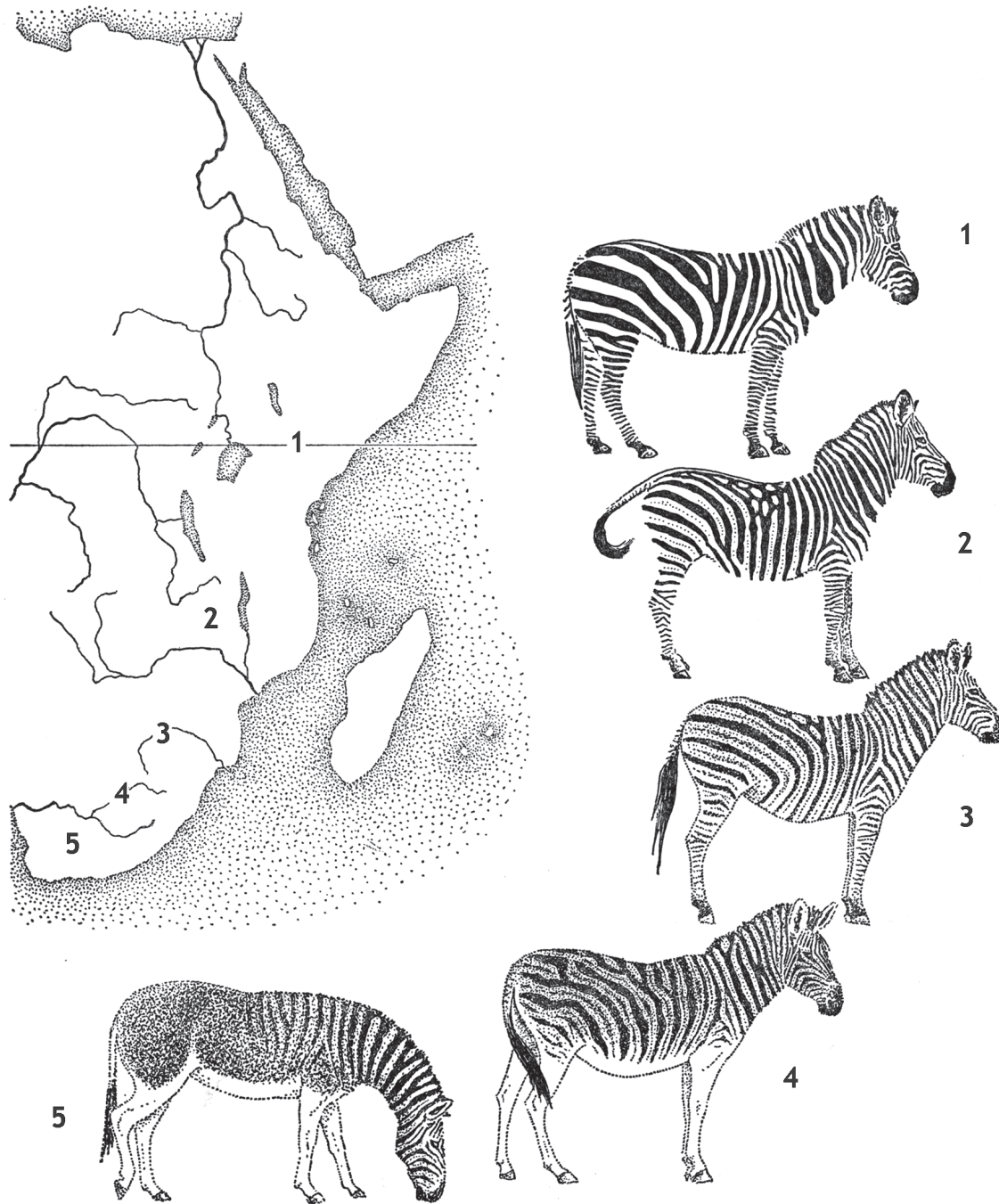


Figure 5. Examples of the geographical variation in stripe pattern in the plains zebra (*Equus quagga*). (1) Grant's zebra (*E. q. boehmi*). (2) Selous' zebra (*E. q. selousi*). (3) Chapman's zebra (*E. q. chapmani*). (4) Burchell's zebra (*E. q. burchellii*; extinct). (5) Quagga (*E. q. quagga*). See text for further explanation. (Drawings by Andreas Suchantke; from Suchantke 2001, Figure 4, p. 8; figure altered and simplified by C. Holdrege.)

In the case of zebras, it has long been noticed that there is geographic variation in the striping patterns of the different subspecies and populations of plains zebras (Cabrera 1936; Suchantke 2001; see Figure 5). Generally speaking, in the equatorial region the contrast between the black and white bands is most pronounced, and the stripes extend all the way down the legs (Figure 5, #1). Further south, many

individuals have lighter stripes between the black and white bands; they are called shadow stripes (#3).

Then there are two extinct subspecies of the plains zebra that lived in South Africa. Burchell's zebra (*Equus quagga burchellii*) was more reddish than black, the stripes were not as defined, especially toward the rear of the animal, and they did not extend down the legs (#4). Finally, the Quagga



Figure 6. Nursing plains zebra foal during the dry season; Moremi Game Reserve, Botswana. (Photo: C. Holdrege.)

(*Equus quagga quagga*) had stripes only in the front half of the body and had no leg stripes (#5).

Of course, within any given population there is, as I mentioned, considerable variation, so the geographical differences are not clear cut. Biologist Andreas Suchantke noted that on the equator the difference between bright light and shade is stronger than in all other latitudes, given the high daily arc of the sun's path each day. He suggested that the zebra's coat pattern variation in a way parallels changing light relations from equator to the subtropics, with the shadow-light contrast becoming weaker further away from the equator. So the changing pattern expresses in a surprising way a relation to the changing light environment, without the connection being in any narrow sense adaptive or utilitarian. It's an intriguing idea. But what gives me pause, as Ruxton (2002) points out, is that the mountain zebra (*Equus zebra*) is strongly striped and lives in South Africa far from the equator, inhabiting areas that formerly the only partially striped Quagga also inhabited.

### “What Are Stripes Good For?”

Most professional biologists who have concerned themselves with zebra stripes have asked a narrow question: what are zebra stripes good for? In other words, they “make the implicit assumption,” as the authors of a recent article about zebra stripes stated, that the stripes are adaptive (Larison et al. 2015). “Adaptive” means that they must now have, or must once have had, a specific function that contributed to the survival of the animal. All

“appearances,” on this view, exist because over time they arose fortuitously through changes in genetic and developmental mechanisms, but were useful to the animal so that they were perpetuated through the generations. This is the standard thought form—the conceptual lens—through which biologists today attempt to account for any and all appearances.

The result has been a plethora of stories (often called hypotheses)—at least 18 different ones—to account for zebra stripes (Ruxton 2002, Larison et al. 2015, Caro et al. 2015; Caro 2016). They provide camouflage in tall grass or in poor light conditions; they make zebras look bigger than they are so as to confuse attacking predators; they reinforce social bonding; they help with regulating body temperature; they protect against biting flies such as horse flies or tsetse flies. The list goes on.

In the past couple of decades, some biologists have looked more carefully at these suggested explanations of zebra stripes (Ruxton 2002, Larison et al. 2015, Caro et al. 2015; Caro 2016). They looked at the evidence on which the conjectures were based. In some cases there are anecdotal observations that support the idea of an adaptive function of stripes in specific situations. But more often than not the stories about why zebras have stripes turn out to reflect, not any compelling evidence, but rather the researchers' need for some functional explanation.

Tim Caro, a professor of wildlife biology at the University of California, Davis, has done the most thorough examination of “explanations” of stripes. To take one example, he says that “biologists have long remarked on the resemblance between the repeated pattern of stripes on zebras



Figure 7. Two plains zebras grazing during the dry season; Moremi Game Reserve, Botswana. (Photo: C. Holdrege.)

and the vegetation of the habitats in which they live” (2016, p. 23). In tall growing grass there can be vertical bands of illumination and darkness. And in the early morning and late afternoon there are particularly vivid shafts of shadows contrasting with the brighter vegetation. Some observers have noted in such appearances a certain resemblance to the vertical stripes in the front part of the zebra’s torso. Or when a zebra is in woodlands, its pattern can, to a degree, mimic shadow-brightness patterns, and also the darker trunks and horizontal branches of trees that are separated by bands of brightness.

Clearly, such observations of what we might call an “agreement of appearances” can be noted in certain specific conditions as fleeting phenomena. But the agreement (camouflage) is even then very approximate (Melin et al. 2016). The zebra does not live in a black-and-white striped world into which it disappears. And during moonless nights all animals blend equally with the darkness and, from a visual point of view, are well camouflaged—yet it is on moonless nights that zebras most often fall prey to lions (Elliott et al. 1977; Funston et al. 2001).

On the whole, zebras are visually highly conspicuous during the day time, whether in open grasslands or in woodlands. Moreover, “compared to many hoofed animals on the plains of Africa, they are remarkably mobile and noisy and never attempt to hide in cover” (Morris, cited in Ruxton 2002, p. 238a). Nonetheless, another popular “explanatory” story is that the striping pattern, especially when zebras are moving and in groups, could in a variety of ways confuse predators. But lions attack and successfully kill zebras whether they are solitary or in groups, and as just mentioned, most kills are at night when stripes could

not dazzle or confuse lions. Again, it may be the case that once in a while, in a particular context, the striping pattern confuses an attacking lion for a moment and the zebra escapes. But it is not a pronounced tendency.

Caro performed many field experiments to test the hypotheses about stripes, and discusses these along with a plethora of other researches in his 2016 book *Zebra Stripes*. The careful research summarized in the book leads him to reject virtually every hypothesis. What he doesn’t do is to question whether a survival-based explanation exists. He is not moved to drop his conceptual lens.

His own conclusion is that stripes are “an evolutionary response to pressure from biting flies” such as tsetse flies, or from horse flies that belong to the Tabanid fly family (Caro 2016, p. 193). Such flies can transmit diseases and cause substantial bleeding in the many large mammals they bite. One supporting observation is that, in field experiments, some of these flies tend to avoid black-and-white-striped surfaces. Caro and his colleagues believe there is a correlation between biting fly abundance and the degree of striping among zebras and other members of the horse family (asses, horses). He marshals a number of additional observations and thought connections that he thinks support this hypothesis. In a 2014 journal article, he and his colleagues concluded that “a solution to the riddle of zebra stripes, discussed by Wallace and Darwin, is at hand” (Caro et al. 2014).

Another group of researchers, led by Brenda Larison at UCLA, disagreed (Larison et al. 2015a, 2015b). They pointed out that biting fly abundance was not directly observed, and there was a lack of data about abundance and distribution. What Caro and colleagues did was to

use two environmental conditions—temperature and humidity—as proxies to estimate the abundance of biting flies, which tend to be more prevalent in warm, humid conditions. As a result, “what they [Caro et al.] call ‘tabanid distribution’ could easily correlate with any number of species distributions, be they insects, plants, or vertebrates.” In their own research on plains zebras, Larison and colleagues found variation in striping pattern to be most strongly correlated with temperature. What that correlation means, and whether—as Larison and colleagues assume—it has to do with an adaptive function, remains open.

Let’s assume, for the sake of argument, that research continues and researchers were to find that there is a correlation between stronger striping in zebras in areas with greater abundance of biting flies. And let’s assume, in addition, that widespread field observations of zebra populations reveal that horse flies are less likely to bother boldly striped zebras than others. Would we, with this additional evidence, have explained or accounted for zebra stripes? Would we have a “solution to the riddle of zebra stripes?” Would we know why zebras have stripes? Of course not.

What we would know is that stripes play a role in defense against horse flies, just as they may under certain conditions provide camouflage, or make zebras stand out more. But all of these “functions” could have arisen as propitious side effects of the striping pattern.

Moreover, in such purported “explanations,” the pattern in its concreteness, in all its nuances and variations, is glossed over because one only focuses on the abstraction: black and white (or dark and light) surfaces that are clearly distinguishable. These could be blocks, circles, blotches, straight bands, etc., so the explanation would not tell us why zebras specifically have *stripes*. The explanation is detached from the real animal.

I do not have an explanation for the zebra’s stripes. I am not looking for an explanation. I’m trying to get closer to what the animal may reveal as its unique way of being. By attending to the stripes I’ve been led to see an expression of nature’s creative power and am intrigued by each new variation. The zebra’s wonderful stripes remain a riddle for me. I’m happy to wait and see whether further insights arise.

---

#### REFERENCES:

- Cabrera, A. (1936). “Subspecific and Individual Variation in the Burchell Zebras,” *Journal of Mammalogy* vol. 17(2), pp. 89-112. doi: 10.2307/1374181
- Caro, T. et al. (2014). “The Function of Zebra Stripes,” *Nature Communications* vol. 5, pp. 1-10. doi: 10.1038/ncomms4535

- Caro, T. and T. Stankowich. (2015). “Concordance on Zebra Stripes: A Comment on Larison et al. (2015),” *Royal Society Open Science* vol. 2. doi: 10.1098/rsos.150323
- Caro, T. 2016. *Zebra Stripes*. Chicago: University of Chicago Press.
- Elliott, J. P. et al. (1977). “Prey Capture by the African Lion,” *Canadian Journal of Zoology* vol. 55(11), pp. 1811-28. doi: 10.1139/z77-235
- Funston, P. J. et al. (2001). “Factors Affecting the Hunting Success of Male and Female Lions in the Kruger National Park,” *Journal of Zoology* vol. 253, pp. 419-31. doi: 10.1017/S0952836901000395
- Larison, B. et al. (2015a). “How the Zebra Got its Stripes: A Problem with Too Many Solutions,” *Royal Society Open Science* vol. 2. doi: 10.1098/rsos.140452
- Larison, B. et al. (2015b). “Concordance on Zebra Stripes is not Black and White: Response to Comment by Caro & Stankowich (2015),” *Royal Society Open Science* vol. 2. doi: 10.1098/rsos.150359
- Melin, A. D. et al. (2016). “Zebra Stripes through the Eyes of Their Predators, Zebras, and Humans,” *PLOS ONE* vol. 11(3). doi: 10.1371/journal.pone.0151660
- Portmann, A. (1967). *Animal Forms and Patterns*. New York: Schocken.
- Riegner, M. (1998). “Horns, Hooves, Spots, and Stripes: Form and Pattern in Mammals.” In Seamon, D. and A. Zajonc (editors), *Goethe’s Way of Science*. Albany, NY: SUNY Press.
- Ruxton, G. D. (2002). “The Possible Fitness Benefits of Striped Coat Coloration for Zebra,” *Mammal Review* vol. 32, pp. 237-44. doi: 10.1046/j.1365-2907.2002.00108.x
- Schad, W. (2012). *Säugetier und Mensch* (2 volumes). Stuttgart: Verlag Freies Geistesleben. (A translation of this book is in progress; a translation of the first edition of the book exists: *Man and Mammal*, Garden City, NY: Waldorf Press, 1977.)
- Suchantke, A. (2001). *Eco-Geography*. Great Barrington, MA: Lindisfarne Books.



20 May Hill Road, Ghent, NY 12075

NON-PROFIT ORG.  
U.S. POSTAGE  
**P A I D**  
GHENT, N.Y.  
PERMIT NO. 5

CHANGE SERVICE REQUESTED

PRINTED ON 30% PCS, FSC CERTIFIED PAPER

---

("What Is Life?" continued from p. 16)

Or, we might ask: "When we command our own limbs by the "force" of our wills, do we experience something relevant to the inner nature of the forces of physics?" Of course, in today's scientific conversation such questions are likely to be dismissed before they are seriously entertained. We already know the direction in which we want our explanations and effective techniques to run. Preferring to start with the world we know least (but can manipulate with greatest reliability), we then grow eager to reduce the "messy" life of organisms as far as possible toward the same sort of reliability.

Yet I venture to say that questions such as I have just now raised are reasonable ones, and the habit of dismissing them out of hand amounts to a refusal of the most obvious and profound mysteries bordering our science on all sides.

"Let there be questions" should be one of the most sacrosanct rules of science. We can only wonder how many worthy questions have disappeared from view by our

reluctance to take living phenomena seriously in their own terms. But the invitation remains open: nothing prevents our being receptive to what we know best. Nothing constrains us to look at the world only from the outside, as if we were unwelcome intruders in an alien landscape. We are free to embrace the gift—and the cognitive advantage—of our intimacy with nature at the very point where nature achieves, in us, its fullest expressive potentials. Surely it is here that the world we seek to know can reveal its most profound truths, if only—which seems so hard for many!—we can accept the natural dignity of our own lives.

#### *Notes*

1. Fields, Helen (2011). "An Infant's Refined Tongue," *Science NOW* (Feb. 18). <http://sciencemag.org/news/2011/02/infants-refined-tongue>.
2. See my article, "Biology's Shameful Refusal to Abandon the Machine-Organism," at [http://RediscoveringLife.org/ar/2014/machines\\_18.htm](http://RediscoveringLife.org/ar/2014/machines_18.htm)