In Context

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The Newsletter of **The Nature Institute**

#26

Dear Friends,

Human life is inconceivable without discovery, without surprises, without continual growth through new encounters, new insights, and the development of new skills. Life is movement and transformation. The power to come to terms with the inexorable flow of the context-providing world and to originate change is vital to our lives.

Much in this issue of *In Context* concerns discovery, surprise, and transformation through new insight. In fact, the main article in the Notes and Reviews section is not only about surprising discoveries that promise to transform the biologist's understanding of life, but about discoveries that themselves relate to fluidity, plasticity, and transformation at the molecular level. These are emerging as strong themes in contemporary molecular biological research — research that, due to the rapid development of new technologies and methods, is accelerating almost beyond all comprehension. The purpose of our article is merely to give you a hint of what is happening, and to point to implications that biologists in general have not yet been able to appreciate fully due to the inertia of old habits of thought.

The feature article in this issue shifts attention from the molecular level to that of common observation — observation of trees, and in particular the sugar maple and white oak. One of the main points of the article is that discovery and surprise can be mediated by the powerful tool of comparison. Looking for similarities and differences focuses one's attention in a healthy way on *what is there*, and invites endlessly detailed investigation. When we look at one subject from the vantage point of the other, we can see the first thing with fresh eyes; one image, clear in our minds, tends to make divergences in a second image "stand out" so as to be noticed more easily. The surprises that arise during this process can transform one's way of seeing.

One of the big, ongoing changes at the Institute has to do with the meeting in our experience, not of two organisms such as the sugar maple and white oak, but of two disciplines: Goethean *natural science* and Goethean *social science.* The news section contains an account detailing Craig and Henrike's recent trip to South Africa to work with Allan Kaplan and Sue Davidoff, consultants who work with professionals and organizations seeking to become change agents in a world of great social, economic, and political challenges. Allan and Sue, who previously spent three months studying at The Nature Institute, wanted Craig and Henrike to work with them in workshops involving participants from several different countries, many of them working for non-governmental organizations. There seems to be a developing hunger for such disciplinary cross-fertilization. This has been a fruitful turn *for us,* and requires a continuing transformation in our own understanding of what Goethean science is (and can be) about.

Craig Holdrege

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In Context

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Promising Themes in Molecular Biology

Stephen L. Talbott

Step back and survey the philosophical commitments evident in the major biological journals, the massive biological research community, and the huge public and private funding organizations, and you may be forgiven for feeling a certain discouragement. It sometimes seems as though the entire world of institutional biology speaks with a unified voice — a voice testifying to the apparently unstoppable inertia of an oppressive and misconceived materialism, and an obsession with explanatory *mechanisms*. And this orthodoxy has managed to erect seemingly impregnable barriers to protect itself against fundamental change.

I will not quarrel with this picture. But pay closer attention and you will hear some unexpected notes sounding a hopeful counterpoint to the monotonous drumbeat of orthodoxy. I would like to highlight, ever so briefly, a few signs of potential health and transformation, particularly in the literature of molecular biology.

Putting Molecules in Context

In one way or another nearly the entire body of current biological research at the molecular level has come down to a reckoning with problems of context. And there seems to be a growing consciousness of this fact, even if its radical implications have not yet dawned on many. For example, the editors of *Nature Reviews Genetics* recently asked, "How much complexity is being concealed by doing research on gene regulation and function in a limited range of biological contexts? ... biology is rarely simple, and studies in multiple contexts often reveal a fuller picture."[1]

Similarly, bioinformatics researcher Alberto de la Fuente, discussing the ever more vexed topic of the relation between genes and disease, reminds us that "To understand the roles of genes in complex human diseases, genes need to be studied in the context of the regulatory systems they are involved in." Further: "Gene networks are context specific: the regulatory structure among genes depends on the developmental stage, cell type, environment, genotype and disease state."[2]

And again, Neil Greenspan, an immunologist and clinical pathologist at Case Western Reserve University, wrote that "A crucial aspect of molecular function, whether with respect to proteins, nucleic acids, other macromolecules or even small molecules, is that function, as normally understood, is generally not a completely intrinsic attribute of a molecule. Most function arises out of the interactions between molecules or between forms of energy and molecules."[3]

The point may seem painfully obvious to many readers of *In Context*, yet it is laden with revelation in a world where the expression, "DNA *makes* RNA and RNA *makes* protein" has become a truism — as if a given molecule could carry the decisive responsibility for *making* anything! And so, as the reality of context and interaction — the reality that life is characterized most essentially by complex *processes*, not *things*, and that the organism as a whole is the organizer of these processes — begins to sink in, we hear countless "wake up calls" of the following sort (to take a few isolated examples):

- "The array of axonal glycoproteins acting as receptors for growth signals may be far more complex than we thought."
- "Induction of cellular immunity seems to be even more complex than we thought 15 years ago."
- "The numerous recent reports of stem cell plasticity suggest that human stem cells will be even more complex than we thought a year or two ago."
- "Obesity and hypertension–the issue is more complex than we thought."
- "Transcriptional networks for lignin biosynthesis: more complex than we thought?"
- "To explain the differences with previous renal studies on this topic, one has to point to several important differences with respect to species, type of stem cells, time course of renal injury, etc .... matters are much more complex than we thought only a few years ago ... Currently, to quote G.B. Shaw, "We have the privilege to be confused on a much higher level."

Of course, taken by themselves, such isolated remarks, extracted from a search engine, don't mean much of anything. But what strikes anyone looking at the current literature is the dramatic way virtually every topic — *every* type of molecular interaction — is being "opened up" to a wider world of exchange in previously unanticipated ways. Connections are being forged in all directions, so that the *crosstalk* between different processes has become an incessant theme, and everywhere one finds the acknowledgment that *context matters*.

The problem in conveying what is going on today is that the only way to do so is to describe the kind of contextual complexity these biologists are talking about — and this would quite naturally require extraordinarily complex descriptions! The cellular interactions are so remarkable, so extensive, so stunning in the coordinated and meaningful play of interweaving factors, that it would take a huge article to do any sort of justice to the reality of even "one" process, and that article would be stuffed with unfamiliar technical terms. I am, therefore, reduced to the unfortunate position of offering a few relatively bland generalities.

One increasingly common theme is that a given factor known for playing some particular role in a cellular process will eventually be found also to play a more or less opposite role in some circumstances. For example, there has been a great deal of excitement in recent years about "epigenetics" — and, specifically, the way various molecular groups (or "marks") attached to the protein structure of chromosomes can affect whether or how a nearby gene is expressed. It turns out, however, that not only do different marks have entirely different associations with gene expression, but the *same* mark can have quite opposite associations, depending on the context. In fact, the innumerable possible combinations of these marks are now presenting biologists with an expressive potential that begins to rival that of the genome itself. The closer we look at chromosomes, one group of researchers wrote, "the more these canonical associations between a given mark and gene expression become nuanced and idiosyncratic."[4]

But it's not just a matter of divergent pictures regarding one particular function. A striking theme in the literature has to do with the fact that almost any given element of the cell is caught up in many different functions, reflecting at its own level the overall contextual unity of the cell. For example, the FOXL2 transcription factor (transcription factors are proteins that bind directly to DNA to help regulate gene transcription) plays a major role in sex determination and female fertility; in its absence the ovaries develop characteristics of testes. But FOXL2 is also involved in the oxidative stress response, the maintenance of cholesterol balance (homeostasis), and steroid hormone production.

Likewise, the p53 protein has received huge attention as a transcription factor with a major role in suppressing tumors. Cancers often involve defects in this protein. But "emerging studies have shown that, in addition to its ability to function as one of the most important tumor suppressors, p53 also controls many other biological functions, including implantation [of the embryo in the uterus], cell-fate decisions, metabolism, and aging."[5]

Again, histones are proteins that form a crucial part of the DNA/RNA/protein complex comprising the structure of chromosomes. Many of the chemical groups ("marks") mentioned above as modifying chromosomes, attach to these histones, with dramatic effects on chromosome structure and gene expression. However, the "so-called histone-modifying enzymes have other roles in the cell beyond histone modifications."[6] So it's not just that differently contextualized marks exert different influences; it's also the case that the enzymes supplying these marks do many other things in the cell. And those enzymes in turn are powerfully affected in their function by yet other molecules that modify *them* ... and such lines of influence, when followed up, eventually merge untraceably into the sum total of the life of the organism. It's a story being told over and over in every field of molecular biology.

And as for genes themselves, they can hardly be thought of as discrete, neatly causal entities. "Diverse genetic loci are organized hierarchically into interconnected genome-wide networks which function dynamically. Not confined to a single pathway, many genetic loci are active at different times, participating in the expression of more than one phenotypic [observable] trait."[7]

In sum, the intense focus of a great mass of today's research has to do with networks, interactivity, dynamism, plasticity, and context. Nothing has just one meaning, and nothing means anything all by itself. One hears "systems biology" being invoked on every hand.

Unfortunately, in common usage "systems biology" today means little more than "we should use computers to try to track the myriad interactions bearing on any given process" — which is fine as far as it goes. But it does not go nearly far enough. Researchers typically pursue interactions in the cell and organism only to the degree they are forced to, and they consider the job done when they think they have "nailed down" local causal factors. The old governing conviction remains strong: we understand the organism by adding isolated cause to isolated cause.

But that's not how the organism works. Every organism is telling a story, not merely being "pushed around" by physical causes. This is why the biologist has to reckon with *contexts*. A collection of parts, or even of words, as in a

dictionary, is not a context in any relevant sense. It becomes a context by being woven into a coherent, meaningful narrative. And our understanding of this narrative arises, not only by considering the causal impact of part upon part or word upon word, but also by entering into the meaning of the whole as it works its way down into, and gives specific content to, all the individual words.

If biologically significant causation flows from the whole to the part, then we must learn, not merely to isolate all the words of the context, but to *think the context as such*, which is also to think the organism as such. This requires us to think qualitatively, a challenge that has as yet scarcely even been formulated as a possible goal within biology.

The Fluent Organism

The old logic — DNA makes RNA and RNA makes protein (and protein makes the organism), all operating in obedience to a kind of mechanistic encoding that originates with DNA and rules the whole organism from the bottom up — while still clearly shaping the mindset of many biologists, is now falling apart. Or, rather, it is being caught up in *fluid* movement. You can glimpse this clearly enough by reading through a single article in *Nature* that briefly traced some of the relevant history. Written in 2003, it talked about the then-dawning awareness of dynamism in the cell nucleus: DNA can "gyrate like a demonic dancer"; the nucleus presents us with "endless acrobatics" and a "subcellular waltz"; whereas the nucleus "was once thought to be fairly static ... now we know it to be a very lively place"; the knowledge of dynamism among DNA-associated proteins "changed the way we thought about the nucleus. The word 'static' is disappearing from our vocabulary."[8]

The organism is above all an organism of movement, or flow. Studies of protein movement have "revealed much more rapid and/or more extensive dynamics than would have been anticipated from either earlier in vitro ["test tube"] work, or from the apparent stasis of certain nuclear bodies, constituting a true paradigm shift in the nucleus field ... Even the nuclear lamina, which had long been viewed as one of the most stable structures in the nucleus, was found to undergo dynamic exchange of subunits ... it was amusing to recall the incredulity expressed by some that interphase chromosomes [chromosomes during the main period between cell divisions], relatively giant structures, are moving, and with no dependence on metabolic energy."[9]

This kind of dynamism is being documented in one domain after another. For example, signaling complexes "typically have half-lives on the order of seconds or less," and the all-important secondary modifications of the molecules in those complexes through the attachment of various chemical groups are "similarly dynamic."[10] The crucial transcription factors — proteins that bind to DNA in order to facilitate or repress gene expression — engage in "highly dynamic interactions ... with their binding sites on the timescale of seconds."[11] Even the structures that give cells their strength and load-bearing ability, such as the plasma membrane and the filamentous cytoskeleton, are caught up in flows. Regarding the cytoskeleton: "Recent work has demonstrated that these structures are dynamic, undergoing assembly, disassembly and movement, even when ostensibly stable."[12] And, again: "The cytoskeleton is not a fixed structure whose function can be understood in isolation. Rather, it is a dynamic and adaptive structure whose component polymers and regulatory proteins are in constant flux."[13]

But it's not just a matter of movement. The rhythm and timing of the movement are coming in for analysis, and are proving to be critically important. The transcription of many genes "has been described to occur in short, discontinuous episodes, called 'bursts'," separated by periods of quiescent resistance to transcription.[14] Perhaps more dramatically, rapid imaging of fertilization in the mouse egg has revealed that "fertilization induces rhythmical cytoplasmic movements that coincide with pulsations of the protrusion forming above the sperm head." Crucially, the character of these movements was found to predict the viability of the eggs.[15]

Oscillations have likewise been noted in key signaling pathways, and "there is growing evidence for the importance of an oscillator's frequency in controlling downstream biological events."[16] And again, "dynamic interactions between oscillators with different frequencies may be a key component of signaling cross-talk in cells. Thus, like cogs in a watch, these networks may interconnect in order to robustly regulate cell fate."[17]

This last remark illustrates the strange mix you often get when new understandings are imported into old mindsets — in this case, when the idea of living flow comes into contact with mechanistic habits of thought. The one thing we do not in fact find in the organism is anything faintly answering to the image of mechanical cogs. The rhythms of the cell are living rhythms, continually modulated by everything going on in the larger surroundings.

There is no place better than the nucleus to show how far from being a mechanism the cell is. The nucleus is populated by numerous organelle-like "bodies" — Cajal bodies, nucleoli, nuclear speckles, paraspeckles, Polycomb bodies, and so on — none of which is in fact an organelle. They all lack a surrounding membrane. But despite this fact, they retain their distinct identities. Moreover, they keep these

identities in the presence of a remarkable in-and-out flow of constituent elements. As one example: nuclear speckles play a role in the storage, assembly, and modification of splicing factors — molecules and molecular complexes that cut apart and stitch together (often in varying patterns) the premature RNA molecules that will eventually participate in the production of proteins. When the turnover rate of a particular splicing factor in speckles was measured, it proved to be on the order of 3 – 5 seconds for replacement of one half of the molecules.

Such rapidity of movement is more the rule than the exception within all the nuclear bodies. "It is a remarkable feature of nuclear organization," write two researchers, that "the overall structure of speckles, as well as other nuclear domains, persists despite the large flux of their components."[18] These bodies seem more like standing waves than mechanical structures.

Fluidity and *plasticity* coming to expression under the influence of a governing *context* — these constitute one pole of the creative tension between plasticity and limitation within which every organism finds its way through the world.[19] The pole of limitation, all too commonly thought of in terms of fixed material structure, rigid causation, and mechanistic determinism, has, of course, long held central place in the biologist's understanding. But the whole idea of a true polarity is that the opposite poles weave through each other and qualify each other. They are held in a tensive unity. Today we can hope that the foundation is being laid for a restoration of balance whereby the organism is perceived as a creature in its own right, bringing its unique character to dynamic expression within the "permissively restrictive" or "restrictively permissive" terms of its physical existence.

On context, meaning, and the organism, see my two articles, "The Unbearable Wholeness of Beings" and "What Do Organisms Mean?" available at http://natureinstitute.org/txt/st/mqual.

On the "fluency" of the organism, especially with reference to genetics and epigenetics, see "Getting Over the Code Delusion" at the same website. All three articles have also been published in The New Atlantis *and are available at http://thenewatlantis.com.*

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Contamination of Honey with GM Pollen

In September the Court of Justice of the European Union ruled on a case involving the contamination of honey with pollen from genetically modified (GM) corn. A beekeeper in Germany who kept bees in the vicinity of research plots that were grown with Monsanto's Bt corn, which is designed to kill the larvae of certain moths, had his honey and pollen (which was sold as a food supplement) tested, and small amounts of Bt pollen were found in some of the samples. He considered his product "unsuitable for marketing and for consumption" (Court of Justice of the European Union Press Release No. 79/11). As a result, this beekeeper and four fellow beekeepers started legal proceedings against the state of Bavaria, which owned the land upon which the corn was grown. The Bavarian court then sought the judgment of the EU Court of Justice.

In its ruling the EU court states that the GM pollen must be considered as an ingredient of the honey, regardless of whether it is an intended or unintended ingredient. Therefore honey or pollen supplements containing GM ingredients would be subject to a special safety and approval process stipulated for any food product in the EU that contains ingredients produced from genetically modified organisms (GMOs). All foods containing GM products must be labeled in the EU, in contrast to the United States, where there is no labeling. It would be unlawful for a beekeeper in the EU to sell honey containing GM pollen — even the smallest amounts — without having gone through the complex safety and approval process.

Most beekeepers will not want to go through this process, knowing that consumers in Europe generally do not want to consume food containing products from GMOs. But they should have other recourse. Beekeepers who find their honey contaminated and can therefore no longer sell it, can take a legal route to receive compensation from the farmers who grow the GM crop and the company that produces the genetically modified crops. In other words, Monsanto will have to pay beekeepers for their losses due to the contaminated honey.

Another consequence is that the large amounts of honey imported from Argentina, Canada and other countries where GM crops are grown, will be subjected to new scrutiny. The waves from this ruling will ripple far beyond the European Union.

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Genetically Modified Corn Is Leading to Insect Resistance

Bacillus thuringiensis is a soil-dwelling bacterium some strains of which produce a crystal protein useful as a natural insecticide. The crystal toxin, known as "Cry," is effective against many moth and butterfly species, as well as mosquitoes and some flies, beetles, and other insects. It has been one of the most effective insect-control agents for organic farmers.

The bacterium itself has been used as an insecticide, but the Cry toxin can also be extracted and sprayed over crops. More recently, genes to produce the toxin have been altered and engineered directly into agricultural crops and approved for general use in the U.S., beginning with the potato plant in 1995. In such cases, for the most part, cells throughout the plant contain the toxin during the life of the crop, regardless of the presence or absence of threat from the targeted insect. Globally, 11.1 percent of corn plantings and 33.6% of cotton were "Bt crops" (genetically modified to produce the Cry toxin) in 2006. The figures today are vastly greater in the U.S.: 65 percent of corn in 2011 and 75 percent of cotton — this according to the Department of Agriculture Economic Research Service.

But now the inevitable is happening: due to this massive application of insecticide over huge crop areas regardless of actual need, the destructive pests are becoming resistant. The engineered Bt toxin can be targeted against different insects, and in 2003 a commercialized variety of corn with a form of the toxin known as Cry3Bb1 was developed for resistance to corn rootworm larvae. It was rapidly adopted by farmers, already amounting to 45 percent of corn plantings by 2009. However, as an article published in the July issue of the scientific journal PLoS One announces, "The evolution of resistance by the western corn rootworm could cut short the benefits of Bt maize [corn]."

The authors of the study, all from Iowa State University in Ames, Iowa, tested larvae of rootworms taken from fields

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Nature Institute Events

Depending on when you receive this newsletter, the following events at (or near) The Nature Institute may still be forthcoming:

• *Goethean Explorations of Light, Darkness and Color*, a course with Henrike Holdrege (Mondays, November 14 & 28, and December 5 & 12). This course is designed for the Free Columbia Art Course with limited space available for others to join. We will work from direct observations and explore color phenomena within the natural world.

• *Franz Marc: A Painter in Search of the Being of Animals*, a talk by Craig Holdrege at 11 Maple Avenue, Philmont, New York (Tuesday, November 29, 2011, three miles from The Nature Institute). Craig will discuss and show slides of the work of early twentieth century painter, Franz Marc. As part of the expressionist group, "The Blue Rider," Marc strove to express something of the essence of animal nature in his paintings. The talk is offered as part of the Free Columbia Art Course.

• *Guided Night Sky Observation* with Henrike Holdrege (only on clear nights); November 12 & 21, December 12 & 19.

Winter 2012 Intensive: Cultivating Perception and Flexible Thinking

This course from February 12 – 17 with Craig and Henrike is intended for farmers, gardeners and others interested in developing a deeper relation to the land and plants.

Can we learn to perceive and understand nature in a truly ecological way? Can we understand plants as dynamic beings that relate to the earth and cosmos in which they are embedded? Can our thinking become as alive as nature herself? These questions will guide the activities in this course. To stimulate the transformation of our capacities, we will carry out exercises in flexible thinking and careful observation. We will engage in explorations of the qualities of plant form and growth and also become familiar with the rhythms of the sun, moon, and planets in relation to the fixed stars.

This course will be held in collaboration with the Biodynamic Farming and Gardening Association and Hawthorne Valley Farm. For registration information about this intensive as well as an additional week-long course devoted to biodynamic agriculture, contact Hawthorne Valley Farm Learning Center: 518-672-7500 x252; caroline@hawthornevalleyfarm.org

Mathematics Alive!

Henrike and Marisha Plotnik will lead this workshop for middle school teachers on March 16–18, 2012 (Friday, 4 pm to Sunday noon). Marisha is an experienced high school math and physics teacher and a middle school math teacher at the Rudolf Steiner School in Manhattan. Contact The Nature Institute for more information.

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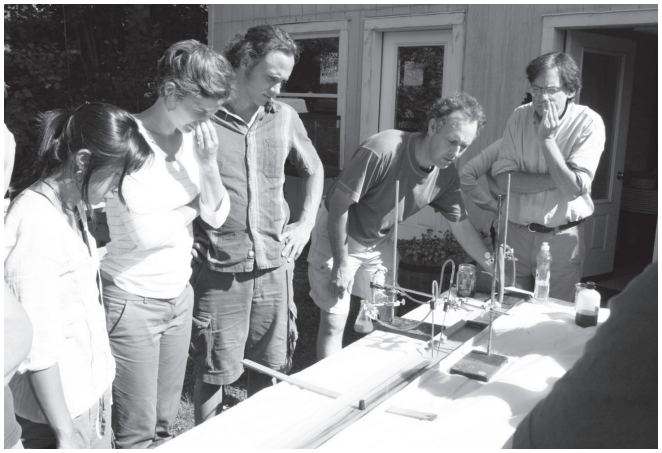
The following events have taken place since publcation of the last issue of In Context:

Professional Development for Science Teachers: Forming Living Ideas & Learning through Experience

In early July, a dozen science teachers from around the country and abroad came together at The Nature Institute to explore how to invigorate science teaching. The course aimed to cultivate the teachers' capacity to help students experience phenomena from a variety of perspectives, and where direct experience is not possible, to portray phenom- ena in a way that engages the students in their thinking, imagination, and feeling. This year we focused on water and fluidity. We observed and considered water from a variety of perspectives and worked to characterize and form a vibrant concept of this special fluid that is so fundamental to life. We worked collaboratively to try to



understand how our thinking as scientists can become more fluid and how as teachers we can become more conscious of flow and rhythm in teaching. Diverse experiences and experiments, as well as a daily seminar with Jon McAlice on pedagogical themes, provided ample opportunity for teachers to enrich and revitalize their teaching capacities. Here are some reflections offered by three participants in this summer's course:

I continue to find this course enriching and enlivening. The substance of the program continues to help me to develop my teaching. Equally important is the confluence and shared presence, questions, experiences, etc., of the participants who are all attending to develop in their profession as science teachers.

As with any good course, I have more questions now than when I arrived...I know these questions will find their way into my teaching...the more questions I have, the better a teacher I am.

The course, as in years past, is fertile ground for me in terms of ideas for my own teaching. Practicing the observation helps wake something up — an awareness, or thoughtfulness — that I would like to bring into my classroom. I find inspiration here for ways I can develop and improve my teaching.

Public Summer Course: Polarities in Nature and the Nature of Polarity

Thirteen participants from the U.S. and abroad gathered at The Nature Institute in mid-June to explore the nature of polarity. The course guided the participants on a path of discovery through dialogue and experiences of polarities in the world. Through practical exercises the group carefully attended to polarities, discovering the dynamic tension, relation and movement between "opposite" poles as an essential feature of all life, without which the world would be static. One participant shared this thought: *"I'll not feel lonely with my little Goethean trials in class anymore. If I do, I'll remember there is a concrete community of people striving for this approach."*

The course included projective geometry, observation exercises, and phenomenological explorations of polarities in plants, animals, and the human being. We also did clay modeling each afternoon with Nathaniel Williams. This rich curriculum enabled participants to deepen and enliven their awareness of polarities as creative and generative forces in the world.

Goethean Science and Social Process

Craig and Henrike spoke to the local community in late September about how the Goethean approach, commonly applied to the natural sciences, also bears fruit for the perception and understanding of social relations and processes. This talk arose out of Craig and Henrike's experiences during their trip to South Africa, where they worked with the Proteus Initiative. They also showed slides of the unique flora and landscapes in the southern Cape region. (See the separate report in this issue.)

Rudolf Steiner and Natural Science

Craig gave a talk as part of the Oct 21–23 weekend celebrating Rudolf Steiner's vision, sponsored by the Berkshire-Taconic Branch of the Anthroposophical Society. Craig discussed Steiner's view of natural science: its significance in the evolution of human consciousness and the importance of a further development of science as exemplified by Goethean phenomenology.

"Sowing the Future"

In collaboration with our neighboring Hawthorne Valley Farm, The Nature Institute sponsored for the third year an event in early October to raise awareness about local agriculture. The main activity was hand-sowing a field of hard red winter wheat at Hawthorne Valley Farm.

Out and About

Experiential Math and Science in the Middle School. Henrike Holdrege taught a weeklong course (three sessions per day) at the Sunbridge Institute in Spring Valley, New York, in June. It was attended by eleven educators (middle school and home-schooling teachers) and dealt with middle school geometry, astronomy, and optics and color. Both method and content were discussed, and participants were treated to an array of experiments, demonstrations, and activities that they can use for their teaching.

In October, Craig participated in the annual meeting of the ***International Association of Environmental Philosophy*** in Philadelphia. He participated in a panel, along with Luke Fischer (University of Sydney) and David Macauley (Pennsylvania State University, Brandywine), on "The Seasons: Phenomenological and Environmental Perspectives." Each of the three panelists spoke about a particular aspect of the topic. Craig addressed "The Seasons Embodied: The Story of a Plant." (*In Context* readers might not be surprised to hear that Craig spoke about the skunk cabbage.)

Henrike and Craig traveled to Toronto in November to give a public weekend workshop on ***Learning to See the World of Life.*** The workshop is sponsored by the Christian Community.

Craig will participate in a weekend invitational conference on ***phenomenological science and science teaching*** with experienced high school science teachers from western North America. The conference will take place in January 2012 at the Summerfield Waldorf School in Santa Rosa, California, and is co-sponsored by the Center for Contextual Studies and The Nature Institute.

At the end of January Craig will travel to Viroqua, Wisconsin, to lead a workshop for biodynamic farmers on ***Schooling Observation & Thinking: A Goethean approach to studying plants and animals.***

In early April Craig will give a weeklong course at an International Conference for Waldorf High School Teachers in Kassel, Germany. His topic will be ***Schooling Observation and Thinking: The Foundations of Science Education.*** He will also give a talk to the 200 or so conference participants on "What is Education For?" This conference attracts people from many European and also Asian countries where professional development courses are not available. Half the courses are given in the English language.

A Trip to South Africa

When Henrike and I arrived on July 29 at the airport in George, South Africa, the sun was just setting. Our friends and colleagues, Sue Davidoff and Allan Kaplan, picked us up and drove us to the Towerland preserve, where we would spend the next two weeks. Looking up at the night sky we saw Scorpio straight overhead. To the south in the sky were many bright stars, the part of the southern sky that we never see at home. In the middle of the night we got up and saw Orion—the constellation appeared, in relation to how we see it in North America, upside down and right-side left. I couldn't get used to that! Sirius, the brightest of all fixed stars, was *above* Orion. These celestial experiences told us that we were on a different part of the planet—we knew we were in the southern hemisphere. When you look to the heavens you can know where you are on earth.

The beautiful but simple retreat center (no electricity) that Sue and Allan have built over many years lies on the cusp between agricultural land (mainly livestock farming) and the pristine fynbos wilderness. The fynbos is a unique floral region in the Cape area of South Africa with hundreds of indigenous plant species and a remarkable diversity of plants. Just try to imagine over 600 species of heather (the genus Erica). The fynbos consists mostly of shrubby vegetation, characterized by the heather family, the protea family (Proteaceae), a family of grass-like plants called Restia (Restionaceae), and geophytes (bulb producing wildflowers such as amaryllis, gladiolas, and lilies). We arrived in early spring and each day new flowers opened to greet us. It was a feast for any plant lover's eyes. But I shouldn't forget the birds: there are also endemic bird species, and in particular we were able to observe the sugar

Towerland Retreat Center, South Africa. Above: outside looking up into the Fynbos. Below: participants at work inside the elliptically shaped course room.

birds and sunbirds close-up — they were not shy. They feed on the nectar-rich flowers of ericas and proteas and pollinate them.

The first week at Towerland was facilitated by Sue and Allan, while Henrike and I were participant observers. The topic was "Building Living Thinking into a New Social Practice." Most of the twenty participants work either as consultants for NGOs or within NGOs that are concerned with social justice, the environment, or both. Most were from South Africa, but there were five Brazilians, as well as individuals from New Zealand, Germany, and the UK. For many years Sue and Allan have worked as consultants to help organizations find their way through difficult situations and to develop practices than can help them become more conscious of the living and evolving organic nature of organizations. In this work they have been inspired by Goethe's approach, which is why they spent three months in 2002 working with us at The Nature Institute.

The purpose of this week was to bring together people familiar with the way Sue and Allan work — in part people who had studied with them. Through consideration of case studies brought by different participants, the aim was to see how this Goethean-inspired practice has become part of practioners' work and to distill some of its essential characteristics — without making it into a schematic "toolkit" or method, which, evidently, often happens. It was clear in the way that Sue and Allan facilitated the process during the week that they were keen to keep it as alive as the complex social phenomena we were considering.

The second week had the theme, "Towards a Thinking which is Alive," and was led by Henrike and myself. Half of the participants from the previous week stayed on for this course and a dozen new participants joined us. Henrike led us each day through exercises in geometric transformation, while I led plant study and facilitated dialogue concerning Goethean methodology. It was wonderful to have the diverse fynbos plant world right outside the classroom door so that we could get to know this unique plant community while also exploring phenomenological methods.

During these two weeks we were enriched by meeting all the different people and by dwelling within a remarkable natural environment. One experience we had during the two weeks was in a sense the capstone for the time we spent in South Africa. Over the years, Sue and Allan had discovered in the Towerland wilderness area different rock overhangs and small caves with ancient paintings from the San people (also called Bushmen). As we stood before these paintings we were in awe. The delicacy and dynamics of the seemingly simple figures and scenes were stunning. There were small figures and large figures, dancing groups, family groups, a variety of animals — elephants and antelopes being most prevalent — and forms that were both human and animal. We felt in a sense transferred into the different time and conscious-

ness of these ancient people who brought their intimate relation to the world into these paintings. Their presence was still discernable as a deep feeling, a feeling that can connect us as modern human beings with our fellow humans who lived here hundreds and thousands of years ago.

Mid-August found us in Cape Town. There we gave a public weekend workshop with 25 people on "Transforming Thinking," which was sponsored by the local anthroposophical society. After that I led a three-day workshop with 20 participants on "Seeing Nature Holistically," which focused on plant study. A certain culmination of both these workshops — applying differently to each of them — was the study of plants that belong to the Protea family. This remarkable family is represented by hundreds of different species in the fynbos. After we had looked carefully at the more typical flowers of other plants, we were prepared to discover what open secrets the Protea flower has to reveal. The Proteas we observed appeared to have big flowers, but with more careful study we discovered that these "flowers" are in fact flower heads consisting of many, often colorful and feather-like bracts surrounding numerous highly reduced flowers. The Protea showed us how "inventive" the plant world is, modifying its leaves into flower-like forms, and reducing its flowers to linear structures. The father of plant taxonomy, Linnaeus, probably had little idea how on-target he was when he named this family "Proteaceae," taking Protea from the Greek God Proteus. Proteus is the God of the sea who can take on all shapes, disguising himself and yet remaining himself in every guise. It was Goethe who came back to Proteus as the image he used in describing his discovery (that is, intuition) of the archetypal plant, when he wrote: "It came to me that in the organ of the plant which we are accustomed to call the leaf the true Proteus lies hidden, who can conceal or reveal itself in all formations. Forward and backward, the plant is always only leaf" (*Italian Journey,* 1982, p. 363; translation modified by Craig Holdrege). In our explorations of Proteas we were confronted with one of those special guises of the plant and were rewarded with a sense of joy and appreciation when we were able to more clearly discern the characteristics of this unique expression of plant-being.

Craig Holdrege

The flower heads of two different species of Proteas: left, ***Leucospermum cuneiforme*** and right, ***Protea repens***, commonly known as the sugarbush, since it contains copious amounts of nectar that birds and other creatures feed on.

Credere Grant in Goethean Phenomenology

This year The Nature Institute sponsored a $1,000 grant in Goethean Phenomenology. The funds were donated to The Credere Fund of the organization Think OutWord, which has a number of grant programs. This is the second year of the Goethean Phenomenology grant program. The 2011 application deadline was October 15 and the grant recipients will be announced in early December. For more information about the Credere Fund or to donate to support the grants, visit www.thinkoutword.org/ grants.html.

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Phenomenon Illuminates Phenomenon
White Oak and Sugar Maple

Craig Holdrege

In all Nature Institute adult education courses we study natural phenomena and also the phenomena of thought. We attend closely to the morphology of a plant, to the way colors arise in a stream of smoke, to the flow of water in a creek, to the form of the cube that we build up in our imagination, or to the kinds of thoughts we apply when thinking about an organism. Often, after attending to a particular phenomenon for a while, we shift our attention to a different, but related phenomenon. In geometry we compare the cube with the sphere, or modify a construction and view variations in relation to each other. We practice different techniques of drawing the same thing: we draw the leaf as a "body" and then we draw the negative space around the leaf. We compare different plant species with each other or specimens of the same species that grow in different environments. We compare different plant communities and environments (e.g., meadow, woodland swamp, bottomland forest, upland forest). We have also compared a machine with an organism, a rock with a plant, a plant with an animal, or still water with flowing water.

It is often through comparison that the unique qualities of a form, a movement, or an organism begin to strike us. The character of meadow plants jumps out at us when we go into the woods and observe the herbaceous plants there (Holdrege, 2002). In all the work of this kind our experiences of the world grow when we allow different phenomena to illuminate one another. In this article I want to highlight this comparative approach and show how it helps us deepen our understanding of two tree species, the white oak (*Quercus alba*) and the sugar maple (*Acer saccharum*). In two Nature Institute summer courses we have carried out comparative studies of these two trees, and I will base my descriptions on that work while also drawing on studies of my own.

When you go out and explore the area around The Nature Institute, you can find and observe both species of trees at roadside and meadow edges. The white oak has a tan, scaly bark that becomes furrowed in larger, older trees. Free-standing white oaks are often broader than they are high. This has to do with the fact that the main trunk sends off numerous long and thick, horizontally oriented branches. It's hard to fathom the strength that allows such growth.

The wavy-lobed oak leaves are alternately positioned along the length of the end of a branch or on side branches. Near the base of a given branch the leaves are first fairly close to each other, then become more widely spaced, only to become tightly bunched (usually three to five leaves) near the tip of the branch. The leaf stalk is very short and thick. Near its base the leaf blade begins to spread out and then forms the oval-shaped lobes. The lobes have different sizes; generally the largest lobes are about two-thirds of the way out on the leaf. The leaf is usually longer than wide, although there are exceptions. In fact, the white oak leaves vary strongly along the course of a branch and even more strongly between individual trees. Another feature of

Fig. 1. Free-standing white oak (Quercus alba) in winter.

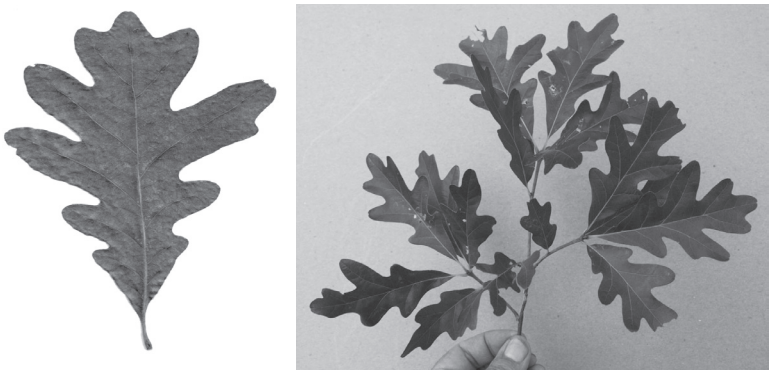

Fig. 2. White oak: end of a branch and a single leaf.

the oak leaf is that the surface of the individual leaf is often bowed and wavy, making it somewhat three-dimensional.

Now we shift our attention to the sugar maple. It has a gray bark that is generally smoother than the white oak's; with aging it becomes more irregular with long, rough, and wavy, streak-like bands of darker gray. A free-standing sugar maple's branches tend to grow in a flowing upward and outward reaching gesture, creating a conically formed crown.

The leaves of the sugar maple grow off long, slender side branches and are paired on opposite sides of the branch. Usually two pairs of leaves emerge from the end of each slender side branch. The individual leaf of the sugar maple has a long, sturdy—but not stiff—leaf stalk. It arches outward, and from it spreads the multi-pointed leaf blade (Figure 4). The leaf blade is about as long and wide as the leaf stalk. It is quite symmetrical, and the pointed lobes radiate out from the veins that originate at the base of the leaf blade. The leaf margin itself is smooth.

Already these initial observations show how different these two trees are from one another. However, as we learn more, the danger arises that we will get lost in all the details that these trees can show us. Do we see the oak or the maple in the midst of all their individual features? I always come up against this problem in research, and we experience it in our courses: after describing many details of a plant, we can feel like we have found many interesting things but have also lost something of the fresh sense of the plant. Likewise, in comparing two plants we can end up with a catalog of differences rather than something that speaks "white oak" or "sugar maple." There is no simple way around this problem. In fact, if we try to skirt it by avoiding analysis, we won't take in carefully enough what the phenomena have to reveal. So what can we do?

This is where the practice of what Goethe called "exact sensorial imagination" comes in (Goethe 1995, p. 46; Holdrege 2005). When we have observed, say, the leaf of a white oak carefully, we make the effort to form a vivid picture of it without having the plant in front of us. We re-create in our mind's eye an image of what we observed. It is not the point simply to produce a kind of photographic image, but rather to craft the image through inner movement so as to participate in the color, form, texture, and other qualities. If we can inwardly feel the solidity of the short leaf stalk, sense the undulating plane of the leaf that expands out into lobes, dwell in the leaf's particular shade of grayish green, then in this process of willful re-picturing the oak becomes part of us. We connect strongly with our perceptions and they become dynamic. A leaf is no longer just a finished form; in recreating the form in our minds, we fashion a movement that takes on form, just as in the developing organism all forms arise out of morphogenetic movements. The forms and colors can become gesture-like qualities.

The fruits of the regular practice of exact sensorial imagination show themselves in a number of ways. First of all, I often notice that I haven't observed carefully: how long is the leaf stalk in comparison with the leaf blade? Is the margin of the leaf actually smooth? I am motivated to go back out and observe and attend to the phenomenon again and more attentively. Second, the practice brings the phenomena I have observed to greater life within me; I don't feel so separate from them. They are no longer so distant from me, not so "over there." Third, I notice how after some time my observing itself changes—I begin to perceive forms, structures, and colors during observation more vibrantly. I can sometimes immediately participate in them and they begin to speak. And they speak more when I move back and forth in my observation and inner picturing between two contrasting phenomena—such as the oak and maple. This is why the comparative method is so helpful.

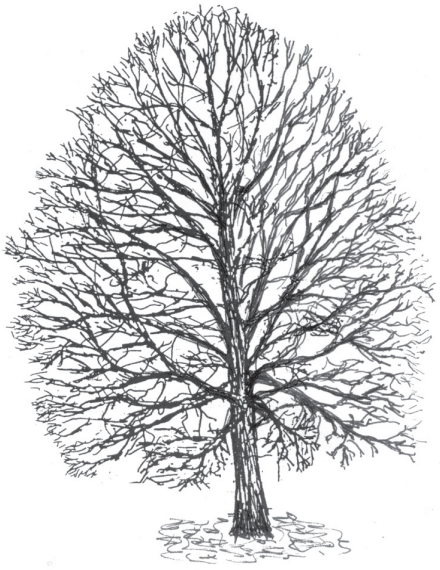

Fig. 3. Free-standing maple (Acer saccharum) in winter.

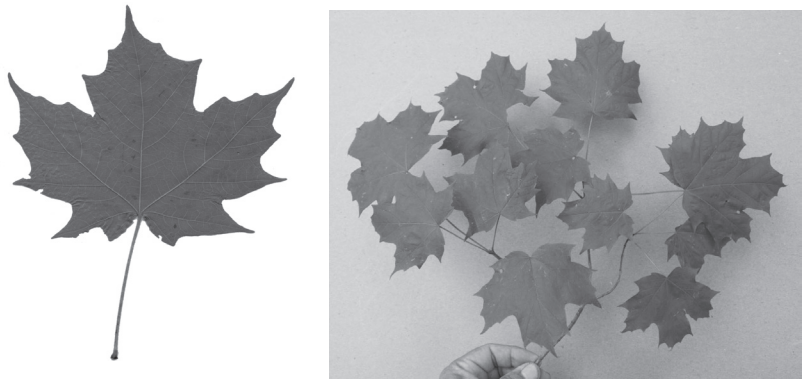

Fig. 4. Sugar maple: end of a branch and a single leaf.

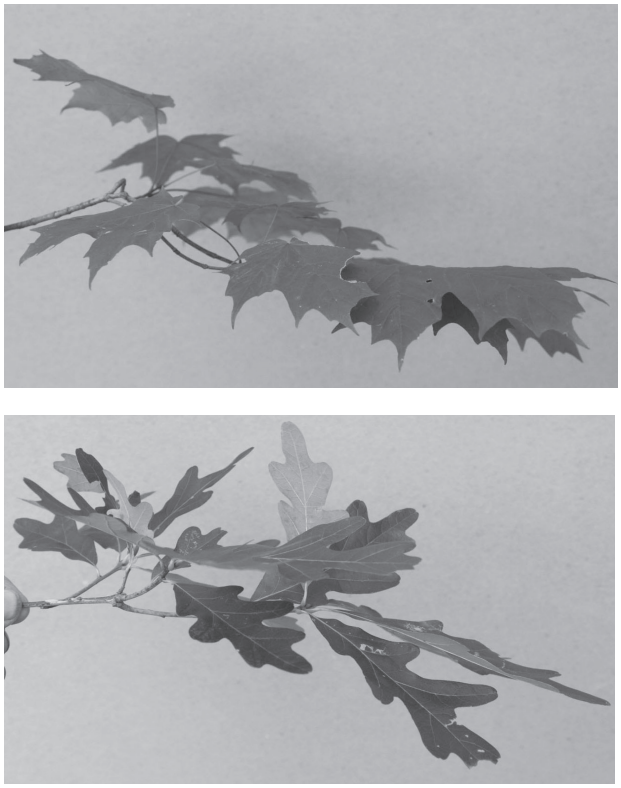

Fig. 5. End portion of branches of sugar maple (above) and white oak (below), viewed from the side.

In one particular Nature Institute summer course we were observing and comparing the end portions of the limbs of white oak and sugar maple. I requested that the participants re-picture what they had observed before we resumed our study the next day. When we returned to the tree limbs the next day there was a kind of "aha" experience for the group. We had noticed that the leaves of the maple spread out more or less in a plane and that they are fairly evenly spaced from one another. In other words, the totality of the leaves on the whole branch form a kind of "superleaf." This planar quality of individual maple leaf and leaf arrangement on a branch spoke all the more strongly when we looked again at the oak.

What a contrast: the oak leaves are bunched in tiers and irregularly spaced so that the end branches are less planar and more three-dimensional. And then we noticed that the surface of the individual oak leaf is also less planar; its surface undulates. In seeing these connections—which are only visible to the active and receptive mind's eye—we had the experience of beginning to meet the oak and the maple. As one participant remarked in a review of the course: "I found the tree leaf studies so amazing yet simple—I found practicing the inner transformations so helpful. Then there were the sudden revelations like the plane-like aspects of maple leaves and branches."

When you look up into the crown of a white oak you see much more sky than when you look up into the crown of a sugar maple. The sugar maple creates a relatively even, shady environment, whereas beneath the white oak the ground is dappled with patches of shade and bright light. The sugar maple is highly shade tolerant and can grow up, albeit slowly, within a dark forest canopy. The white oak not only lets more light reach the forest floor, but also needs more light to thrive (Niinemets & Valladares 2006; Canham et al. 1994).

Interestingly, when maple branches of a free-standing tree or of a tree at the edge of a forest are illuminated by

Fig. 6. Looking up into the crowns of a sugar maple (left) and a white oak (right).

direct sunlight for much of the day, they give up the planar tendency to some extent and grow more into three dimensions, just as oak branches in greater shade become more planar. Such observations bring awareness of the flexible, context-sensitive nature of organisms.

When you continue to study these trees, more features of their inner coherence become apparent. In the maple we perceive the extending outward of the long slim stalk and the symmetrical spreading into the finely formed, pointed lobes of the leaf blade. The clarity of form in the sugar maple is also expressed in the regular, opposite arrangement of the leaves and in the V-shaped branching pattern of the limbs: each year the terminal bud dies, so that two branches (originating from the pair of buds just prior to the terminal bud) form a V-shape, then grow further, branch again in a V-shape and so on.

This symmetry and clarity of expression contrasts with the oak's leaf, which is characterized by the flowing oscillation between lobing out and holding back in the spaces between the lobes. The leaf surface itself is wavy, and in texture the oak leaf is more leathery, the maple leaf thinner and more translucent. The dynamic, irregular lobing in the individual oak leaf is mirrored in the oak tree's leaf arrangement described above—many leaves grouped in three-dimensional bunches that form areas of concentration separated from other bunches by empty space. This is, you might say, a branch-level expression of the alternation of concentration and open spaces ("indentations") that we can see in the lobing of each individual leaf.

When we look at the fruits of white oak and sugar maple, the contrasting ways-of-being of the two tree species become even more apparent. The sugar maple has a light and symmetrical, winged fruit. The fruit dangles from a stalk and flutters in the wind. When released at maturity, it spins in an airy dance while falling in spirals to the ground. The acorn is formed out of a woody, scaled cup that holds a nut. The nut is formed in one year, overwinters, and then grows and matures during the second summer. The weighty acorn falls to the ground in the autumn. In the fruits, we see new expressions of the outward spreading, radiating, planar tendency of the maple and a tendency toward densification, three-dimensionality, and concentration in the white oak.

Fig. 7. Fruits of sugar maple and white oak.

Through this work we begin to see the unique expression of each species. We recognize how each species has a unified quality and, although we may not see this in all aspects, we at least get a glimpse of the organism as an integrated whole. This is an invigorating experience.

In his 1844 essay *Nature*, Emerson describes beautifully the significance of meeting the world through perception:

> It seems as if the day was not wholly profane, in which we have given heed to some natural object. The fall of snowflakes in a still air, preserving to each crystal its perfect form; the blowing of sleet over a wide sheet of water, and over plains, the waving rye-field, the mimic waving of acres of houstonia, whose innumerable florets whiten and ripple before the eye; the reflections of trees and flowers in glassy lakes; the musical steaming odorous south wind, which converts all trees to windharps; the crackling and spurting of hemlock in the flames; or of pine logs, which yield glory to the walls and faces in the sitting-room,—these are the music and pictures of the most ancient religion.

While many people are deeply moved by the grandeur of a sunset or a rainbow, it is less likely that we will be moved by seemingly insignificant phenomena that appear everywhere in nature. They can all too often become "mere facts" for us. It is clear that to see more than the profane in nature depends on our state of mind. Can we become so sensitive, receptive, and alive that the living qualities of nature speak to us? To move from a distanced to a participatory relation to things involves activity on our part and I have tried to describe this activity:

We go out to the plants and study them carefully; we activate our senses and dwell with the phenomena. We make our meeting with the plant more vivid, concrete, and connected with ourselves through practicing exact sensorial imagination. We oscillate between direct observation and re-picturing. When we have worked with one plant for a while, we engage with another. We carry the experience of the first plant with us. It can help us recognize the special features of the second plant. Through our comparing and contrasting, the plants mutually illuminate each other. The more intensively we have experienced one plant, the more the meeting with the next will tell us and it, in turn, will work back into our understanding of the first plant.

What is important is that we do not carry the picture we have formed of one plant as a kind of standard against which we measure the second plant. We don't judge one phenomenon through the other. Rather, we need to carry our experience as an illuminating gaze, as an enriched inwardness that allows us to see more in the world. So when I say that the method is to let phenomenon illuminate phenomenon, we can't forget that we ourselves are the mediators of this process. The quality and degree of illumination depends upon us—how closely we have studied the phenomena, how vividly we have connected with them and internalized them, and how able we are to let past experiences metamorphose into sources of illumination for revealing the qualities in the next phenomenon we study. Inasmuch as we work in this way, the profane veil that dulls our view of the world falls away.

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(continued from p. 7)

of Cry3Bb1 corn where farmers reported severe root injury. These larvae demonstrated in the laboratory that they were indeed more resistant to Cry3Bb1 than larvae taken from control fields where no injury was reported. Further, the resistance increased with the number of years the transgenic corn had been grown in these fields.

One strategy that is supposed to at least delay the onset of resistance is the interplanting of "refuge" fields between transgenic fields. This provides an opportunity for nonresistant insects from the refuges to interbreed with any that may be developing resistance from the Bt fields, thereby diluting the resistance. However, the researchers note that "a lack of compliance in planting of refuges has been documented among farmers that grow Bt maize in the United States." They also refer to other recent reports of resistance. "Typically there is a lag between the introduction of an insecticide and the first occurrence of resistance, which is then followed by a steady increase in the cumulative number of occurrences."

The strategy of the biotech seed producers will surely be to develop new and more powerful Bt crops. But this is an unsustainable strategy since it entails continually creating problems (new forms of resistance) by trying to solve them with the same means that caused them (new Bt crop varieties). This seems, unfortunately, to be the standard approach for modern, business-driven ways of dealing with complex problems. And to make matters worse, as scientist and biotech critic Charles Benbrook notes, "traditionally, about two-thirds of corn acres have not required an insecticide spray application."

SLT & CH

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From Mechanism to a Science of Qualities

The papers collected here are part of a work in progress by Stephen L. Talbott. They are attempts to describe our reigning (and mostly unconscious) cognitive habits, the limitations of conventional science, and the redirections required for a new, qualitative science. By virtue of its qualitative character, such a science will be holistic and irreducibly ethical (or unethical).

These papers may be continually revised. I have placed them here in order to invite the most thorough criticism possible. Send any comments you have to stevet@netfuture.org. You can also write me at The Nature Institute, 20 May Hill Road, Ghent NY 12075.

The general public still seems largely unaware of it — and even many scientists have not fully picked up on its true significance. Nevertheless, the ongoing transformation of molecular biology, including but by no means restricted to the "epigenetic revolution" that has lately been entering the news — is rewriting our understanding of the living organism. The new developments do not mean merely that one more layer of "control" is laid on top of DNA. What they really require is a radical reconceptualization of biology — and indeed of science in general — that may rival any paradigm change of the past. This ongoing series of papers is my attempt, first, to sketch the actual findings of the molecular biologists (with a focus on gene expression), and then, in later parts of the series, to bring out the significance of these findings.

Yearnings for holism have periodically surfaced among biologists over the past few hundred years; it looks as though we are finally reaching a position where even the hardest core of biology demands that those yearnings begin to be satisfied.

Getting Over the Code Delusion: Biology's Awakening

- Published in *The New Atlantis* #28 (summer, 2010), pp. 3-27

The Unbearable Wholeness of Beings

- Published in *The New Atlantis* #29 (fall, 2010), pp. 27-51

What Do Organisms Mean?

- Published in *The New Atlantis* #30 (winter, 2011), pp. 24-49

Evolution and the Illusion of Randomness (forthcoming)

Glossary of Epigenetics — also accessible by clicking on technical terms within the main articles

More Relating to the Organism

- Logic, DNA, and Poetry. What would happen if geneticists took the genetic *text* seriously? A look at the appeal to word, text, and information in genetics and also in artificial intelligence.
- Ghosts in the Evolutionary Machinery. The strange, disembodied life of "digital organisms" tells us a good deal about certain tendencies of science today, including the tendency of professed materialists to seek comfort in a science of the abstract and immaterial.

  A version of this paper was published in *The New Atlantis* #18 (fall, 2007), pp. 26-40. Christoph Adami, a leader in the field of digital organism research and co-author of a paper in *Nature* that I criticize in my article, wrote a response in *The New Atlantis*. You'll find both Adami's response and my rejoinder there.
- Can the New Science of Evo-Devo Explain the Form of Organisms?

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Winter Intensive for farmers, gardeners and others who love the land

February 12–18, 2012, with Craig Holdrege & Henrike Holdrege

See description on page 8 of this issue. This course is held in collaboration with the Biodynamic Farming and Gardening Association and Hawthorne Valley Farm. For registration information about this intensive and an additional week-long course devoted to biodynamic agriculture, contact Hawthorne Valley Farm Learning Center: 518-672-7500 x252; caroline@hawthornevalleyfarm.org

Coming Alive to Nature: Practicing the Goethean Approach to Science
Public summer course

June 17–23, 2012, with Craig Holdrege, Henrike Holdrege & Nathaniel Williams

Our public summer course is for people from all walks of life and will provide a practical introduction to Goethean phenomenology in which we explore phenomena from the natural world and work to develop a living thinking modeled after the dynamism of the natural world.

Bringing Science to Life
Professional development for science teachers

July 8–14, 2012, with Craig Holdrege, Henrike Holdrege & Jon McAlice

A course to stimulate the practice of science teaching as an experiential, open-ended process that empowers students to think and perceive for themselves. Collegial exchange and concrete scientific exploration are essential parts of this course.

Please contact us early in 2012 for brochures and registration forms for the summer courses:
(518) 672-0116 or info@natureinstitute.org or visit our website http://natureinstitute.org.

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