In Context

Number 27 Spring 2012

The Newsletter of **The Nature Institute**

#27

Dear Friends,

With this issue we take you far and wide—in more than one sense. Geographically, we range from Kenya and other East African nations to South Africa to New Zealand to Boston.

Craig's feature article looks at the remarkably healthy transformation of hundreds of family farms in Kenya and elsewhere. The transformation has been brought about through the efforts of a nonprofit scientific organization, its funders, and the intense involvement of many local participants. The project combines scientific sophistication with a sensitivity to the human requirements for a renewal of agriculture. Craig finds in the effort a number of lessons for effectively bridging the gap between an initial scientific vision and the meeting of the concrete needs of actual people.

In our opening article, we take you to South Africa, where Craig and Henrike worked in the Towerland Wilderness with Allan Kaplan and Sue Davidoff of the Proteus Initiative. Here the reach was not only geographical, but also cross-disciplinary. Allan and Sue have brought their interest in Goethean methods to bear on their work as facilitators of social and entrepreneurial transformation. Our article tells the story of one participant in workshops that Allen, Sue, Craig, and Henrike conducted. This participant—Gael is her name—has been in charge of a New Zealand government program to stem the tide of domestic violence in the country. It was a problem few people close to it were willing to talk about. You will be fascinated to hear of the productive methods Gael and her team—influenced by Goethean methods—were able to employ so successfully in taking up their huge challenge.

And, with a different sort of travel, we introduce you to some of the research making headlines in the molecular biology world. In particular, the field of bioelectricity—long a topic "far, far away" relative to the biological mainstream—has received a "jolt" as a result of dramatic research being carried on by scientists at Tufts University's Center for Regenerative and Developmental Biology, near Boston. We'll give you some idea of what that's about.

All in all, an issue of rather far-flung adventures. We hope you enjoy them.

Craig Holdrege

Steve Talbott

The Nature Institute

Staff
Linda Bolluyt
Sarah Hearn
Craig Holdrege
Henrike Holdrege
Stephen L. Talbott

Adjunct Researchers/Faculty
Jon McAlice
Nathaniel Williams
Johannes Wirz

Board of Directors
John Barnes
Douglas Feick
Craig Holdrege
Henrike Holdrege
Jan Kees Saltet
Signe Schaeffer
Jeffrey Sexton
Douglas Sloan

Board of Advisors
Will Brinton
Ruth Hubbard
Gertrude Reif Hughes
Wes Jackson
Andrew Kimbrell
Fred Kirschenmann
Johannes Kühl
George Russell
Langdon Winner
Arthur Zajonc

In Context

Editor: Stephen L. Talbott
Layout: Mary Giddens

Single copies of *In Context* are available free while the supply lasts. The Nature Institute's online *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
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).

Holding Gently: A Story of Social Practice

Henrike Holdrege & Craig Holdrege

In the summer of 2011 Henrike and Craig were invited to South Africa by Allan Kaplan and Sue Davidoff to collaborate in two courses at the Towerland Wilderness Centre (see In Context #26*). Allan and Sue lead an organization called Proteus Initiative, which sponsored the courses. Our connection with Sue and Allan goes back to the winter of 2001/2002, when they spent part of a sabbatical at The Nature Institute studying Goethean methodology with us. They live in Cape Town, South Africa, are organizational consultants, and offer organizational and leadership training internationally, utilizing Goethean practice. Gael Surgenor from New Zealand, who studied with Allan and Sue, participated in the courses last summer. There she reported on a campaign she had led concerned with family violence. She described how Goethean practices contributed to the way the campaign developed and to its success. We were inspired by her report, not only because it gave us a glimpse into the achievements of a remarkable woman, but also because it showed how schooling in attentive nature observation can metamorphose and bear fruit in our work upon social tasks and issues.*

In 2006 the New Zealand government decided to address the issue of family violence through a social marketing campaign. The Ministry of Social Development's Family and Community Services gave Gael Surgenor the task to lead a team to design and execute a program of family violence prevention. Gael also led a campaign on parenting.

Before the new campaign began Gael participated in programs led by Sue Davidoff and Allan Kaplan concerned with social practice and leadership. In their work, Sue and Allan are clear that they are not teaching techniques that can be learned recipe-like and then applied. Rather, they are interested in helping participants to attend more carefully and wakefully to the social processes themselves, so that they can help orchestrate change in situation-specific ways. To facilitate such awareness, Sue and Allan incorporate Goethean nature observation exercises into their courses. These exercises made a strong impression on Gael and helped her significantly in the way she led the campaign on family violence. They were instrumental in giving her perspectives that were key to the campaign's success. And because she carried out the same kind of exercises with her team, they became an integral part of the campaign.

Preparing their campaign, Gael and her team looked closely at cases of family violence. They were faced with disturbing and in part horrendous criminal acts of domestic violence. It is easy here to blame and to condemn. But, Gael realized, it would not do much good to focus on condemnation. That would not be an approach that could foster change and transformation; and that was what was needed. In pondering possible approaches, Gael had a kind of "aha" experience stimulated by observations with prismatic colors she had made in the work with Sue and Allan.

When you look through a prism at your surroundings you see prismatic colors where something darker borders something lighter. The colors are most pronounced and clear when, say, you hold the prism horizontally and observe where a white wall meets the horizontal window trim.

Gael Surgenor (right) and Sue Davidoff (left) at the Towerland Wilderness in South Africa. (Photo: Alice Ashwell)

You can experiment with the conditions under which such colors appear by using black and white pieces of paper. When you look at a strip of white paper bordered above and below by black, you see at the one border red and yellow, and on the other light blue and dark violet. When the white strip is gradually narrowed, yellow and light blue move toward each other and eventually yield green as a new color. You then see the color spectrum that we know as the rainbow.

You can reverse the conditions and place a strip of black paper bordered above and below by white. As before, at one boundary light blue and dark violet appear and at the other boundary red and yellow. When the black strip is gradually narrowed, the dark colors of violet and red will eventually merge and magenta (a bright, rich pink) appears as a new color.

The way in which colors manifest at boundaries between light and dark, and especially the appearance of the radiant magenta, had struck Gael—just as they had Goethe more than two centuries before. She experienced how altering conditions of a polarity (a white strip sandwiched between black, versus black sandwiched between white) can bring about significant and surprising change—wholly new qualities can arise. In the family violence campaign, this experience helped her to formulate a new kind of question: Can we find "the magenta place" in relation to family violence? How could a change toward that magenta place be stimulated in the violent family member? This question became a guide in the campaign.

One result of their efforts was the formulation of an initial campaign phrase that was broadcast on television: *Family violence is not okay. It is okay to ask for help.* While the first sentence makes a clear statement about violence, the second suggests that there is an opening with the possibility of change and movement, and that there are people willing to help. This campaign phrase was then followed by true stories of men who had committed violent acts and who then had been able to escape the cycle of violence. They documented those cases of change and broadcast them.

To comply with the federal government, which funded the program, Gael's team designed a four-year plan for the campaign that outlined sequential steps. This had to be done, but Gael knew that such an outline would have to change and develop if the campaign was to be successful. The campaign needed to be "alive" and only then could one hope that it would have a lasting effect.

This sense of "aliveness" grew in Gael and became an important guide in the campaign. It was facilitated by observational work with plants that Gael also had done with Allan and Sue. In one exercise participants spent a day in the wonderful botanical garden of Cape Town, where you find the rich flora of South Africa represented. There are many imposing trees. Each person had to find a tree to spend their time with. They had been instructed how to observe the chosen tree carefully in all its details and then stay with it for quite some time with the imagination exercise so as "to be the tree." From this and other exercises Gael learned the value of careful observation, and also that it is possible to enter into conversation with every living thing. If you attend to things, they tell you something significant.

In another observation, course participants had been asked to attend to growth and decay in a plant. Looking at a tree in fall, when the leaves have turned into their particular fall colors, you perceive the leaves in the process of dying and beginning decay. But if you look closely at the leaf and its stalk, you will find at its base, in the axil of every leaf, a tiny bud. This is dormant life and is the potential for new growth; out of the bud will grow a twig with leaves or perhaps flowers in the next growing season, if the conditions are right. Everywhere in the plant world you can find growing and decaying side by side, the blossoming of forms and their disappearing through decay. Plant life plays itself out in these complementary processes.

When you carefully study natural things and living processes and internalize your experiences, something like "organs of perception," as Goethe called them, begin to develop. You begin to become more aware of "aliveness" also in other realms of your experience. And this is what happened with Gael.

If their campaign was to be alive, she and her team could not hold on to forms that had been established. They needed to keep in touch with what was actually happening and respond creatively. For example, when they learned that many people did not want to access services for help, they asked the question, "Where are the potential effective helpers?" They found that in cases of family violence it is often a friend or neighbor who, after encountering possible evidence of violence, will turn away and say and do nothing, pretending not to have seen. Their fear of interfering and getting involved in a difficult situation prevents people from asking: "How are you? Are you all right? Do you need help? You do not look well."

Step by step Gael's team developed content and messages that were directed toward those potential helpers. They broadcast scenes in which neighbors, family, friends, and co-workers were portrayed as cardboard cut-outs representing latent potential for help. The final scene let one of the cut-outs come to life and ask, "Are you okay?" Those mes-

sages were in effect saying: You can be instrumental in helping someone to change their behavior. Are you?

When Gael's team evaluated after some time whether this part of the campaign was successful, they found that whereas previously one out of five people had taken action, now one out of three people had. A survey carried out earlier in the campaign showed that 57% of the surveyed people believed that they could alter somebody's behavior; now it was 81%.

Gael expressed how important it was for her and her team to let go of the idea that it was "their campaign" and to see that for it to be truly effective it needed to find its roots in communities. In this way the campaign could avoid the pitfalls of so many programs that vanish—together with their effects—when they come to an end. Gael's team involved local communities in the intervention from the start, engaging mayors of towns, members of sports clubs or other local groups throughout the country. That the program with time became alive at the community level proved to be crucial. Federal funds were cut back after four years of the campaign.

During this time, however, family violence intervention had found its place within various local community groups and had in part become independent of federal funding. It had become, as Gael said, a social movement. Their campaign of Family Violence Intervention won the supreme award for excellence in 2010 from the nonprofit Institute of Public Administration in New Zealand. The team was also given a new task, namely to work on changing the behavior in the country toward disabled people.

Gael ended her report with reflections on her leadership. For that she had interviewed the members of her team with the question of how they had experienced the work and Gael's leadership. Team members felt that the Goethean exercises that Gael had met and practiced in her leadership training in South Africa were also alive in the team. As the campaign developed, they said, they learned to become more observant, more intentional and to value the time for explorations. Gael guided and encouraged them as she had done before quite naturally, but now more consciously and with more confidence. Team members felt that Gael encouraged them to be who they are. There were no strict job descriptions and each team member found her niche where she could contribute most. They said:

"We created an environment where people started to think differently."

"We listen to people."

"We have a culture of trying things out."

"We have not made big mistakes because we were able to adapt."

Importantly they felt that they were not observers or managers who stood outside the issue; they felt themselves to be involved.

Gael said about the campaign that "it did not come easy." She held the space for people; she encouraged them not to come up with an answer too quickly. She intervened as leader to guide the team in observation, to cultivate openness and interest in everything, to encourage a willingness to grapple with things. Gael herself became clearer during the process and also more comfortable with confusion. She grew more confident during difficult times in the campaign so that she could say, "It's going to be okay; let's wait and see." And also, when the tendency to hold on became too strong, "We can leave this behind." There wasn't a felt need to control or to be able to predict the future; the process itself became the guide.

Allan Kaplan, who mentored Gael, described her leadership as "fiercely gentle." He saw that her descriptions of people were not effusive and also not negative, but they were accurate; she observed situations and people in a respectful way.

Gael said of her leadership that it was about leading "with a light touch." She characterized this quality in relation to an exercise she took home with her from South Africa: the balancing of an egg. With skill and endurance you might be able to—on a smooth and horizontal surface—stand a raw egg on end. (There is a widespread misconception that this can only be done at the equinoxes. This is not the case.) In balancing the egg, you use your fingertips, carefully sensing it, and with the lightest touch bring it closer to that position where it stands on its own. You cannot stand an egg upright. You can only assist it in coming into that place. Only a light, gentle touch will do.

Events at The Nature Institute

Program for Hawthorne Valley Farm Apprentices

Each spring and fall Craig works with the apprentices from neighboring Hawthorne Valley Farm. In the spring the focus is on the landscape and plant communities in and around the farm, while in the fall animals take center stage. The main focus is usually the cow, since Hawthorne Valley has a dairy herd. We observe herd behavior and also study the cow's morphology and aspects of its physiology. One favorite activity is to put together, out of individual vertebrae, the vertebral column of different animals. Such an activity gives you a real sense of the interconnectedness of the parts of an organism.

Mathematics Alive—Geometry for Middle School Teachers

Eleven teachers from seven different Waldorf schools in the Northeast met for a middle school geometry workshop at The Nature Institute. The workshop was led by Henrike Holdrege and Marisha Plotnik, who has taught math and physics for many years in middle and high school at the Rudolf Steiner School in Manhattan. The workshop focused on the topic of area and included activities such as constructions with compass and straightedge, free-hand drawings, movement, imagination exercises, and much dialogue.

Here are some written comments from the participants:

It was wonderful to be a part of a group of people excited about mathematics/geometry and not inhibited to ask questions or say "I don't get it." (5th grade teacher)

I found this weekend very enlivening. It helped me to see the "big picture" around math teaching – all the way from the younger grades into high school. (6th grade teacher)

I found there to be a good balance between mental stimulation and practical application. I liked that light was shed on the vastness of the subject, but that I had enough time to come to an understanding. (5th grade teacher)

Not only did I learn a lot, I felt like you were guiding me towards seeing a universal truth that was/is very awe-inspiring. (4th grade teacher)

This weekend was inspiring, deep but peaceful, interesting and challenging without being overwhelming. It leaves me curious, wanting more exploration, not "too full" the way trainings have occasionally left me in the past. (7th grade teacher)

The teachers appreciated working with colleagues from other schools, and expressed their interest in future workshops on geometry as well as on arithmetic and middle school algebra. The Nature Institute will certainly continue with this work.

Activities Elsewhere

Evolving the Future: The Human Being in Nature & Nature in the Human Being

In November, Craig gave a short workshop and public presentation as part of this November's Think OutWord conference on nature and ecology, held in Harlemville, NY. You might not think that November is a particularly good time for observing plants. However, there is much to learn, for example, by observing the buds and branching patterns of trees. In addition, in northeastern deciduous forests, there is a small understory tree (or large shrub) that offers every

observant person (and some insects, of course) a special treat in late October and November.

Witch Hazel (*Hammelis virginiana*) flowers at this time—the only tree in our region that does so. Its flowers are easy to overlook, but once you notice them with their bright yellow and wispy petals, you'll not miss them again. In the workshop the participants broke up into small groups, and after Craig pointed out one tree to them, he asked them to find others that were in flower and then to observe them carefully. How is the flower shaped? Is the number of petals constant? How are they arranged on the branches? Does every Witch Hazel have flowers?

In this way the workshop participants got to know a special member of the local forest community.

Other Events

• In April, Craig traveled to Kassel, Germany, to offer a weeklong course and lecture at an International Conference for Waldorf High School Teachers. Craig guided the teachers in practical exercises to make the activities of thinking and observation more conscious. This led them to a clearer understanding of the Goethean phenomenology that is foundational to Waldorf science education. While the course focused on method and on schooling our abilities as scientists and science teachers, course content was drawn mainly from the ninth grade biology block.

• Earlier, in March, Craig gave an afternoon workshop on plants and animals at the Pfeiffer Center, Spring Valley, New York.

• In January Craig traveled to California. He participated in a weekend invitational conference on phenomenological science and science teaching at the Summerfield Waldorf School in Santa Rosa, California. The working conference was sponsored by the Center for Contextual Studies and The Nature Institute. It was a first step in creating new opportunities for science teachers to deepen their understanding of phenomenological science and experienced-based teaching, and also to collaborate with fellow scientists and teachers.

While in California, Craig also gave a talk on "The Plant as a Teacher of Living Thinking" at the Kalliopeia Foundation. In his talk, Craig demonstrated, through many concrete examples, how we can learn to model our thinking after the way plants live and grow.

• Also in January Craig traveled to Viroqua, Wisconsin, to lead a workshop for biodynamic farmers on "Schooling Observation & Thinking: A Goethean approach to studying plants and animals." The forty workshop attendees engaged in phenomenological explorations of the qualities of plants and animals, the beings that lie at the heart of all agricultural endeavors. At the same time they practiced what Goethe called "exact sensorial imagination"—a way of coming alive to nature, or we might say, bringing nature to life in us.

• In November and December Henrike led four afternoon workshops on "Goethean Explorations of Light, Color, and Darkness." Most of the participants were students in the local Free Columbia Art Course (Columbia County, New York).

• This past February and April, Steve facilitated two conversations at the Free Columbia Art Course. The conversations centered on the work of British semantic historian and student of the evolution of human consciousness, Owen Barfield (1898-1997). Course members were particularly interested in how we can work to escape the habits of thought of our own era, and enter more consciously into a creative relation with nature.

• The Harvard University Press book *(Genetic Explanations: Sense and Nonsense),* in which Steve will have a chapter, has been proceeding at the slow but thorough pace of that publisher. The book is now in advanced copy-editing stage, and presumably will be appearing within the next few months. We should be able to give you the particulars in the next issue of In Context. Steve's chapter is called "The Myth of the Machine-Organism: From Genetic Mechanisms to Living Beings." The list of high-profile contributors to the volume includes, among others, Harvard University's Ruth Hubbard, co-author of the classic and pioneering work, *Exploding the Gene Myth;* Stuart Newman, professor of cell biology and anatomy at New York Medical College; Eva Jablonka, the Tel Aviv University professor who has played a leading role in bringing the importance of epigenetics to wider awareness among biologists; and Evelyn Fox Keller, professor of the history and philosophy of science at MIT.

• Also on the publication front, Craig's chapter, "Exploration and Theory in Science," appeared in *Grow Small, Think Beautiful,* a book edited by Stephan Harding and published by Floris Books (Edinburgh). In this chapter Craig shows how in the Goethean approach to science "knowledge grows out of the careful interaction of human being and phenomena . . . Flexibility of mind, openness to the new, and the ability to let each new phenomenon stimulate the growth of fresh conceptions are the living qualities that characterize an evolving science . . . It is precisely this approach to the scientific study of nature that is now so desperately needed if science is to address the disconnect between humanity and the rest of nature that is the root cause of the global environmental crisis." In addition to Craig, contributors to the book include Satish Kumar, Jules Cashford, Fritjof Capra, Rupert Sheldrake, James Lovelock, and Helena Norberg-Hodge, among others.

Farmers' Course

In February, twenty three farm apprentices, farmers, and gardeners came to The Nature Institute for a weeklong course, a collaborative venture with Hawthorne Valley Farm and the Biodynamic Association of North America. On the first evening we all introduced ourselves and one theme in particular shone through: How can I, as a farmer, not become buried in all the day-to-day work? How can I gain a deeper inner relation to this work and sustain it over time?

It was clear: like most people today, farmers often feel overwhelmed; they are under pressure of time and have too much to do. How can they find ways to consciously cultivate relations to the plants, soil, and animals they work with, as well as to consumers and to the farm organism as a whole? These questions are real and personal, because no one in the course looks at farming as a mere job. Hardly any of them grew up on farms, and most have chosen to enter farming because they see the need for humanity to interact with nature in healthy ways. Is there a more fundamental place to begin than in agriculture?

In preparing the different sessions each day (projective geometry, plant study, walks and observation outside, and astronomy), Henrike and Craig kept these questions in mind. We focused on a variety of exercises and practices that could help farmers become more attentive and to grow inner connections with their work. We also hoped that they would see how seemingly unrelated content areas do in fact relate to each other. When we begin to see such connections, we gain a deeper understanding of the world. As a young apprentice remarked in her evaluation:

The combination of the activities worked really well in fusing different concepts into a comprehensible focus. As the week progressed the intent behind each lesson became clearer, along with its connection to other lessons and to biodynamics as a whole. Switching from geometry to plants and then back to astronomy was nice because it provided me with an opportunity to explore and use different parts of focus. All lessons engaged me and excited me – because it just made so much sense.

FARMERS' COURSE · FEBRUARY 2012
HAWTHORNE VALLEY FARM, GHENT, NY

Thank You!

We wish to honor all our friends who have contributed money, services, or goods to The Nature Institute between October 1, 2011 and March 31, 2012. We are deeply indebted to you.

Anonymous (9)
Warren & Mary Adis
John & Monica Alexandra
Johan Alvbring
David Anderson
Henrik & Lylli Anthon
Kahlil Apuzen-ito (In memory of Kimberly Epps)
Susan Arstall
Elizabeth & Arthur Auer
Tito Autrey
Pamela Avery
Brigida Baldszun
Gary Banks
Janet Barker
John & Diane Barnes
Ricardo Bartelme
Olga & Felix Bauer-de Wit
Sylvia Bausman
Carol Beauvais
Ursula & Klaus-Georg Becher
Bob Beck
Terrell & Jean Beck
Gerhard Bedding
Jeanne Bergen
Linda Bergh (In memory of Kirsten Bergh)
Glenda Bissex
Monique Blais
John Bloom
David Bolluyt
Edith Borie
James & Mavis Bottenhorn
Christina Bould
Barbara J. Bowman
John Breasted
Betty Brenneman
Will Brinton
Caleb Buckley
Sylvie Busser (In memory of W.F. Busser & Katie)
Ingrid & Matt Cain
Camphill Village Copake
John & Margaret Carlson
Jim & Meg Cashen
Burley & Mary Lynn Channer
Ivan D. Chase
Darlene & Larry Clark
Jennifer Clifford
John & Annette Conlon
Gail Conway
Barbara Coughlin & John Fallon
Siral & Myra Crane
Annelies Davidson
Jim Davis & Brooke Heagerty
Bill Day
Karole Delaney
Susan Delattre
Peter & Dorothy Denning
Jean-David & Karen Derreumaux
Dennis & Marianne Dietzel
Andy Dill
Charlie Doheny & Cate Decker
Ruth T. Dufault
Stella & Peter Elliston
Judith Erb
Douglas Feick
Susan Fine
Nancy & William Foster
Eileen Frechette & Ed Gutfreund
Douglas Frick
Bruce & Karen Frishkoff
Branko Furst
Mark & Adrianne Gardner
Douglas Garrett (In honor of Dorothy Ballon)
Connie & Douglas Gerwin
Mary Giddens
Joel Goldstein & Betty Stevenson
Gary Gomer
John Gouldthorpe
Glynn & Anthony Graham
Martha Grib
Joan Dye Gussow
Andy Hahn
Paula Hall
Judith B. Haney
Steven Hecht
Marsha & Ed Hill
Lisl Hofer
John & Kay Hoffman
Barbara Holdrege & Eric Dahl
Christina Holdrege & Edmund Muller
Craig & Henrike Holdrege
Betsy Horn
Judy Isacoff
Wes & Joan Jackson (In honor of Doug & Fern Sloan)
Van James
Fred Janney
Nelle Johansen
Susan Junge & Richard Ailes
Annette & Christoph Kaiser
Gerald Karnow
Gloria Kemp
Ann Kleinschmidt
Rita & Gary Kobran
Myron Koch
Ellen LaConte
Lesli Sharon Lang
Elan Leibner & Tertia Gale
Howard Lemberg
Yotam Lev & Gili Melamed-Lev
Martin Levin
Nancy & Ted Lewis (In memory of Ingeborg Schippel)
Barry & Janet Lia
Christof Lindenau
Elizabeth & Alan Lombardi
Peter Luborsky
Rich Lumma
Miriam MacGillis
Ben & Veronica Madey
Rachel & James Madsen
Carmeletta Malora
Are & Karin Mann
Peter Mann
Irene Mantel & Tim Hoffman
Paul Margulies
Lawrence Mathews
Patrice & David Maynard
Mark McAlister
James & Denise McCauley
Lance McKee
Mac & Ellen Mead
Rick Medrick
Christoph & Annelien Meier
Simon Meinhard
Fred & Masako Metreaud
Bruce Middendorf
Ron Milito
Douglas & Marguerite Miller
Daphna H. Mitchell
James & Bonita Mueller
Joyce Muraoka
Marcia Murray
Astrid Murre
Lin Notzelman
Wendy & Sandy Noyes
Robert Oelhaf
Jeffrey Onans
Tim & Maggie Paholak
Renate Pank
James Pewtherer & Jan Baudendistel
Grace Ann Peysson (In memory of Doris Detore)
Martin & Janene Ping
Marisha Plotnik & Ihor Radysh
Don Pollock
Marcia Post
Karen Prince-Weithorn
Bob Quinn
David Ramsay
Natti Rao
Gail & Rip Rapson
Emil Ravetto
Anna & Brian Ree
Wolfgang & Josephine Reigl
Renate Reiss
Gloria Rico
Mark Riegner
Wanda W. Ries
Geoffrey Robb
Jannebeth Roell & James Lee
Christina Root & Donald Jamison
John & Nancy Root
Roland Rothenbucher
Twila Rothrock
William Rowley
Sandra & Gary Ruggiero
George & Leonore Russell
Jan Kees & Polly Saltet
Liza Trent Savory
Signe & Christopher Schaefer
Paul & Ann Scharff
Tim Scherbatskoy & Carin Cooper
Thomasius Schmidt
Steffen & Rachel Schneider
Karl Schurman & Celine Gendron
David Seamon
Volker Seelbach
Jeff Sexton & Connie Camerson
David Shufelt
Peter & Phyllis Skaller
David & Christine Sloan
Douglas & Fern Sloan
Amie Slate & Loren Smith
Jerome & Rebecca Soloway
Mado Spiegler
Joanne Spitaliere
Diederick Sprangers
Anne & Claus Sproll
Ann Stahl
Susan Starr
Carolyn Stern
Stuart & Laura Summer
Elizabeth Sustick
M. Kelly Sutton
Candyce Sweda
Christian Sweningsen
Michael & Elisabeth Swisher
Chris Tekverk & Deborah Enright
Thorwald Thiersch
Jo Valens & Michael Thomas
Conrad & Claudia Vispo
Rick & Shirley Visser
Steve Voorhies
Jeremy Wadsack
Andree Ward
Christian Wessling (In memory of Anne Bryan Wessling)
John White
Gisela Wielki
Elisabeth Wiley
Thomas Wilkinson
Basil & Christina Williams
Hugh Williams & Hanna Bail
Kathleen Williams
Linda Williams
Nathaniel & Andrea Williams
John Wires
Christian Wittern
Dominic & Lauren Wolff
Waltraude Woods
Grace Worth
Jean & Marietta Yeager
Francis Young
Paul Zachos
Arthur & Heide Zajonc
Tatiana Zybin

FOUNDATIONS

Hawthorne Valley Association
Hudson River Bank & Trust Company Foundation
Hungry Hollow Coop
Kalliopeia Foundation
The Kresge Foundation (matching gift)
Mahle-Stiftung
The Michael Foundation
Rudolf Steiner Charitable Trust of RSF Social Finance
Salvia Foundation
Software AG Stiftung
T. Backer Fund

Context-Sensitive Action

The Development of Push-Pull Farming in Africa

Craig Holdrege

Maize interplanted with desmodium. (Photo: ICIPE)

It is easy to find countless examples of how we human beings are destructive and undermine not only our own existence but that of the planet as a whole. But there are also many cases—ones that often do not find their way into the news—that show human creativity and engagement at its best. Here I present a project in Africa that can give us hope and from which we can learn much about the characteristics of context-sensitive human engagement.

> The Obinga family are subsistence farmers who eke out a living on the Kenyan shore of Lake Victoria. It is not an easy life; their farm is small and rainfall is often unreliable…. Years of cereal cropping without inputs had reduced soil fertility and the maize plants were being attacked by insect pests and parasitic weeds. The family's thin zebu cows produced little milk, and herding them along the roadside to find forage was a full-time job for the children. Meanwhile, Mrs Obinga was constantly engaged in the backbreaking, seemingly fruitless task of weeding the fields. The granary was empty, the family frequently went hungry, and there was no maize left over to sell. That meant no money to invest in fertilizer or other inputs to improve the situation. The family seemed trapped in a downward spiral of declining yields and deepening poverty and hunger. (Gatsby Report, 2005, p. 1)

Such stories are not at all uncommon in Africa. But the downward spiral is not inevitable. The situation can change, and it has for the better for many small farmers. The shift began with a change in farming practices. Actually, it began with a perceived need and an idea.

In 1970 Thomas Odhiambo founded the International Centre of Insect Physiology and Ecology (ICIPE) as a research organization that would work on problems faced by families like the Obingas. As an insect physiologist, Odhiambo knew well how insects could devastate a maize crop. But he also knew that providing insecticides was not the answer: poor farmers could not afford them, and supplying them through government or international development programs would only mask the problem by increasing dependency on

outside sources. In addition, widespread pesticide use would lead to increasing pest resistance. Wasn't there another way, a way of working that would both address the insect problem and increase the farmer's independence? As Hans Herren, director of ICIPE from 1994 to 2005, remarks, "there was an opportunity here in Africa to implement knowledge on biological control, not only in natural ways, but in a very sustainable way when nobody talked about sustainability" (http://www.silentkillerfilm.org/interview_herren.html).

Caterpillars (larvae) of certain moth species called stemborers decimate on average between 20 and 40 percent of maize grown in Africa—and maize is the main food crop. Sometimes nearly the entire crop is lost. The female moth lays eggs on the maize plant and then caterpillars eat their way into the stem tissue of maize, feed on it, and thereby weaken or kill the plant.

A mature field. Napier grass (on far right) is planted on the borders of a field, with desmodium planted in between the rows of maize. (Photo: ICIPE)

Extensive Observation & Experimentation

Stemborers existed in Africa before maize was introduced and have a variety of plants they can feed on. So the ICIPE scientists asked: Are there other plants that might be even more attractive to stemborers than maize? If so, farmers could plant them around their fields to attract the stemborers away from the maize. They also knew that not all plants are attacked by stemborers and that some plants produce substances (semiochemicals) that lead insects to avoid them. So they asked a second question: Might there be plants that could repel stemborers? If so, these plants could be interplanted with maize to "push" the stemborers away. These questions could only be answered by extensive research: it was necessary to gather many different plant species and investigate the degree to which stemborer females would lay their eggs on the plants.

The research team investigated 400 species of wild grasses (maize is a member of the grass family). About 30 of the wild grasses were found to attract egg-laying females. A few of these did more than this: they also attracted wasps that lay their eggs in the stemborer caterpillars. When the wasp eggs develop into larvae, they feed on the organs of the stemborer caterpillar and kill it. So these plants not only attract stemborers but also, via the wasps, reduce their numbers. One particular plant, Napier grass, attracts egg-laying females, but when the larvae bore into the stem the plant exudes a sticky material that traps the caterpillar so that it cannot pupate and metamorphose into a moth. Since Napier grass is also known as a fodder plant for livestock, it seemed to be an ideal plant to use in field trials. When plots of maize were surrounded by a perimeter of Napier grass, the plots were beset with between 39 and 52 percent fewer stemborer larvae than maize plots without the perimeter of Napier grass. This was a promising beginning.

While the researchers were investigating the 400 different kinds of grass, the head of the project, Zeyaur Khan, was struck by the strong sweet smell of a plant called molasses grass. He then noticed that a plot of this grass had inadvertently been planted next to a plot of maize and that "there was little stemborer damage on the maize closest to the molasses grass, but the other side of the plot was heavily infested" (Gatsby Report, p. 4). This is one of those fascinating instances that can be found again and again in creative research efforts: a person attends to something he or she could easily have overlooked and the fortuitous observation becomes the basis of further important work. It shows how important the openness to new perceptions can be in science.

In this case, field trials were carried out in which molasses grass was planted in between the rows of maize. The results were impressive: whereas in the control maize plots without molasses grass 39 percent of the plants were stemborer infested, only 4.6 percent of the maize plants were infested when they had molasses grass as their neighbors (an 88 percent reduction in infestation).

Scientists and Farmers in Dialogue

The next step—or the next phase in this story of orchestrated action—was critical. The scientists had developed a promising approach to pest management. It was relatively simple and did not require that farmers buy expensive inputs. But would farmers want it? Clearly it was important to communicate with farmers—to open a conversation. And the subsequent successes of ICIPE's efforts show that the organization understood the farmers as partners in a developing dialogue. It was not a matter of the experts telling the farmer how to do things "right" and then leaving, as happens in the classic advice monologue.

Initial conversations with farmers revealed skepticism. The idea sounded too good to be true. Would it really work? ICIPE established a garden in which maize was intercropped with molasses grass and surrounded by Napier grass. Farmers were invited to see the results with their own eyes—something very different from simply hearing about a promising idea. More dialogue occurred and some farmers expressed interest in carrying out on-farm trials. Two different areas in Kenya were selected for the trials—one wet and fertile and the other arid and unfertile. "Farmer days" were held in the regions to discuss the new practice and "modifications were made to allow for current agricultural practices" (Hassanali et al. 2008, p. 615). Most farmers ended up planting one row of molasses grass for every five or six rows of maize and the fields were planted with a border of Napier grass (or sometimes Sudan grass, another stemborer attractor). This approach became known as "push-pull." Molasses grass "pushes" the stemborers away while Napier grass "pulls" and subsequently traps them. Farmers saw the positive results and the method became more popular.

One benefit of this farming method is that the farmers lose fewer maize plants and therefore their yields increase. But beyond that, both molasses grass and Napier grass provide fodder for livestock. This allows farmers to feed their livestock better and increase milk production. Some farmers have extra fodder that they can sell, and with this income buy a new cow.

Unintended Positive Effects

Because the scientists were interested in listening to the farmers, they developed the push-pull method further in new directions that had additional beneficial effects that were in part wholly unexpected. Traditionally, some farmers plant an edible bean in between rows of maize. They asked whether the scientists could find a bean that would repel stemborers and therefore replace molasses grass. The scientists responded by carrying out a survey of legumes (bean family plants) as possible "push" plants. While they did not find an edible legume they did find one, silverleaf (Desmodium), which was a good fodder crop. As a legume it has the additional advantage of improving soil quality by enriching the soil with nitrogen.

In the test plots ICIPE scientists made a further—and wholly surprising—observation: "All our experimental plots are infested with striga [a weed]. So imagine our amazement when we found that maize plots with a Desmodium [silverleaf] intercrop not only had little stemborer damage but also became virtually free of striga after only two seasons" (Gatsby Report, p. 5). Striga is a parasitic weed that, after germination, connects with the roots of the host plant and draws nutrients from it. Therefore, the weed can have devastating effects on crop yields. It is an especially large problem for farmers in the wet and fertile areas. They were eager to plant silverleaf as the "push" intercrop and had good results. The suppression of striga growth led to even greater maize yields.

The change began with a few hundred farmers in 1997, and by 2011 over 40,000 farmers were using the push-pull method, mainly in Kenya but also in Uganda and Tanzania. The Obinga family, described at the beginning of this article, was one of those families that adopted push-pull, and their lives changed dramatically after two years:

> Fields of tall, strong maize plants promise ample food for the next six months; three crossbred dairy cows enjoy a plentiful supply of fodder brought to their stall; the children drink milk every day; and sales of milk, maize and fodder grass bring in vital cash to spend on daily necessities and to invest in farm and household improvements. (Gatsby Report, 2005, p. 1)

A cow feeding on Napier grass and desmodium harvested from push-pull fields. (Photo: ICIPE)

Prior to using the push-pull method, the Obingas harvested about half a bag of maize (45 kg) from a 20 x 30 meter field. With push-pull farming they harvested two bags (180 kg).

Both farmers with very small farms (less than an acre) and ones with larger farms (100 acres) have adopted push-pull, and, as already mentioned, it can be applied in arid or wet regions and areas with poor or rich soil. This adaptability of the approach to different conditions is important and is enhanced by the efforts of both farmers and scientists to modify techniques depending on the specific ecological, agricultural, economic and social conditions. Farmers are not simply given a recipe to follow.

Partnership, Not Control

From an agro-ecological perspective the push-pull project is remarkable. Two seemingly simple additions to the farming practice bear fruit in a variety of ways. Napier grass not only attracts the stemborer away from maize, it reduces the numbers of stemborers by trapping them and by attracting wasps that parasitize stemborers, attracts other natural predators of stemborers such as ants and earwigs, provides fodder for livestock, and serves as a windbreak that protects the maize plants from falling over in strong winds. Silverleaf repels stemborers, suppresses the growth of a prevalent weed, improves soil fertility, acts as a ground cover to reduce soil temperatures and water evaporation, and provides fodder for animals. Both Napier grass and silverleaf are perennials, so they need planting only once; with less bare soil, there is also less erosion. The careful and thoughtful introduction of these two plants into maize fields stimulated a whole array of ecological relations to develop that enhance overall vitality and resilience.

The spread of the approach has been a team effort by scientists and farmers. One key development was that some of the farmers who were using the push-pull approach became "farmer-teachers." They receive further instruction about the method by ICIPE staff and then visit a few farms on a regular basis; they also stay in contact with the ICIPE staff so that there is both ongoing practice, exchange, and training.

It's clear that collaboration is a central feature of this effort: scientists look to nature for ways of modifying one-sided agricultural practices so that nature becomes a partner and not an adversary. Scientists and farmers are also partners. ICIPE collaborates with a research institute in the UK that works mainly on determining the physiological details of plant-insect interactions. African agricultural extension services are also involved. Something that is easily overlooked is the attitude of the funders of such projects. As the Gatsby Foundation, one of the major funders of this work, states in a 2005 report (pp. 23-4):

> In 1994, when Gatsby began supporting research on maize stemborers, push-pull was little more than a promising idea in the minds of an informal global network of chemical ecologists. That it has now become mainstream thinking in several national research systems is due in large part to the freedom enjoyed by the scientists involved to pursue new research directions as these arose—and in particular the links between the environmental aspects of the technology and its implications for poverty eradication…. The flexibility of the project's funding mechanisms was a key factor in maintaining the open-ended nature of the work.

This is an approach to funding that allows creative work to happen—it allows project members to explore, take up new directions as they appear, and respond to changing situations and insights.

As with any project, challenges arise that aren't expected. For example, as more farmers began to apply the push-pull method, a shortage of silverleaf seed arose. The seed had previously been imported from Australia. Some farmers began raising extra plots of silverleaf primarily for seed production. Then a seed company was contacted and encouraged to go into the silverleaf seed business and provide contracts to farmers to produce silverleaf seed. In this way the supply of seed grew and farmers had a new source of income. However, if farmers plant larger fields of silverleaf as a monocrop, pest pressure will likely increase, as it typically does when just one crop is planted. Scientists are currently investigating pests of silverleaf with the hope of finding plants that repel or attract silverleaf pests. This shows that the work never stops. One cannot simply establish a system that works by itself. That's an illusion. What is needed is the wakeful attention to new developments and their possible effects so that dynamic processes are followed and new ideas and flexible strategies can be developed.

Characteristics of Context-sensitive Action

The push-pull work shows how human beings have gone about the work of establishing a healthy relation to one another and the planet. Here I distill some of the key features of context-sensitive action that we can keep in mind in any project we are working on.

Attentiveness/Observation. The push-pull work has its roots in countless observations made by ecologists and

Photo: ICIPE

entomologists about the relations between plants and insects. But there is also the attentiveness to the concrete situations of the different farmers and to the concerns that the farmers express. The farmers observe the effects of different techniques and follow changes. Attentiveness and observation never stop in a living enterprise. They provide stimulation for new ideas and correctives to ideas or practices that have become stuck or routine. Ongoing attentiveness and observation is a commitment to staying open to what is concretely given. The push-pull work shows on the one hand the importance of systematic and detailed observation (to find the push and pull plants) and on the other hand the gifts that come from open attentiveness, which, for example, led the researcher to discover "by chance" molasses grass as a good push plant.

Ideas/Insight. Without the generation of guiding ideas, there would be no push-pull method. The many observations of agro-ecosystems formed the basis of the insight that when humans create monocultures of crops, they are in a sense inviting the demise of the crops by attracting insects, weeds, or other organisms that can thrive under one-sided conditions. To work against this tendency ICIPE decided to look for ways to create more diverse and thereby resilient conditions, working with, rather than against, nature. This is a central guiding idea that motivated the development of the push-pull method.

Interest/Compassion. One of the main motivations for the push-pull work was to help poor African farmers establish more sustainable livelihoods. It was not born out of self-interest. There was perception of great want and the desire to do something to help. In other words, the people at ICIPE were interested in the plight of their fellow human beings, felt compassion, and wanted to work to better the situation. Without such feelings that bring us out of ourselves and let us dwell as empathetic beings among other beings, good works would not occur.

Cultivating Relations. The work of the ICIPE scientists is all about getting to know the relations between plants and insects, and then working with these relations in practical applications. But the relational insights of the scientists are not enough. Dialogue between farmers and push-pull technicians and scientists started early in the project.

This cooperation remains essential and continues to this day. The scientists cooperate with other scientists and ICIPE interfaces with a variety of governmental agencies, nongovernmental organizations, and funders. This is not just a matter of networking, but of cultivating relations through which the work of each member enhances the work of the others.

Staying in Process. The scientific investigation of plants and pests doesn't stop, and adaptations of existing methods are continually developed. New forms of communication between farmers and scientists are tried out. It is expected that unexpected challenges will arise—and they do and are addressed. The funders responded to such challenges; they didn't focus rigidly on projected outcomes. Challenges can morph into opportunities, such as when farmers begin planting silverleaf for seed production. Context-sensitive action always remains engaged—active and at the same time responsive, with a willingness to change and take new directions.

Keeping a Focus. There is danger in flexibility inasmuch as there are so many needs and so many problems. If one project were to try and address them all, it could become too diffuse and dissipate its energies and resources. It's interesting that before silverleaf was discovered as a means to suppress the growth of the weed striga, a government agricultural officer visited ICIPE scientists and asked whether they might be able to address striga, which was such a problem for many maize farmers. They said "no", which is perhaps surprising, but also intriguing. Their

reason? They knew that they are entomologists with an expertise in insect pests and that they did not have an expertise in plant pests. They didn't want to stray too far afield. Little did they know at the time that their context-sensitive approach within their specialty would in the end lead them to a solution for the striga problem! But this unintended solution to a weed problem arose out of their following their pathway as plant-insect interaction specialists and at the same time staying open to observing unexpected effects. This points to the importance of knowing what you do best and sticking to that, while at the same time having the willingness to be stretched. There is a real tension here, but it is a tension that brings life into the process. The ICIPE scientists work within some self-set boundaries, but also know they need to venture into some unfamiliar territory in order to stimulate fruitful change. So, for example, the ICIPE scientists work to establish and uphold real dialogue with farmers—something they were not trained to do as scientists.

There is no "one way." ICIPE works from the perspective of agricultural insect pest control. This is a specific entryway and from one perspective addresses a narrow problem: insect pests of maize. But from another perspective the push-pull project addresses hunger and poverty in Africa. There are many other possible entryways. So, for example, there is a project called "Integrated Management of Child Health" that began in 1997 in a number of African countries. Often when a mother brought her child to a rural clinic, she met the "old 'factory-line' method where practitioners often made a quick guess at what was wrong with the patient and dispensed standard medication" (IRDC/CRDI 2004). Through the new project the health care staff of participating clinics is trained to take more time to look at the whole child, including its diet and eating habits. The program involves "a participatory process with the community [that] developed actions tailored to regional variations rather than a predesigned uniform strategy." The project has led to "substantial improvements in health and micronutrient status in each of the five African countries including reduction in iron-deficiency anemia, sustained broad coverage with vitamin A supplements, improved dietary diversity and community development and empowerment." It is clear that although the push-pull project and the health care project differ greatly in content focus, the quality of engagement is similar. Both are context-sensitive.

Wholeness. It is not contradictory that an approach that is specific can also be holistic. In fact, that is crucial. The specificity grounds the approach and holism relates to the effort to establish and orchestrate relations that mutually support each other. Through such activities, synergies arise that give the work a kind of organic integrity and resilience that characterize a living organism. Because human beings—their ideas, feelings, goals, and concrete actions—are part of this emerging social-ecological organism, its character is highly dependent on the ability of people to perceive vital relations and to respond to new situations with creative and concrete ideas. In this sense a small, local project can be dynamically whole while a large and multifaceted project can be fragmented. It is not the particular content or the scope of the project that makes it whole; it is the quality of human engagement.

SOURCES

Gatsby Occasional Paper (2005). *The Quiet Revolution: Push-Pull Technology and the African Farmer.* The Gatsby Charitable Foundation.

Hassanali, Ahmed et al. (2008). "Integrated Pest Management: The Push-Pull Approach for Controlling Insect Pests and Weeds of Cereals, and its Potential for other Agricultural Systems Including Animal Husbandry," *Philosophical Transactions of the Royal Society* B vol. 363, pp. 611-21.

ICIPE (2011). *Planting for Prosperity. Push-Pull: A Model for Africa's Green Revolution.* The International Center of Insect Physiology and Ecology (ICIPE).

IDRC/CRDI (2004). *Fixing Health Systems.* Available online: http://www.idrc.ca/tehip

Khan, Zeyaur et al. (2011). "Push-Pull Technology: A Conservation Agricultural Approach for Integrated Management of Insect Pest, Weeds, and Soil Health in Africa," *International Journal for Agricultural Sustainability* vol. 9, pp. 162-70.

Form and the Electrified Organism

Stephen L. Talbott

We trust our readers understand that our reporting on current research—even when we find profound significance in it—does not always imply happiness about all the various aspects of the work. We are, in fact, currently looking at some of the issues raised by the kind of experimentation now being conducted on "model organisms," and also at the issues involved in reporting on these experiments. On a separate matter: from a phenomenological perspective, terms such as "molecule," "ion," and "electric field" raise interesting questions concerning what sort of reality one is actually talking about, and how it might best be described. These are matters requiring an ongoing and critical self-awareness as we go about our work.

Since the earliest days of biological science the question, "How does the organism develop and maintain its form, or morphology?" has vexed human inquirers. Today we understand that a zygote (fertilized egg) possesses the ability to become a full-grown organism. But how does this more or less spherical and undifferentiated zygote, with all its contents, "know" to shape itself into a trout or red oak or grey wolf? How do all the dividing cells "know" where and when in the developing mass of the embryo to change into the appropriate cell types and form the appropriate organs?

It's a mystery that has intrigued and puzzled the greatest minds in biology. In the nineteenth century, that fierce defender of Darwin's theory, Thomas Huxley, described his loving observation of the development of one particular organism:

> Examine the recently laid egg of some common animal, such as a salamander or a newt. It is a minute spheroid in which the best microscope will reveal nothing but a structureless sac, enclosing a glairy fluid, holding granules in suspension. But strange possibilities lie dormant in that semi-fluid globule. Let a moderate supply of warmth reach its watery cradle, and the plastic matter undergoes changes so rapid and yet so steady and purposelike in their succession, that one can only compare them to those operated by a skilled modeller upon a formless lump of clay. As with an invisible trowel, the mass is divided and subdivided into smaller and smaller portions, until it is reduced to an aggregation of granules not too large to build withal the finest fabrics of the nascent organism. And, then, it is as if a delicate finger traced out the line to be occupied by the spinal column, and moulded the contour of the body; pinching up the head at one end, the tail at the other, and fashioning flank and limb into due salamandrine proportions, in so artistic a way, that, after watching the process hour by hour, one is almost involuntarily possessed by the notion, that some more subtle aid to vision than an achromatic, would show the hidden artist, with his plan before him, striving with skilful manipulation to perfect his work. (Quoted in Barfield 1963, pp. 144-5)

Today, in this age of molecular biology and invisible "building blocks," you can hear very different descriptions of embryonic development. A great deal is said, for example, about gene networks and cascades of gene expression producing proteins, which then diffuse throughout cells and tissues, creating various chemical gradients. Then, depending on the nature of the interacting gradients at particular locations, the proteins at those locations stimulate the expression of further genes, and so it goes on.

But there is no more *explanation* of form in this kind of description than there was in Huxley's rather more poetic one. It's just that patterns of gene expression and chemical gradients are substituted for the patterns produced by finger tracings and the invisible trowel. Certainly it is right to dismiss the fanciful finger and trowel, but they were merely a way of drawing attention to significant form. And far from being *explained* by genes and chemical gradients, this form is now simply being *described* at another level of observation. For, after all, the complex patterns of gene expression and chemical flows are no less manifestations of form than the precisely corresponding form they are meant to explain. (How could it be otherwise?) And this process of explanation seems to go on forever, since those gene expression patterns and elaborately structured chemical gradients need their own explanations, and on the trail of such explanations we find ourselves pursuing pathways that lead us further and further throughout the entire organism and invoking ever new manifestations of form (Talbott 2007).

The organism can at times seem to be almost nothing but interweaving fields of form. There are the forms of individual chromosomes, elaborately structured by the seemingly endless modifications that now are being related to gene expression as "controlling" factors. There is the way chro-

mosomes position themselves in the nucleus, writhing and interacting with each other and with other nuclear "bodies" under all the influences working into the nucleus from the cell as a whole. There is the finely detailed transport and localization of RNAs and proteins to the "correct" places in the cell; the continual shaping and re-shaping of the cell's outer and internal membranes, each with its own significant and ever-changing mosaic of embedded proteins and other molecules; the spatial and temporal rhythms of various signaling processes; and so on without end.

And now, after several decades of low-key investigation—long kept in the background due to the prevailing fixation upon genetics and related molecular studies—another kind of form is suddenly and dramatically breaking in upon the awareness of biologists. Dynamically changing electric fields, it is now becoming evident, can play a crucial role in structuring the developing organism.

The Shaping Power of Bioelectric Fields

Last July a team of researchers at Tufts University near Boston produced a startling, time-lapse video in association with a paper they published in *Developmental Dynamics* (Vandenberg et al. 2011). It showed a developing tadpole embryo, and due to the use of special dyes that reported the electric potential across cell membranes, areas of the image successively lit up brightly and then went dark. The researchers' focus was on the development of craniofacial features, and what was striking was the way something like an image of the face lit up prior to the actual development of the corresponding features. Regional changes in electric potential, these scientists concluded, "regulate expression of genes involved in craniofacial development."

The electric fields at issue here need to be distinguished from those routinely studied in nerve and muscle cells. Whereas nerve impulses act on a scale of milliseconds, the fields now getting attention can be maintained from minutes to days. They result from, among other things, the flow of ions across cell membranes, and because of the communication channels between cells, entire groups of cells can develop roughly the same membrane potential at any particular time.

According to Michael Levin (2012), director of the Center for Regenerative and Developmental Biology at Tufts, where the tadpole research was performed, "Ion flows and the resulting V_{mem} [membrane voltage] changes are components of long-range conversations that orchestrate cellular activities during embryonic development, regeneration, and ... tumor suppresion." He adds that "bioelectric cues are increasingly being found to be an important regulator of cell behavior," controlling the proliferation and death of cells, their migration and orientation, and their differentiation into different cell types. "We are," he writes, "just beginning to scratch the surface of the bioelectric code—the mapping between voltage properties and patterning outcomes, akin to the genetic, epigenetic, and perhaps other codes remaining to be discovered."

Bioelectric fields are the result of physiological processes at a considerable remove from gene expression. While genes are certainly required, for example, in the production of the ion-transporting proteins that help produce electric fields, bioelectric signaling of the sort involved in craniofacial patterning of the tadpole is, Levin emphasizes, not in the first instance a genetic event, but "a *physiological* event ... causally responsible for a given patterning outcome." Bioelectric states, in other words, "are an important source of *non*-genetic heterogeneity." Cells in which genes have produced the same set of ion-transport proteins can generate completely different membrane potentials, while cells differing in their gene-expressed proteins can generate the same membrane potential. And, in either case, the potentials—so Levin and the tadpole researchers are arguing—can stimulate cascades of gene expression leading to the formation of entire organs.

But the most dramatic development is still more recent. A second group of researchers in Levin's laboratory (Pai et al. 2012) has now manipulated the membrane potentials of tadpole cells destined to become eyes, with the result that the eyes became deformed. The extent of deformation (all the way to complete loss of the eyes in some cases) was correlated with the extent of deviation from the normal, eye-associated electric field.

Moreover, the researchers did the reverse: on the back and tail of a frog embryo they altered the membrane voltage to be that of normal eye regions, and by this means they succeeded in producing more or less eye-like formations in these decidedly unexpected places. It is indeed a startling and surprising discovery, which is the way the researchers themselves seem to have experienced it. Surely the experiments pose many puzzles and will require a lot of reckoning from the community of biologists in the coming months and years.

Looking for Explanations

Electrical phenomena in organisms have been recognized for a very long while. It's not only the dominance of genetics during the era of molecular biology that has moved this field of inquiry to the background, but also the appeal electrical effects have had for the ignorant and deceptive.

As University of Aberdeen biologist Colin McCaig and colleagues (2009) write, "In the past, bogus electrical therapies to 'cure' ailments ranging from impotence to baldness were common. 'Electric air baths', for example were a popular Victorian spa treatment and, when Mary Shelley was writing *Frankenstein*, public demonstrations using electrical shocks to raise corpses were popular for their theatrical impact. Much of the bad reputation associated with bioelectricity is rooted in this quackery."

The more recent work will surely change this. McCaig et al. note many of the now well-established findings in the field of bioelectricity (some of which were first recognized many decades ago):

> Bioelectricity influences cellular processes as fundamental as control of the cell cycle, cell proliferation, cancer-cell migration, electrical signalling in the adult brain, embryonic neuronal cell migration, axon outgrowth, spinal-cord repair, epithelial wound repair, tissue regeneration and establishment of left-right body asymmetry. In addition to direct effects on cells, electrical gradients interact with coexisting extracellular chemical gradients. Indeed, cells can integrate and respond to electrical and chemical cues in combination. (McCaig 2009).

One thing I'm confident of is that the range of interactions and contextual dependencies will continually expand as the research continues. Nevertheless, old habits die hard, so that one reads in the literature, for example, how "transmembrane voltage gradients *determine* anatomical polarity and function as *master regulators* during appendage regeneration and embryonic left-right patterning." Similarly, electric fields are said to *control* this or that, and biologists are urged to *crack the bioelectric code*. It recalls the way particular genes have been designated master regulators, only to be caught up in sprawling networks of interacting, fluid, bi-directional causes as the whole field of gene regulation research has explosively expanded to encompass just about anything and everything going on in the organism.

The habit of mechanistic thinking received a huge impetus during the era of molecular biology, and will not disappear quickly. Every new discovery is supposed to cause, control, or determine something. Its action is supposed to be definitive, corresponding to a one-dimensional code. Yet what we always find is meaningful context, significant form, a weaving together of causes that are never precisely repeated in the same pattern and therefore are never precisely the same causes. Causes of the moment are forever being transformed and adapted to the particular character and strivings of the organism (Talbott 2010; 2011).

The fact is that we understand the organism through the elucidation of its many dimensions of form. We do not so much explain form, as explain by means of form. Even the physicist, in applying mathematically formulated laws, is invoking a kind of abstract form. The problem the biologist (curiously, much more than the physicist) has with this is that dynamic form is not a physically graspable thing, and therefore is not accepted as a principle of explanation, but rather is thought to need explanation. But the organism is what it is, and therefore biologists will continue along the path they have really, in their best work, been traveling from the very beginning: recognizing the character and functioning of organisms by exploring at every level and in every dimension the expressing, gesturing, forming, and transforming "speech" by which each organism declares its own distinctive way of being.

REFERENCES

Barfield, Owen (1963). *Worlds Apart: A Dialogue of the 1960s*. Middletown CT: Wesleyan University Press.

Levin, Michael (2012). "Molecular Bioelectricity in Developmental Biology: New Tools and Recent Discoveries," *Bioessays* vol. 34, pp. 205-17. doi:10.1002/bies.201100136

McCaig, Colin D., Bing Song and Ann M. Rajnicek (2009). "Electrical Dimensions in Cell Science", *Journal of Cell Science* vol. 122, pp. 4267-76. doi:10.1242/jcs.023564

Pai, Vaibhav P., Sherry Aw, Tal Shomrat et al. (2012). "Transmembrane Voltage Potential Controls Embryonic Eye Patterning in *Xenopus laevis*", *Development* vol. 139, pp. 313-23. doi:10.1242/dev073759

Talbott, Steve (2007). "Can the New Science of Evo-Devo Explain the Form of Organisms?", *NetFuture* #171 (Dec. 13). Latest version available at http://natureinstitute.org/txt/st/mqual/form.htm.

Talbott, Stephen L. (2010). "The Unbearable Wholeness of Beings," *The New Atlantis* no. 29 (Fall 2010), pp. 27-51. Latest version available at http://natureinstitute.org/txt/st/mqual/genome_5.htm.

Talbott, Stephen L. (2011). "What Do Organisms Mean?" *The New Atlantis* no. 30 (winter), pp. 24-49. Latest version available at http://natureinstitute.org/txt/st/mqual/genome_6.htm.

Vandenberg, Laura N., Ryan D. Morrie and Dany Spencer Adams (2011a). "V-ATPase-Dependent Ectodermal Voltage and pH Regionalization Are Required for Craniofacial Morphogenesis," *Developmental Dynamics* vol. 240, pp. 1889-1904. doi:10.1002/dvdy.22685

Upcoming Courses at The Nature Institute

Coming Alive to Nature — The World of Color and Light
Public Summer Course

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

In this course we want to practice Goethe's way of knowing in all its aspects and gain greater insight into human experience and the nature of light and color. We will engage in nature observation, experiments and painting, as well as in conversation about Goethe's method of research. We will train capacities that we can engage in other fields of life.

Bringing Science to Life — Coming to Our Senses
A Course for Science Teachers

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

We will focus on the senses, our primary gateway to experience. We want to research the nature of sense experience itself and the qualities of different senses. Based on these explorations we will discuss the significance of direct encounter in learning and how this can be achieved in a variety of ways through different disciplines.

Please contact us for brochures and registration forms: Tel. (518) 672-0116
or info@natureinstitute.org or visit our website http://natureinstitute.org.

PRINTED ON 100% POST-CONSUMER WASTE RECYCLED PAPER

The Nature Institute

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