In Context

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The Newsletter of **The Nature Institute**

#11

Dear Readers,

Much of this issue is about genetic engineering—a rapidly growing discipline whose risks (unlike its promises) are scarcely noted within mainstream American politics and journalism. To focus on these risks is therefore to court an "alarmist" label. It is also to place oneself on the edges (some would prefer to say "fringes") of society. The question, of course, is whether such a stance amounts to little more than self-marginalization, or can also be a worthy struggle to avoid catastrophic degradation of the biosphere.

In such a situation one is well-advised to engage in a little critical self-assessment. "Am I simply a contrarian by temperament, preferring to take pot-shots at the established powers in society for my own gratification? Do I truly understand the risks inherent in the dominant social trends, and do I appreciate not only the dangers in these trends but also the positive values and ideals driving them? And what can be said about the real-world effectiveness of my work toward healthy change?"

There is no single way to answer these questions. Certainly we need to receive with an open mind *all* the critical feedback that comes our way. We also need to engage the larger world in constructive conversation wherever this is possible. And we must continually deepen our own inner capacities for imaginative understanding, for sympathetic and heart-felt openness to our surroundings, and for practical, well-grounded action.

We hope we are moving along such a path at The Nature Institute. But we would prefer never to *assume* we are doing the job adequately. Your advice and criticism, your support and withholding of support, your participation and lack of participation—these all help us along in our task of self-assessment. An organization is always much more than its formal structure and "official" staff. Its life and vitality, its social relevance and effectiveness, always reside in the larger community that contributes to its vision and its work, taking these to heart.

All of which is to say that we need your engagement, your criticism, your encouragement, your suggested course corrections.

Meanwhile, we hope this issue of *In Context* will give you a sense for the work we are doing within one of the primary spheres of our activity. Could anything be more fateful than our society's wholesale venture into genetic engineering? At the very moment when humanity sees itself inheriting the earth (and we certainly *are* inheriting it as an inescapable burden of responsibility), the very meaning of inheritance has come up for question. We are claiming our own inheritance by arbitrarily scrambling the genetic inheritance of all creatures. This looks less like an acceptance of responsibility than an abdication of it.

Perhaps all of us participating in and supportively surrounding The Nature Institute should think of ourselves as a voice for the disinherited.

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The Nature Institute

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The Trouble with Genetically Modified Crops

Craig Holdrege

I. Percy Schmeiser's Plight

In January, the Canadian farmer Percy Schmeiser spoke in Albany, NY. The talk was arranged by the Regional Food and Farm Project in Albany and co-sponsored by The Nature Institute. Craig was asked to introduce Percy and had the opportunity to speak with him before the talk.

If it weren't true, you'd think you were hearing someone's worst nightmare, or a plot crafted by a Hollywood screenwriter. I mean the case of the Canadian Farmer, Percy Schmeiser.

Schmeiser, who is seventy-three years old, has a farm in Saskatchewan about 250 miles north of the U.S. border. He and his wife have spent fifty years as farmers, and for the last thirty years have been saving their canola seed in order to develop a hardy and pest-resistant variety adapted to their region. In 1998 Schmeiser received notice from the biotech company Monsanto that he was growing their genetically modified (GM), herbicide-resistant canola (so-called Roundup Ready canola) illegally. They accused him of patent infringement, since farmers are allowed to plant the GM variety only if they sign an agreement and pay a $15-per-acre fee. According to Monsanto, Schmeiser was growing their protected variety but had paid no fees. Schmeiser admitted never paying fees, since he had no interest in GM canola. After all, long years of experience had convinced him that his own seeds were higher in quality than anything he could buy from a biotechnology company.

But Monsanto had received an anonymous tip on its call-in hotline that Schmeiser was using Roundup Ready canola. In 1997 it sent investigators from a "private eye" company to take samples near the road from edges of Schmeiser's fields. (Since they were within the "road allowance" they didn't consider this trespassing.) Tests came back positive. That is, Monsanto's herbicide-resistance gene construct was present in at least some of the samples. In the same year Schmeiser discovered, after having sprayed the herbicide Roundup around power poles and on a roadside ditch, that a significant number of canola plants survived. Normally Roundup kills everything green in its path. Schmeiser had no idea where the resistant "volunteers" came from, but it was a disturbing sight: herbicide-resistant canola was becoming a weed, mainly at the edge of his fields.

In 1998, samples were again taken from Schmeiser's fields, GM canola was found, and Monsanto took Schmeiser to court for patent infringement. You can imagine Schmeiser's dismay: a seed-saving farmer, who values his decades of work, is accused of unlawfully using someone else's seeds. From Schmeiser's perspective, *his* rights were being infringed upon, because Monsanto's plants were infiltrating his fields and perhaps cross-pollinating with his own plants, which would wreak havoc with his seed development.

So the case was heard before a federal judge in Saskatchewan. The judge ruled in favor of Monsanto and Schmeiser was ordered to destroy all the seeds from his 1998 crop—which brought his seed-saving efforts to an abrupt end. He was ordered to pay a fine of 19,832 Canadian dollars for not having paid for the Monsanto plants that grew in his fields (in addition to C$153,000 court costs). The judge ruled that it was irrelevant whether Schmeiser grew the crops intentionally or not—"intention is immaterial" (§ 115 of ruling). Focusing on very narrow legal questions, the judge argued that Schmeiser knew already in 1997 that there were resistant volunteers in his fields, and he saved his seeds in that year and planted them in 1998. In his view, Schmeiser knew or "ought to have known" (§ 120 of ruling) that there were GM seeds in his seed stock. It didn't matter that Schmeiser didn't want such volunteers and, of course, never sprayed Roundup over his fields—which he ought to have done if we wanted to make use of the GM crop's herbicide resistance. He was found guilty nonetheless. If you are shaking your head in disbelief, join the crowd.

A federal appeals court (consisting of three judges) upheld the ruling, but Canada's Supreme Court agreed to hear Schmeiser's case. The court heard the case on January 20 of this year. The judges allowed Schmeiser to address broader issues than in the original case. These included the question whether higher life forms such as plants can be owned via patents and whether the rights of farmers to save their own seed and to grow organic and conventional crops are being protected. The Supreme Court will deliberate on the case this spring and a decision will probably be announced in late spring or in early fall.

After all he's been through, you'd think Schmeiser might have become a cynical, embittered man. But, no, he is modest and soft-spoken, radiating integrity. He had been a mayor of his town and also a member of the provincial parliament. As he said in his Albany, NY talk, "I've spent my life working for the rights of farmers." The Monsanto case was more than he bargained for, but Monsanto probably had no idea that Schmeiser would become such a tenacious foe, gaining worldwide attention for his case. Schmeiser firmly believes in the rights of individual farmers to save and develop their own seeds and views his court appeal as a test case for all farmers. Despite all he's been through, Schmeiser will keep fighting. He jokes that he had planned to retire a number of years ago, but his wife complained, "what will I do with you around the house all the time?" So he planted his fields again, and along came Monsanto. Little did he know what kind of activist retirement lay before him. In the past four years he has not only been in the courts, but has also traveled the globe, speaking to the public, farmers, scientists, and governments.

Schmeiser has filed a counter-suit against Monsanto for contaminating his crop. But until the other case is brought to closure, he cannot afford to pursue it. For more information on Percy Schmeiser and his plight, go to www.percyschmeiser.com.

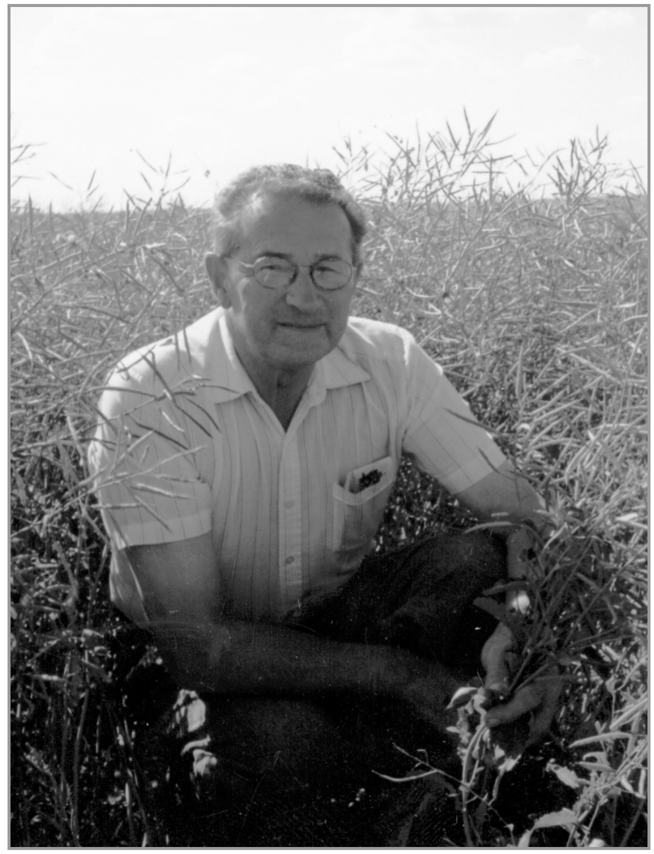


Photo courtesy of Percy Schmeiser

Percy Schmeiser

II. Some Larger Issues

Contamination, Social Fabric, and Pest Resistance

When farmers save their own seeds, they know what they are dealing with. The seeds have a history. But even when farmers buy seeds from a seed company, they expect a certain quality. The spread of GM crops brings—especially for those farmers who choose not to plant them—a whole new set of problems.

Within the last eight years the annual acreage of GM crops grown worldwide has increased from zero to 140 million acres—that's four times the area of New York State. Most of this acreage (about 110 million acres) is in the United States. But the acreage figures are ambiguous, since the crops do not stay put in the fields where they were first planted, as Schmeiser's case illustrates. Seeds and especially pollen can be transported through the air, landing in other farmers' fields. The seeds can then grow up among conventional or organic crops and the pollen can pollinate non-GM crops as well as weedy relatives.

There is now evidence of widespread contamination. For example, two years ago a Canadian scientist sprayed herbicide on twenty-seven varieties of pedigree canola grown from seed that was not supposed to be genetically modified for herbicide resistance. Nearly half of the plots—fourteen varieties—had plants in them that survived. These plants were genetically modified, herbicide-resistant plants whose had somehow found their way into the commercial varieties (*Manitoba Co-operator*, August 1, 2002). In February 2004, the Union of Concerned Scientists published a study showing a high degree of contamination of conventional soybeans, corn, and canola by GM crops (see box).

It's clear that non-genetically engineered crops planted anywhere near the engineered versions of the same crop will sooner or later be contaminated. If you are an organic farmer, this is an issue on which your livelihood depends. Your consumers assume they are getting non-engineered food, but you will have trouble guaranteeing the purity of your seeds and crops. Interestingly, the USDA's organic standards are process-based, which means that a farmer commits to following certain methods and not using others (such as genetic engineering). As long as a farmer follows these practices, the food can still be labeled organic, even if there is some contamination from GM crops, since he or she did not *intend* to use genetic engineering technology. Here (unlike in the Schmeiser court ruling) intention still matters

Widespread GM Contamination of Seed Supply

This past February the Union of Concerned Scientists (UCS) published a study demonstrating that DNA from genetically engineered crops is contaminating the American supply of conventional, non-engineered seeds.* UCS staff bought 50 pound bags of conventional soybean, corn, and canola seeds from seed retailers. They purchased six different varieties of each species, "representing a substantial portion of the 2002 traditional seed supply for these three crops" (p. 28). They then sent batches of these seeds to two different testing labs to determine whether there is any foreign DNA from genetically modified crops in the seeds.

The testers ground up thousands of seeds and then took a sample of the ground material, which they tested for the foreign genes using the PCR (Polymerase Chain Reaction) method. At one lab foreign DNA sequences were detected in three of the six varieties of soybeans and corn (50 percent) and in all the varieties of canola (100 percent). In the other lab, foreign DNA was found in five of six varieties of all three crops (83 percent). The foreign DNA came both from herbicide-resistant GM plants as well as insecticide-producing GM plants and included DNA from varieties sold by the biotech companies Monsanto, Syngenta, and Bayer.

The other question the study addresses is the degree of contamination. Knowing that 50 to 100 percent of the seed batches are contaminated is not the same thing as knowing the level of contamination within the batches. The contamination level ranged from 0.05 percent to over one percent of the DNA. (European Union regulations allow one percent contamination of organic crops by genetically modified DNA; above this level farmers can no longer call their crops "organic.") The scientists estimate that if one percent of the conventional seed supply of corn in 2002 was contaminated by genetically modified seed, the contaminated seed would fill 240 large tractor trailers (or 250,000 50-pound bags).

How did this widespread contamination occur? The study did not attempt to answer this question. GM seeds could have mixed with conventional varieties anywhere in the process of seed planting, harvesting, processing, storing, transporting, or packaging. Or pollen from GM plants could have pollinated non-GM crops, creating hybrids that contain the foreign DNA. Since soybeans are mainly self-pollinators, it is likely that their contamination is due to seed mixing.

Whatever the pathway, an astoundingly broad contamination of the seed supply has occurred without notice over the past years. (The first commercial GM soybeans, corn, and canola were planted in 1996.) Farmers buying conventional seeds of these three crops cannot at all be sure that their seeds are GM-free. Any illusion that GM crops and seeds are being kept separate from conventional (and organic) crops and seeds is clearly dispelled by this study.

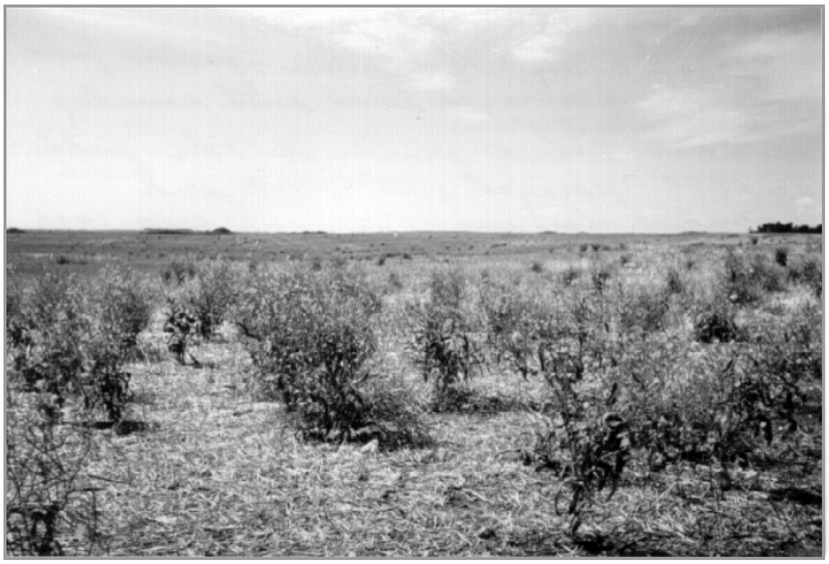
(* The study referred to above is entitled *Gone To Seed: Transgenic Contaminants in the Traditional Seed Supply*, by Margaret Mellon and Jane Rissler. Cambridge, MA: Union of Concerned Scientists, 2004.)

—but, at the same time, a label such as "GM-free" becomes problematic. This problem is addressed in Europe by organic standards that include a one percent contamination limit for organically labeled crops. This, of course, gives American exporters of organic food further reason to worry about GM contamination.

There is a social issue involved in the spread of GM agriculture that Schmeiser described in his Albany talk. He spoke about the trust between farmers and how they help each other out in times of need. With the advent of GM crops, licensing fees, and the containment problem, social and personal barriers arise between farmers. One farmer suspects the other of using proprietary seed without paying and calls the industry hotline; another sees his fields being contaminated by some (often unknown) farm in the neighborhood. The fabric of the agricultural community, which has been deteriorating for decades with the onslaught of industrial agriculture and its ever larger and fewer farms, only unravels more with the advent of GM crops.

So why, asks Schmeiser, did farmers start using GM crops in the first place? Well, they were promised higher yields and a reduced need for chemicals. Monsanto argued that biotech brought sustainability into industrial agriculture. Every farmer would like to spray less poison on his fields, both for economic and environmental reasons. If this could be coupled with greater yields—well, then, few would argue with the GM option.

What has actually occurred? Those farmers using GM pesticide-producing crops (Bt crops) have been able to reduce the amount of insecticides they spray, since the whole crop has become a pesticide. When certain insect larvae begin feeding on the plant, they die. There is, however, one caveat in the calculations concerning reduced insecticide use: they don't take into account the amount of pesticides that the plant itself is making; only what the farmer buys and sprays is counted. If we factored in the plant-produced insecticide (no one has done this yet), it is questionable whether we would find a reduction in pesticide use.



In 1999 this field in Canada was planted with wheat. Then in 2000 the farmer let it lie fallow and sprayed it twice with the herbicide, Roundup, to stop weed growth. But herbicide-resistant GM canola plants thrived on the field—they appear as the "bushes" on the otherwise barren soil. No one knows how the seeds for these plants got into the field. [Photo: Percy Schmeiser]

In the case of herbicide-resistant crops, farmers are spraying more herbicides than before, which is due to rising herbicide resistance in weeds and also to the falling price of the herbicide glyphosate due to competition (Benbrook 2003). Since herbicide-resistant soybeans are by far the most prevalent GM crop being grown, the overall amount of pesticides (herbicide plus insecticide) applied in the U.S. has increased by fifty million pounds between 1996 and 2003.

With the increased use of the herbicide glyphosate (found in Monsanto's Roundup and in various other commercial products), there has been an increase in the number of weeds that have become resistant to it. At the outset, farmers could spray their field and everything green except for the GM crop would wither and die. Now weeds such as horseweed and waterhemp are no longer being killed by the herbicide. Anyone with knowledge of the history of pest management and ecological interactions could have foreseen this trend. Resistance to herbicides is nothing new and the more an herbicide is used, the more quickly resistant weeds develop. Farmers hope that the chemical industry will soon come up with new herbicides to "solve" the problems the previous generation of herbicides has caused. In reality, the problem is never solved; farmers simply exchange one poison for another at the cost of the environment. The biotech crops now in use are certainly not contributing to greater sustainability.

And what about financial gain? A 2002 study of the economic effects of GM crops by USDA scientists found that farmers rapidly adopted herbicide-resistant soybeans—"even though we could not find positive financial impacts in either field-level nor the whole-farm analysis" (Fernandez-Cornejo and McBride 2002). So even in a narrow economic sense the most widely used GM crop is not benefiting the farmers who are using it. Evidently farmers are so strongly invested in the industrial model of agriculture, which now incorporates biotechnology as the newest means of "progress," that they continue to use it despite its problematic features and effects. (For a discussion of many problematic aspects of biotech agriculture, see Holdrege and Talbott 2000 and 2001.)

III. County Bans Growing of GM Crops

On March 2, voters in northern California's Mendocino County banned the cultivation of GM crops. The grassroots ballot initiative won fifty-six percent of the vote. It is the first such decision by a local community in the U.S.

The outcome was a surprise inasmuch as many observers assumed that the power of the biotech industry, with its financial clout and publicity machine, would prove unbeatable. Funneling its efforts through an organization called CropLife America, the industry poured over $600,000 into the campaign—more than has ever been spent on a ballot measure in this county of 46,000 voters. The ban supporters, in contrast, spent about $100,000. It's heartening to find that money does not always decide the outcome in such contests.

The vote also shows that there can be real concern about GM agriculture in a rural, agricultural community such as Mendocino County. And if such concerns are articulated and communicated via a grassroots initiative, as was there the case, the concern can translate into positive action via voting. Mendocino County is home to many organic farms and vineyards and these farmers are concerned about their livelihood in view of the specter of contamination by GM crops. This ban will definitely give them greater protection from contamination, which of course can't altogether be ruled out, since no place exists in a vacuum. (The law, for example, only prohibits the growing of GM crops. It prohibits neither the transport of GM seeds through the county nor the sale and use of GM food and feed.)

The campaign and the result of the vote are catalyzing and energizing similar initiatives in other counties. It's always easier once a precedent is set. The more such initiatives arise, the more the problem of GM food and agriculture will come into national awareness. As it is, there was little national coverage of the Mendocino ban. I was in the Bay area when the vote occurred and there was coverage in the regional newspapers, but the *San Francisco Chronicle*, northern California's largest daily, mentioned the vote only in a sentence tucked away in an article covering a variety of issues. It's a major task to make what is a real concern for the future of food and agriculture around the globe into a public issue in the country that is growing the bulk of GM crops. Such local initiatives are one means to help raise this awareness.

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Genesis of the Gene

What Genes Can't Do, by Lenny Moss. Cambridge MA: MIT Press, 2003. Paperback, 228 + 20 pages, $20.

Today biochemists can identify and characterize countless substances in the human body—sugars, lipids, proteins, and so on. But one type of substance—the nucleic acids of which genes are composed—is conceived in a manner radically different from all the others. This is why we would be surprised to hear someone say, "I have my father's oligosaccharide for stubbornness"—whereas we speak of genes that way all the time. Yet oligosaccharides, like genes, are present in every living cell. "Is it possible," Lenny Moss asks, "that two biologically ubiquitous types of molecules could be so fundamentally different that it would make perfect sense to speak of one as a determinant of, for example, one's stubborn disposition, but only humorous to ascribe as much to the other?"

Not really. And one way to summarize Moss' book would be to say that it gives thorough substance to this negative answer. Moss, a cell biologist who now teaches philosophy at Notre Dame, approaches the task with a historical sensibility. This brings him to understand that two very different genes haunt the scientific imagination. One is thought to predict the traits (or "phenotype") of an organism. We speak of this gene when we say, "She has the gene for blue eyes" or "He is genetically predisposed to retinal cancer." The other sort of gene specifies low-level, cause-and-effect developmental pathways. Such genes are said to provide templates for RNA and protein synthesis, but they have no clear and determinate relation to the observable traits of organisms.

We establish the presence of the first gene by finding a heritable pattern for a particular trait, and then by assigning the term "gene" to the hereditary factor—whatever it is and however complex its operation—that is presumed to account for the trait. In Moss' words, this concept began "not with an intention to put a name on some piece of matter but rather with the intention of referring to an unknown *something* … which was deemed to be responsible for the transmission of biological form between generations."

On the other hand, we pursue the second gene by using highly refined biochemical techniques to trace molecular interactions at the level of the chromosome. But between these interactions and the observable traits of an organism there lies all the unfathomable and indeterminate complexity of cell, tissue, organism, and environment. In the organic interaction and mutuality of thousands of substances in every cell, it is impossible to trace unidirectional paths of cause and effect from gene template to manifest trait—this despite the fact that researchers routinely speak as if they were articulating exactly such paths. Moss calls the gene as viewed from the molecular-template standpoint the "epigenetic" or "developmental" gene.

The central thesis of his book is that we are witnessing an unjustified conflation of these two notions in modern genetics. The resulting, composite gene, "held together by rhetorical glue," is alone what supports the widespread belief that genes are self-contained units of information determining traits—that they are, in other words, blueprints for organisms.

Moss summarizes the conflation this way:

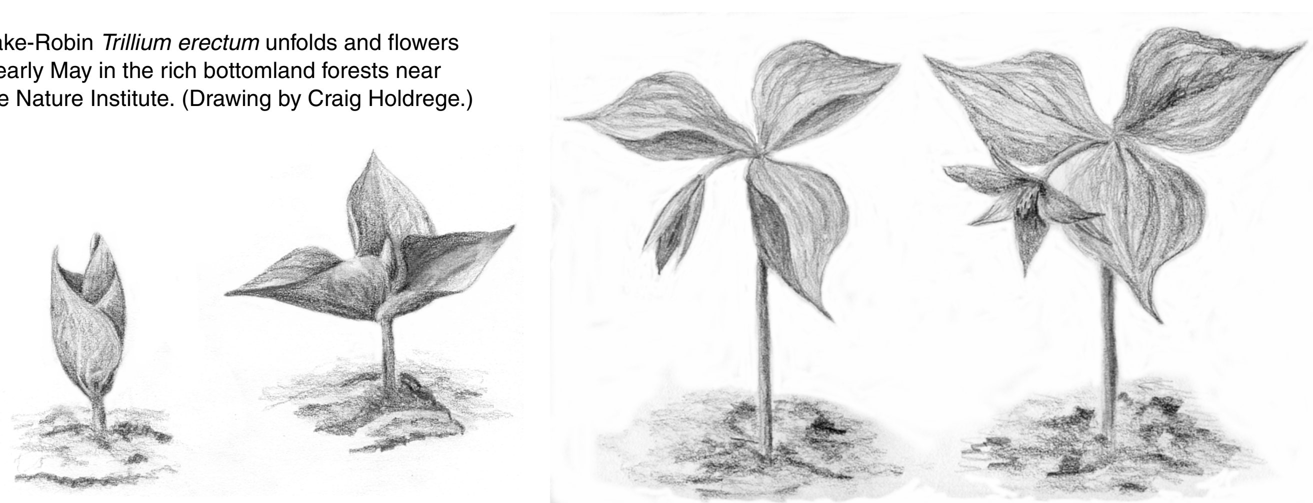
> The empirical fruits of several decades of research in molecular, cell, and developmental biology have revealed that what distinguishes one biological form from another is seldom, if ever, the presence or absence of a certain genetic template but rather *when* and *where* genes are expressed, *how* they are modified, and into *what* structural and dynamic relationships their "products" become embedded. If genes are to be both molecules which function as physical templates for the synthesis of other molecules *and* determinants of organismic traits and phenotypes, then somehow genes would have to, in effect, provide their own instructions for use. They would have to be able to specify when and where their templates would be put to use, how such products would be modified and targeted, as well as in what structural and dynamic relationship they would reside. Indeed, it is just this sense of genes being able to do this which appears to be conveyed with references to genes as information, as programs, as blueprints, as encyclopedias of life, and the like.

Thus was born the "gene (or genetic program) envisaged as context-independent information for how to make an organism." The way we speak of genes today, he goes on to say, has been determined "not by those whose hypotheses were successful but rather by those whose metaphors were successful." And the chief aim of Moss' book is to demonstrate the inadequacy of the hypotheses thought to undergird the gene as both marker for observable traits and precise, molecular cause of those traits.

The fact is, he argues, that "biological order is distributed over several parallel and mutually dependent systems such that no one system, and certainly no one molecule, could reasonably be accorded the status of being a program, blueprint, set of instructions, and so forth, for the remainder." For example, cells are structurally and functionally compartmentalized by a complex network of subtle membranes. These membranes regulate the role of gene products (proteins) within the cell and organism by, among other things, controlling the movement of proteins toward different functional compartments. Yet, despite their central importance in the cell, the membranous bodies cannot be reduced to the usual terms of genetic explanation. They "constitute the necessary and irreplaceable templates of their own production and reproduction, are passed along from one generation to the next [extragenetically, via the egg cell], and provide the unavoidable context in which DNA can be adequately interpreted, that is, in which *genes can be genes*."

(continued on page 23)

Wake-Robin *Trillium erectum* unfolds and flowers in early May in the rich bottomland forests near The Nature Institute. (Drawing by Craig Holdrege.)



On the Road and In Print

The work of The Nature Institute continues to ramify and to find ever more outlets in the world. Here are some of our recent and forthcoming activities.

Geometric Imagination. Henrike Holdrege, who for the past two years has taught projective geometry at the Institute, has now taken her work to other venues. During the winter she introduced groups of teachers and students in Chicago and Eugene, Oregon, to the perplexities and rewards of this far-too-little-known branch of geometry.

Projective geometry, which originated several hundred years ago, is geometry with an artistic, imaginative, and flowing character. It is a geometry of movement and transformation, of unity within variety. Pursued as an inner exercise, it leads to a more flexible and organic style of thinking—the kind of thinking required in order to grasp the natural world in a living way. By wrestling with such puzzles as that of the infinitely distant point, the student undergoes a kind of inner, cognitive stretching.

Henrike is currently teaching a morning projective geometry course at the Institute, and will also contribute instruction to the three upcoming summer courses. She is particularly pleased to work with many students who claim they were "never any good at math." Projective geometry, as Henrike teaches it, almost invariably proves a happy surprise for these students, who learn that mathematics need not be like the "dry" subject they remember from school.

Craig's Travels. Craig also headed west this past winter, first to Chicago, and then to Eugene, Portland, and the San Francisco Bay area. He gave numerous public talks on genetic engineering and agriculture—for example, at several Waldorf schools, the Ecotrust Center in Portland, and the University of California at Berkeley. The latter engagement was arranged by best-selling author, Michael Pollan, who is now a professor of journalism at Berkeley. Pollan has referred to The Nature Institute's work as "the best regular commentary on genetic modification available anywhere right now."

Craig also gave several seminars and workshops presenting a Goethean, phenomenological approach to science. Some of these were for teachers-in-training—for example, at the Waldorf teacher training institutes in Eugene and the East Bay area—and others were for the general public. He focused on how nature can help us change our way of thinking. Instead of thinking about discrete objects that interact in external, cause-and-effect ways, we can learn to "think like a plant lives." This requires us to deal with context, fluid processes, and transformation.

Craig's trip was especially rich in personal contacts. To cite one example: he met with Zenobia Barlow, the executive director of the Center for Ecoliteracy in Berkeley. The Center's mission—to cultivate a contextual, systems approach to nature—makes it a sister organization of The Nature Institute. Through many such contacts we have been strengthened in our conviction that an important part of our work is to find those people and organizations who share our deepest concerns and with whom we can cooperate in achieving our common goals.

Among Craig's upcoming engagements in May he will speak in Wuppertal/Langenberg, Germany, in support of a grass-roots initiative to create a "GM-free zone" for the protection of organic and biodynamic agriculture. While in Europe, he will spend a few days collaborating with our affiliate researcher, Johannes Wirz, in Dornach, Switzerland, after which he will travel to Krakow, Poland, for a conference entitled, "Touched by the Elements: Ecology and Art in Polish-German Dialogue." There he will give a lecture (in German). Then, in October, he will again cross the ocean to teach a course at Schumacher College in England. His topic will be "Understanding the Wholeness and Integrity of Nature."

Publications. The winter, 2004 *New Atlantis* carried Steve's article, "A More Child-like Science?" (which Steve has adapted for use as a feature article in this issue of *In Context*). Steve has also been publishing a series of articles critiquing the foundations of conventional science and pointing the way toward a new, qualitative science. These have been appearing in The Nature Institute's online publication, *NetFuture*, under the general heading, "Habits of the Technological Mind." Among the points he has argued so far are these:

- Mechanistic explanations do not even explain machines. The reason the contemporary notion of a machine focuses on the machine as an algorithmic device is that abstract algorithms (rules, software) may appear to meet the requirements for mechanistic explanation, whereas actual constructions of metal, plastic, and glass do not.
- The world's phenomena are neither predictable nor explainable in the sense required by mechanistic science. We find lawfulness implicit or immanent *within* phenomena, and it is less true to say that these laws determine the phenomena than that the phenomena determine the laws.

- The only fully adequate causes we have are formal causes in the older sense of this term—qualitative causes given in the way a meaningful unity or whole organically governs and manifests itself through its parts. The cherished causes of today's science—precise and unambiguously stated "efficient" causes—are what you get when you analyze formal causes down to purely quantitative or logical statements stripped of content. Efficient causes are nothing but the ghosts of formal causes.

You'll find links to these articles at www.netfuture.org.

Also, Steve is putting the finishing touches on a new booklet in our Nature Institute Perspectives series. This one is tentatively called *In the Belly of the Beast: Technology, Nature, and the Human Prospect*. In it, Steve traces the history of technology, from Odysseus, "man of many devices," to the Silicon Valley "man of many gadgets." He also asks about the troubled relation between humans and nature: should we struggle to master and control nature, or instead quarantine ourselves from nature as if we were disease organisms—or is there a third way? And, finally, the booklet explores the terms of our responsibility for the future of the planet.

Finding Strength in Ignorance. Wes Jackson, member of The Nature Institute's board of advisers and founder of the Land Institute in Salina, Kansas, is intrigued by the significance of ignorance. He puts it this way:

> Imagine an ignorance-based science and technology in which practitioners would be ever conscious that we are billions of times more ignorant than knowledgeable and always will be. What better way to deal with this reality than to begin to operate as though the twentieth century will be the last century in which we believe that knowledge is adequate to run the world? With such a consciousness one would ask before launching a scientific or technological venture: "How many people will be involved?" "At what level of culture?" "What are the chances of backing out?" Scientists, technologists, and policy makers would be assiduous students of exits. They would want to know not only how to exit, but also how to not leave irrevocable damage. Knowledge seeking would not stop, but would, as Wendell Berry has said, force us to remember things, cause us to hope for second chances, and provide an incentive to keep the scale small. Acknowledging ignorance might be the secular mind's only way to humility. By embracing an ignorance-based worldview, at least we go with our long suit. And knowledge and insight accumulate fastest in the minds of those who hold an ignorance-based worldview. Having studied the exits, their imaginations are less narrow.

In March The Nature Institute's staff, along with board member Douglas Sloan, enjoyed an informal conversation with Wes on this and related themes. Wes was in the area to deliver one of the E. F. Schumacher lectures (co-sponsored by The Nature Institute) in Great Barrington, Massachusetts. But Wes is carrying his interest in ignorance beyond lecturing. From June 3 - 5 The Land Institute will host a conference on "The Need for an Ignorance-based Worldview." It will be a conversation among eighteen or so people aimed at exploring the various implications of ignorance for human action. Farmer-novelist-scholar Wendell Berry will be among the participants, as will environmental educator David Orr. Steve will represent The Nature Institute. We expect to report further on the event in the fall.

Goethe's Delicate Empiricism: Call for Papers

Craig has been named guest co-editor for a special issue *Janus Head: An Interdisciplinary Journal*. Entitled "Goethe's Delicate Empiricism," the issue will explore the philosophy, history, impact, and usefulness of Goethe's scientific method.

Contents will include essays, short fiction, poetry, and art. The other co-editor is William Bywater, professor of philosophy at Allegheny College.

If you wish to contribute to the special issue, see the submission guidelines at **www.janushead.org.**

The deadline for submissions is **August 15, 2004.**

For further information, contact **jhinfo@janushead.org**

Tracks Reveal the Animal

Everywhere in the world we are surrounded by tracks. The smooth, yet grooved surface of bedrock attests to the presence of glacial ice thousands of years ago; the branching pattern of a tree limb speaks of its growth over the past years; the tracks in the snow tell us how the fox moved, early the same morning, over the meadow. It was with this last, more ephemeral sort of track that we were concerned during two Saturday wildlife-tracking workshops this past winter led by Michael Pewtherer and Jonathan Talbott.

With Michael's and Jonathan's help we learned to make sense of many different imprints. The cold, snow-covered landscape, to all superficial appearances barren of life, revealed a wealth of animal tracks—red fox, coyote, mink, raccoon, Eastern cottontail, mice, voles, and white-tailed deer, to name only the mammal tracks we identified. But Michael and Jonathan were not satisfied to point, name, and move on. They urged us to look, to wait, to question. Look at the meander of the tracks through the woods into the opening. How does the pattern change? Can we tell which are hind and which are forefeet? Look—there it stopped and urinated. Then it must have sped up, the track pattern showing the walk changing into the larger stride of a lope. The more we can visualize the animal in movement, the more the tracks tell us.

They begin to reveal the sentient creature as it lives in its world. When you've been outdoors in this way—"seeing" the leaping squirrels, the undulating mink, the foraging and then bounding deer—your sense of place changes. The forest and pastures come alive in a wonderful way. When you learn to bring an active eye to the world, the world begins to mirror its activity back to you. Tracking is a rich aid in seeing and building up concrete pictures of the living world. CH

Michael Pewtherer points out the gait pattern of the eastern cottontail during a tracking workshop.

Skunk Cabbage Makes the *Times*

Craig's article on the skunk cabbage in the Fall, 2000 issue of *In Context* seems to have been as effective in attracting readers as the cabbage itself is at attracting flies. Readers from Coos Bay, Oregon, to Akron, Ohio, to Waterford, Ireland, have written to thank Craig for his "informative" and "wonderful" article. And now the nationally known garden expert, Ken Druse, has written a feature on the skunk cabbage in the *New York Times* (March 25, 2004). Having interviewed Craig while writing the article, he cites Craig's research and quotes him in the *Times* piece.

Earlier a microbiologist working for the U.S. Department of Energy wrote to thank Craig for the article, and offered some of his own observations about the skunk cabbage. He has done cultures to test for micro-organisms on the plant, and has taken photos of the plant with an infra-red thermal camera. He asked for advice regarding his own research with skunk cabbage.

A Boeing Corporation researcher referred to the skunk cabbage article as "an eye opener" and offered some photos. And a professor of botany at the University of Washington wrote that "it was a superb essay on the eastern skunk cabbage, what I'd call an *ecological life history*," adding that "someone like Craig needs to do a similar essay on our [western skunk cabbage]".

We never quite expected to get so much mileage out of an essay about a smelly plant! You'll find the essay online at www.natureinstitute.org/ic/ic4/skunkcabbage.html.

Summer Courses

When Goethe wrote that the human being is the "best and most exact scientific instrument," he was actually formulating a goal to strive toward. We can transform ourselves to become ever more adequate instruments for understanding the depths of wisdom in the world. But much today discourages this transformation. We form abstract concepts about the world that we take to be more real than the things themselves. Filled with our own predilections, we don't perceive carefully how the world actually appears and how we are interacting with it. And our experience is increasingly mediated by all sorts of instruments and gadgets, so we lose faith in our senses and in our ability to judge.

At our weeklong intensive summer courses we practice observation: observation of natural phenomena, observation of thought processes, and observation of how we form judgments about the world. And this observing always involves doing—getting out into nature and observing and drawing plants; painting elements of a landscape; drawing geometric forms that "track" a progression of thought. By weaving together reflection and observation, a taking in and an active creating, the practice of science and art, we bring ourselves into inner movement. Our own process of knowing becomes more transparent and nature shows herself from new sides. As one participant from last summer stated, "It is such a gentle Aha! experience for me—a peeling away of a veil or film that has covered my eyes for years. It again gives me context and tools for seeing the familiar in a deeper and more penetrating way."

This is the third year we are offering summer courses. We are adding a new course this year, "The World of Light and Color," which will bring two new teachers into the program: Jim Kotz, a physicist and physics teacher in Waldorf high schools, who is also a member of the Board of Directors of The Nature Institute; and Mark Gardner, a cabinetmaker by trade and a painter by passion. Both Jim and Mark have a long-time interest in a Goethean phenomenological approach to science, and are looking forward to leading participants into a more vivid experience and understanding of light and color. Both this course and the one on "Reading the Gestures of Life" are for people from all walks of life; no previous experience is necessary. The Advanced Course will bring people together who have already participated in previous courses or who have been working with the Goethean approach. This course is part of our effort to create a "community of researchers" working to develop a new, qualitative science.

Reading the Gestures of Life (July 11-July 17)

In our all-too busy, often fragmented lives, nature provides a source of focus and renewal. In this course we will practice a phenomenological approach that opens our thinking and perception to the deeper patterns and gestures of the natural world. We connect with nature and our own selves in new and unexpected ways. Daily course work:

Flexible Thinking Through Projective Geometry (Henrike Holdrege, biologist / mathematician, The Nature Institute)

- Hands-on and thought exercises to start the day.

Reading the Gestures of Life: Plant Study (Craig Holdrege, biologist, director of The Nature Institute)

- Study of local plants and habitats; observation exercises.
- Reflections on a holistic understanding of nature and plants.

Artistic Work (Martina Müller, artist/painting teacher, Hawthorne Valley School)

- Drawing exercises to enhance our perception of nature.

The World of Light and Color (July 25-July 31)

This course is for anyone interested in schooling their perception and immersing themselves in the richness of the visual world. Following Goethe's phenomenological approach, our aim in this course is to achieve a greater awareness and understanding of light and color through nature observation and experiments. As an interdisciplinary course it will be of special interest to teachers, artists, and scientists. However, no previous experience is necessary.

Laws of Perspective (Henrike Holdrege)

- Practical Exercises.

Light and Color (Jim Kotz, physicist and physics teacher)

- Observation exercises and experiments.
- Reflections on a phenomenological approach to light and color.

Artistic Work (Mark Gardner, craftsman and painter)

- Learning to see through oil painting.

Practicing Goethean Science: Advanced Course (June 27-July 3)

This course is for persons familiar with a Goethean approach to science who would like to continue and deepen their practice and understanding of this method. Besides group observation work and discussions of methodology, students will focus on a specific plant or habitat of their choice. They will also share from their own ongoing research projects. Daily course work:

Thinking in Transformations: Exercises out of Projective Geometry
(Henrike Holdrege)

Plant Study and Goethean Methodology
(Craig Holdrege)

Individual Study
(may include drawing/painting)

Project Presentations

For information, or to register for the courses, please contact us at 518-672-0116 or info@natureinstitute.org.

Dates with Nature

Current/Upcoming

March 23 - June 1: "Projective Geometry—Extending our Boundaries and Experience of Thought." A weekly course with Henrike Holdrege, at The Nature Institute.

May 1 & 8: "Wildflowers of the Spring Forest: Ecology and Identification." Two Saturday workshops with Craig Holdrege, at The Nature Institute.

May 22: "Genetic Engineering and the Future of Agriculture." A talk by Craig (in German) at Wuppertal/Langenberg, Germany. Craig was invited to speak on behalf of a grass-roots initiative to create a "GM-free zone" to protect organic and biodynamic farms.

May 22: "Spring Wildlife Tracking." A Saturday workshop with Michael Pewtherer and Jonathan Talbott, at The Nature Institute.

May 27: A talk on genetic engineering by Craig at the Science Research Lab (Goetheanum), Dornach, Switzerland.

May 31: "A Goethean Approach to Understanding Genetic Engineering." A talk by Craig (in German) at a conference in Krakow, Poland. The general theme of the conference is "Touched by the Elements: Ecology and Art in Polish-German Dialogue."

June 3-5: "The Need for an Ignorance-Based World View." Steve will participate in this conference in Matfield Green, Kansas, and give a presentation. Sponsored by The Land Institute.

June 27 - July 3: "Practicing Goethean Science: Advanced Course." At The Nature Institute.

July 11 to July 17: "Reading the Gestures of Life." At The Nature Institute.

July 25 to July 31: "The World of Light and Color." At The Nature Institute.

October 13-21: "Understanding the Wholeness and Integrity of Nature." Craig will teach on this topic as part of a three-week public course at Schumacher College (England): "Holistic Science—Seeing With New Eyes." He will also teach in the college's Masters Degree in Holistic Science program.

Recent Past

April 21: "How Ecological Can Farming Be?" A talk at The Nature Institute by Hugh Williams of Threshold Farm.

April 17: "Here Come the Birds." An early morning bird-watching walk with Harry Lazare.

April 7: "The Promise and the Gift of Plants." A presentation on healing plants (with slides) by Jean-David Derreumaux. At The Nature Institute.

March 25: "Truth, Beauty, and Goodness in Science." A talk by Craig at the Anthroposophical Branch in Arlington, Massachusetts.

March 4: "Life Beyond Genes: The Trouble with Genetic Engineering." A talk by Craig at the University of California, Berkeley.

February and March: "Genetic Engineering, Food, and Agriculture." Craig gave six public talks on this theme during his west coast trip (see report on p. 11). He also spoke on this theme at Healing Earth Resources, Chicago, sponsored by GenWise and the Organic Food Network. And again on the same topic he addressed the participants in the Biodynamic Agriculture Training at Pfeiffer Center in Spring Valley, New York; spoke to organic farmers at the Vermont Northeastern Organic Farmer's Assoc. annual conference in Richmond, Vermont; and spoke to the 10th grade of the Manhattan Rudolf Steiner School.

February 2-6: "The Human Being and the Animal Kingdom: Understanding Ourselves in Light of our Fellow Beings." A five-evening public course by Craig, sponsored by the Seminary of the Christian Community, Chicago.

February: "Projective Geometry: Extending Our Boundaries and Experiences of Thought." Short courses by Henrike; one for the public and seminarians at the Seminary of the Christian Community, Chicago; the other for students of the Eugene (Oregon) Waldorf Teacher Training and the public.

Thank You!

Our deepest thanks to all of you who responded so generously to our Fall Appeal. Our financial position did not look positive as we entered the fall, but your response to the appeal made the difference. The growing circle of Friends of the Institute matched the final installment of the three-year, $90,000-per-year challenge grant from European foundations, and we once again finished the year in the black! (Our total organizational budget for the year was $250,000.)

So we entered the new year of 2004 with renewed optimism, an optimism grounded in both our firm sense that the Institute is fulfilling an important task and that a community of people surrounds the work, giving it a much broader base than our five acres in Harlemville! So, once again, thank you ever so much for supporting the Institute.

Following are the persons and organizations who have contributed money, services, or goods to The Nature Institute (or to its online publication, NetFuture) between October 2003 and the end of March 2004.

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From Wonder Bread to GM Lettuce

Craig Holdrege

This article is, in part, based on a talk given at the Organic Trade Association's 2003 Annual Conference in Austin Texas.

When I was a young boy we used to drive on the highway to Denver and I remember the lovely scent of baking bread wafting into the car. After a number of trips I discovered the source: a large Wonder Bread factory. I didn't really connect this sensual experience with my daily consumption of Wonder Bread. I consumed Wonder Bread in two ways. One was as the covering for my peanut butter and jelly sandwiches. The other was in advertisements: "Wonder Bread Helps Build Strong Bodies in 12 Ways!" I didn't know what this meant, but I sure loved squishing two or three slices into a little ball and popping it into my mouth. Only later did I learn that Wonder Bread had everything nutritious in wheat flour processed out of it, only to receive the wondrous 12-fold enrichment conceived by nutrition scientists and industry marketeers.

Like most other Americans, I grew up with the subliminal message: food is composed of individual nutrients and each one does something different for you; just take in enough of the right kind and you'll be fine. When, in the early seventies, I turned my back on processed food (as part of an overall protest against our materialistic culture) and started eating whole foods, I didn't really know why and what I was doing. I just did it, and with time my relation to food changed. Not only did Wonder Bread, Puffed Rice and their companions feel more and more like poisons when I occasionally ate them, but I also realized that food and nutrition are all about activity—sensing, mixing, and taking apart the food we eat. In digesting we analyze—break down—the food we eat and then actively build up our own individual bodily substances. But the All-American processed food industry would have us believe that eating is a passive endeavor. Not only does it need minimal preparation, but enriched food has everything we need already in it. Just swallow and it will do the rest.

Moreover, we have very little awareness of how our food is produced. It's not only the increasing number of children who don't know milk comes from cows; most of us have no idea about the agricultural production of our fruits and vegetables, where they come from, how they are grown, and how they get to the supermarket. This alienation from food is increased by single-nutrient thinking. We don't eat eggs; we eat a combination of proteins and cholesterol. So for most of us food has become isolated from the context of its production and turned into a simple, cause-and-effect abstraction. (Cheerios lower your cholesterol levels.)

This Wonder Bread ad is from the 1950s. Only in the 1960s were four new ingredients added so that Wonder Bread could help build strong bodies in twelve, rather than eight, ways.

What's on the Way

With the advent of genetic engineering, food processing takes on a new dimension. Instead of adding new ingredients into foods in the factory, we put them into the plants themselves. Food processing no longer begins in the factory but in the living organism. The idea is to provide plants, animals and food with characteristics they wouldn't otherwise have by adding genes from other organisms.

The first generation of genetically modified (GM) crops has been designed to make pesticides or to be resistant to certain herbicides. Since 1996, transgenic plants with these characteristics—soybeans, corn, canola, cotton—have been commercially cultivated. In 2003, 140 million acres of these crops were planted world wide (that's four times the acreage of New York state), eighty percent in the United States. Since this application of genetic engineering serves solely the desires of the producers, the changed characteristics are called producer-oriented input traits. We will likely see a greater variety of such modified crops in the coming decade—for example salt-resistant plants that can grow in salt-rich desert soils.

A next generation of GM crops is currently under development in university and industry labs around the globe. Scientists are working to genetically alter plants to produce characteristics and substances that are useful and enticing to a market broader than farmers. Genetic engineers also hope that these new "consumer-oriented output traits" will redeem the bad name that GM crops have acquired over the past decade.

To date there are three different categories of next-generation GM crops—industrial, pharmaceutical, and nutritionally enhanced transgenic plants. Prototypes of these have been produced in the laboratory, but none is presently on the market. Industrial transgenic plants would produce silk proteins, bioplastics or industrial enzymes. Such crops are not meant to produce food, and they all would be farmed solely for the valuable substances they produce for other industries.

The second, pharmaceutical class of next-generation GM crops would produce therapeutic substances for human or animal consumption. Some would be grown on a large scale so that a specific hormone or therapeutic enzyme could be isolated from the harvested crop, purified, and sold as a medication. Other GM crops are being modified with the goal of having, say, edible vaccines. A child could eat a banana and receive flu vaccine along with it. Or corn grown for animal feed could produce vaccines for swine, cattle or chickens. The hope is that, in the long run, we could produce these transgenic plant vaccines cheaply and also save on costs needed for doctors and vets to inject the vaccines. And what child wouldn't rather eat a banana than get a tetanus shot!

The third category encompasses traits that would improve (according to proponents) the quality of food. Examples of such nutrient-enriched plants that have been produced in the lab are rice that stores beta-carotene ("golden rice") or iron in the otherwise nutrient-poor white rice kernel, tomatoes that produce large amounts of an antioxidant (flavonol), and lettuce with vitamin C (ascorbic acid). It's these nutrient-enriched biotech food plants that I want to focus on here.

The idea of fortified white rice is conceived with the Asian third world in mind, since vitamin A deficiency (our body makes vitamin A out of beta-carotene) and iron deficiency are two main proximate effects of malnutrition. This approach to alleviating world hunger is simplistic and naïve—and the subject of a whole other article (see Holdrege and Talbott, 2000). Suffice it to mention here: seventy-eight percent of countries with significant child malnutrition and hunger *export* food; beta-carotene needs proteins and fat in order to be digested and assimilated by the body, so providing single nutrients does next to nothing to alleviate the problem; and if white rice, which is cherished in Asia for its pure whiteness, were suddenly golden through beta-carotene, would the people eat it?

But what about high-flavonol tomatoes or vitamin C-enriched lettuce? Wouldn't they catch on in our single-nutrient-conscious America? Here the GM industry would profit from the market built up over the past few decades by the processed food industry. (The industry has had the help of nutrition science and government policies.) "Health-bestowing, enriched" GM foods, if intelligently marketed, would certainly find eager consumers in the U.S.

The Illusion of Single-Target Effects

One of the illusions associated with improving plants through genetic technologies is that you can alter one specific trait in the plant without changing anything else. Examples abound in the literature; let's look at a few:

* Bioengineers had the idea of enriching animal feed plants with the amino acid lysine, which is an essential amino acid for animals but is not contained in large amounts in corn or soybeans. So they genetically modified these two species and the plants doubled the amount of lysine in the seeds. But they also found that lysine was being broken down in the seeds and very different amounts of these break-down (catabolic) products arose in the two different species (Mazur et al. 1999). Attempting the same experiment in tobacco, they found that lysine accumulated in the leaves but not in the seeds; they discovered a new metabolic pathway through which tobacco seeds actively break down lysine. So each species reacts differently and unforeseeably to the manipulation.

* Tomato plants were genetically modified to produce more carotene. To their surprise, the researchers found that the more extra carotene a plant produced the smaller it became (Fray et al. 1995). In some unknown way the extra production of carotene was linked with decreased production of a particular hormone related to growth.

* Different lines (genetic varieties) of transgenic potatoes were created that break down sucrose in different ways. This entails a small genetic change that is associated with the production of a new enzyme in each of the transgenic lines. The scientists wanted to know if other changes were being

effected, so they carried out a so-called metabolic profile. They investigated the amounts of eighty-eight different substances (starch, different sugars, different amino acids, and so on) being produced in the tubers. Surprisingly, the changes observed were not restricted to substances in the specific breakdown pathway affected by the genetic manipulation. Rather, most of the eighty-eight substances showed changes in their amounts. The transgenic lines differed from each other and from the non-manipulated potatoes. For example, the transgenic potatoes often produced more amino acids than the non-manipulated potatoes. Moreover, nine substances were found in the transgenic potatoes that could not be detected in the non-manipulated potatoes.

Genetic engineering has been advertised as a method to introduce well-defined, single-target effects. It's startling, therefore, to discover that a seemingly small genetic alteration in the metabolism of *one* sugar is associated with global changes in substance production within the potato tuber. And the scientists investigated only eighty-eight of the thousands of substances produced within a potato. (The mustard plant *Arabidopsis*—the workhorse of plant geneticists—is known to make more than five thousand different compounds.)

CSA (Community Supported Agriculture) pick-up day at Hawthorne Valley Farm in Ghent, New York. [Photo: courtesy of Hawthorne Valley Farm]

So we can be sure that any genetic manipulation is likely to have myriad unnoticed effects on the physiology of the plant. A gene does not function in isolation from the rest of the organism. The substances associated with it are involved in numerous metabolic pathways and, ironically, genetic engineers often discover new metabolic pathways through unintended effects within their experiments. The life of the plant is much more complicated and dynamic than the scheme in the mind of the engineer. What we're doing is influencing plants to take on functions we desire and yet we have little or no knowledge of the larger consequences of these intrusions.

If our concept of nutritional value is based solely on a desired array of different nutrients, and we put blinders on in relation to anything else that might be occurring, we may have no problem with this approach. In fact the dream crop will be, as Dartmouth biologist Mary Lou Guerinot imagines, the one that contains as many as possible of the 13 essential vitamins and 14 minerals required in our diet (Guerinot, 2000). It's Wonder Bread all over again, except that the living organism itself will be the vehicle to transport all those "valuable" nutrients into our bodies. I can already imagine: "Enjoy your movie and enhance your health by eating our vitamin- and mineral-enriched popcorn!"

In this view there is no interest in the "small" fact that individual plant species have evolved very different qualities and substances that make them unique. Maybe it's *not* desirable to have bananas and lettuce that are fortified in the same ways. And the "sameness" would be only in connection with the desired trait; we'd be overlooking all the other subtle changes taking place.

We have next to no idea how the particular constellation of substances in a specific plant enhances or modifies the effects of each particular substance and how such effects bear on the whole organism. We just naively assume that substances isolated and purified in the lab and then combined in a new mixture will have essentially the same effects on the human organism as the much more complex composition in the whole food. And now we take this isolating and mixing paradigm and transfer it into the plant. Can we truly believe we know what we're doing?

Health is in the Whole

I believe that what I've just described will have little effect on traditional food scientists, government bureaucrats, or GM proponents. The faith in simple solutions to complex problems is rock-solid despite myriad examples of its failings. And, unfortunately, many American consumers are in a deep sleep regarding these issues. Faith in experts and reliance upon the media and Madison Avenue are like sedatives, robbing us of independent and critical judgment. When Americans start eating flu-vaccine containing vitamin C-enriched lettuce because the food industry and the government are telling us it's good and wholesome, we'll know how bad the situation has become.

But, thankfully, many people are unsatisfied with the status quo and are engaged in the organic food and sustainable agriculture movement—as farmers, food processors, distributors, retailers, and consumers. As consumers we have a significant role to play in assuring that this deep sleep does not overtake the whole of society and that a heightened and new awareness for agriculture, food, and health enlightens our culture. I'd like to focus on only one aspect of this task.

If we view organic food only as a commodity characterized by the fact that it lacks certain "bad things," such as pesticide and herbicide residues, and that it is healthier for *me* (and my family), then we're operating within the same mindset that dominates the GM-food industry. It is a substance-based, egocentric view of food and health. Organics can only provide a real and significant choice if it supports the awakening of a new ecological and process-based view of food and health. Let me explain.

Most of us have grown up with an egocentric notion of health. A food or substance is good or bad for me. I form a bubble around the food and myself and ignore the larger context. In this larger context, food is connected with transportation and distribution, processing, marketing, and a specific kind of agriculture being carried out at a specific place on the planet by a specific farmer. The farming takes place within complex ecological, social, political and economic environments. So when I buy a carrot I am, in fact, supporting everything that contributed to the production of this carrot—including, for example, any fertilizer runoff that pollutes a stream.

Realizing that with each meal I'm connected with, and a supporting member of, a whole world of processes, I begin to see the carrot as much more than an isolated food product lying on the table. It begins to matter where the carrot came from and how it was farmed. By connecting myself consciously with the carrot writ large, my concept of health also shifts. It's not just a matter of *my* health but of the health of the whole system. Or, rather, my health expands beyond vitamins and minerals and beyond the carrot and becomes part of the health of the whole. I cannot separate myself out of the whole anymore. A future culture based on this principle will assess quality in terms of sustainable and thriving processes and not only in terms of nutrients.

Of course it's no simple matter to gain such a concrete process-relation to all the food we eat. I joined a CSA (Community Supported Agriculture) so that I can have a pretty good sense of the process involved from seed to harvest of the vegetables I eat from a local biodynamic farm during the growing season. But I also buy in stores—coffee, bananas, and, yes, organic cornflakes. In these cases the staff of the retail store and food labels are my main window into the processes that brought forth the product. The organic food industry has a significant task here—to give consumers as vivid a picture as possible of the product's story. Product labels, store posters, and store staff can help draw the consumer into the larger picture and to conscious participation in it.

But labels need to be truthful and transparent. I believe that when consumers buy organic milk, they will naturally assume that the cows have access to pasture and grazing during the months of the year where this is possible and that the farmers are practicing sustainable, organic agriculture. They will *not* assume that it is possible to label milk as organic if the cows are basically factory-farmed but fed organic hay and grains, having never stepped on a pasture in their lives. But this is possible under the definition of "organic milk" in the federal organic standards. Consumers Union provides a valuable service in its "eco-labels" program, which investigates and describes the regulatory definitions and the sometimes misleading nature of "natural" and "organic" food labels (www.eco-labels.org).

If organic agriculture is truly to provide an alternative to the industrial, technologically enhanced model of food, and if it is to serve consumers who long for responsible human efforts within nature, then it must be concerned about viewing food as part of a whole process. Then it will provide a real counterbalance and alternative to a coming generation of "enhanced" GM food that the biotech industry would like us all to embrace.

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Science and the Child

Steve Talbott

This is a revised and somewhat truncated version of an article that appeared in the Winter, 2004 issue of The New Atlantis. *I had been invited to write a response to a report of the President's Council on Bioethics,* Beyond Therapy: Biotechnology and the Pursuit of Happiness—*and specifically to the chapter entitled "Better Children." The chapter deals with attempts to improve children through genetic engineering and through the use of drugs to control behavior. You will find the report at www.bioethics.gov.*

Why do leaves turn red? Where does the sun go at night? What made Whiskers die? Will Mommy die sometime, and, Daddy, will you die, too?

Children are notorious for posing naïve and perplexing questions. When one of our sons was four years old, he asked, "Why did God make poisonous snakes?" I do not recall our answer, but very much doubt whether it was helpful. And who among us can do justice to the most perplexing question of all—the one incarnated in every newborn child: "Who are you, and for what purpose have you entered our lives?"

The child's large and difficult questions arise, not from complex theoretical constructions, but from simplicity—"childish simplicity" we are tempted to say, with a slightly patronizing smile. We need, after all, to defend serious discourse against fruitless inquiries about God and the moral significance of poisonous snakes. This is why our more child-like questions have, over the past few hundred years, disappeared from science. They are anachronisms, echoing hollowly off the instrument panels and surgically precise tools of the laboratory. Their implications would be only an embarrassing distraction oddly disjoined from the prevailing paths of technical investigation. "Child, for what purpose have you come?" Imagine a genetic engineer or an evolutionary theorist asking such a question!

Yet a strange thing is happening. Questions rather like the child's impossible ones are now being forced upon us from the side of science. The biotechnologist, faced not with poisonous snakes but with "defective" children, is led to ask, "Where do these defects come from? Can we unmake them?" And further, regarding the child's destiny: "Why do we age and die? Must we submit passively to human limitation?"

I say "rather like" the child's questions. For the child is always inquiring about meaning and purpose. *His* question about why we age and die is morally, teleologically, and aesthetically tinged. The scientist, by contrast, is asking about the mechanisms that "implement" aging and death, and wondering to what effect we might manipulate them.

Such, at least, is the usual distinction, not only between child and scientist, but also between the scientific dialogue and the larger human conversation. But the distinction is muddied when scientists tell us (or conspire in our belief) that they are gaining the knowledge to engineer better children. How can you recognize a better child if you must shun the language of value? More specifically, how can we, as scientists or parents, propose to manipulate an individual child's destiny if we cannot seriously ask about that destiny—about identity and purpose and tasks?

If the scientist is to join in such a conversation, then nothing less than a second scientific revolution will have occurred. Science will have been reopened to the categories of meaning, value, and purpose. The genetic engineer and the evolutionary theorist *will* learn to ask, "Child, for what purpose have you come—and how can we make things better for you?"

Without such a revolution there will be no true societal conversation. Rather, we will hear two utterly different and dissonant styles of speaking and they will spawn endless confusions between them. Using one style we will converse *with* the child, and therefore at least partly in the child's terms. With the other we will converse *about* the child, concerning ourselves with the manipulation of genetic, hormonal, neural, and other mechanisms as if we were engaged in little more than an engineering project.

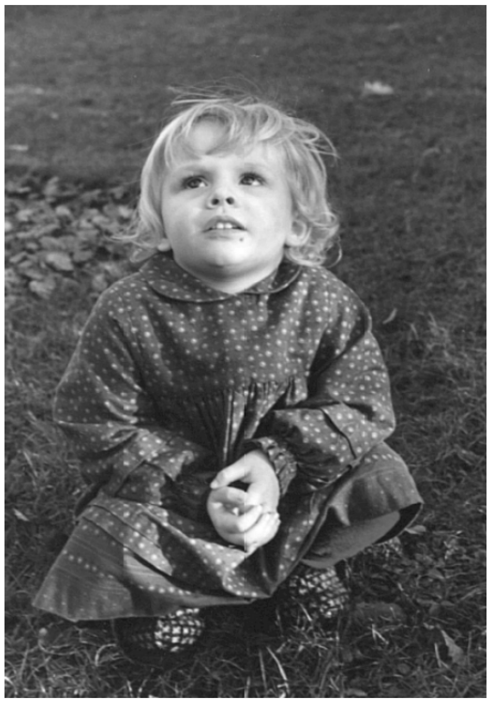
Beyond Passive-Aggressive Objectivity

The President's Council on Bioethics, with its discussion of "Better Children," has stepped boldly into the no-man's land between these two ways of speaking, and has done its best to clear out the confusions. Perhaps wisely, it has not asked for a revolution in science. Instead it has tried only to delimit the engineering project, and then, by its own excellent example, to establish the propriety of conversation about the ends and purposes of human life.

For example, in discussing Attention Deficit/Hyperactivity Disorder (ADHD), the Council's report endorses the therapeutic use of drugs in difficult cases, while questioning the casual reliance on drugs as a general strategy for obtaining well-balanced children. It notes that "most children whose behavior is restless and unruly could (and eventually do) learn to behave better, through instruction and example, and by maturing over time." Drugs short-circuit this learning process by acting directly on the body. They raise the question whether we are looking for the mere outward, behavioral result, or instead for the inner shaping of character that can only be learned:

> If the development of character depends on effort to choose and act appropriately, often in the face of resisting desires and impulses, then the more direct pharmacological approach bypasses a crucial element. The beneficiaries of drug-induced good conduct may not really be learning self-control; they may be learning to think it is not necessary.

The child, that is, may come to "look upon himself as governed largely by chemical impulses and not by moral decisions grounded in some sense of what is right and appropriate."


[Photo: Craig Holdrege]

So the control of behavior is one thing, and the moral education of the child is quite another. Given where we are now, making this distinction is an important step. But we should not imagine (and I doubt the Council imagines) that we have harmonized the two conversations. The dilemma remains: how do we bring the researcher's language of fact and control into worthwhile dialogue with the parent's language of ethics and purpose? Wouldn't this be like bringing the sober, sophisticated world of the mature scientist into meaningful relationship with the naïve, morally infused world of the child?

The idea of any such convergence may seem outrageous. And yet, when the scientist offers the parent a menu of options for obtaining "better children," it is he himself who puts the questions of meaning, value, and purpose on the table. When the going gets tough, he cannot fairly retreat into the "silence of objectivity." He cannot reasonably say, "I offer you better children, but do not ask me what 'better' means or who the child is." This passive-aggressive refusal to engage the issue is least acceptable when coming from the person who forced the issue in the first place—even if the issue threatens revolution.

Can We Get from "Ought" to "Is"?

In the blithe spirit of the child—whose destiny we are, after all, presuming to address—I wish to say a few words about the revolution. Desperately brief words, necessarily, but words suggestive, I hope, of an ultimate potential for our two conversations to become one.

Not that we should underestimate the challenge. Scientists have apparent reason for their reluctance to "come out of the closet" with their values. It has long been part of their discipline to refuse as best they can all explicit dealings with questions of value, and the practical benefits of this austere objectivity appear to have been spectacular. In this light, the latter-day quandaries of biotechnology look suspiciously like a trap, baited with all those metaphysical and discipline-sapping enticements that scientists have till now taken such great pains to flee. How, then, can we possibly ask the scientist, as a scientist, to participate in discussions about the moral education of the child or the value of a genetic alteration? Don't we leave those topics for the ethicist?

More and more we do (as the President's Council on Bioethics can surely testify), which helps to explain the disjointed nature of the two conversations. The disjunction has long been canonized in the philosophical proverb, "You cannot get from facts to values." There is no way to get from statements about *what is* to statements about *what ought to be*. "Is" and "ought" seem to come from different, incommensurable worlds. It hardly needs adding that the scientist is passionately committed to the factual and objective—to the is-ness of things.

Look at the world through more child-like eyes, however, and the situation is wondrously transformed. The question becomes, not how do we get from an "is" to an "ought," but rather the reverse. Putting it broadly: how do we manage to narrow our understanding down to a mere statement of fact when we start with such valuative and psyche-laden terms as "good," "evil," "ugly," "beautiful," "meaningful," and "purposeful"?

For we *do* start that way. Historically, the narrowing down is exactly what happened. By all accounts the ancients experienced themselves as living within an ensouled world—one thoroughly drenched in perceptions of goodness and value. Even the *physis* or "elementary substance" of the early Greek philosophers was, as the classicist Francis Cornford remarked, not only a material thing but at the same time a "soul-substance." Further, "the properties of immutability and impenetrability ascribed [by some Greek philosophers] to atoms are the last degenerate forms of divine attributes."

What is true historically is true also of the individual biography. The child, too, lives in an ensouled world. His incessant questions of meaning and purpose ("Why ...?") testify to an inborn conviction that the underlying reality of the world is psychic and voluntary, bearing an obligation to sustain good and reasonable appearances. Only with maturation does the child slowly gain a world of fact, an is-world, to set beside his birthright-world of congenial value.

Moreover, the birthright is never relinquished. Look at the mature human being—in the life of family and community, of work and recreation, of friendship and enmity, of politics and the academy—and you will be hard put to find a single act, word, or gesture that is not suffused with value and purpose. This is true even of the scientist in his laboratory, who, if he could really drain all his actions of their valuative content—say, by treating his colleagues like objects or, for that matter, treating sophisticated instruments like junk—would be dismissed as a psychopath.

No, we do not find a realm of value-free, psychically disinfected fact within the human sphere—except in one place: the intellectual constructions we have lately undertaken in the name of science and its philosophy. These constructions are aimed, as far as possible, at representing an antiseptic world cleansed of everything human. It has, of course, been doubted whether such a cleansing is possible. In any case—and speaking from the naïve, child-like vantage point—we might naturally paraphrase Cornford by asking whether the antiseptic world of mere fact is the last "degenerate" form of the psyche's intrinsically much fuller affirmations. Certainly this is the way it looks historically. But there is a further question whether, even as a final achievement, the fact-world attains independence. Or does it remain parasitic upon the less denatured reality from which it arose?

Don't forget that these intellectual constructions of science take place according to certain restrictive rules, and the historical acceptance of the restrictions was a matter of choice. Moreover, the choices amounted to a decision, conscious or otherwise, to exclude from consideration everything meaningful and psyche-laden—everything that did not serve the insistent drive toward a pure is-world. And it remains highly significant that these very same choices are linked to the most problematic aspects of science today. Here are two examples of what I mean:

Focusing Down to a Null Point

The child who asks about the red leaves of autumn is asking about *red*, not the wavelengths and frequencies of a physics text. He lives within a vivid world of sense qualities. This is why the Dutch psychologist, Jan Hendrik van den Berg, conceives the following exchange:

> "Why are the leaves red, Dad?" "Because it is so beautiful, child. Don't you see how beautiful it is, all these autumn colors?" There is no truer answer. That *is* how the leaves are red.

Of course, this is not the final or complete answer. As the child gets older, the answer could be enriched, not diminished, by an understanding of the interworkings and so called "mechanisms" of a natural world that remains qualitative through and through. But a fateful choice intervened to alter any such understanding.

Beginning with Galileo there was a conscious disregard of qualities within science—and this for the simple reason that qualities, as every child knows, are inescapably freighted with psyche. We experience qualities "in here"—within consciousness. But what is insufficiently realized is that we also experience qualities "out there," in the only external world we have. We cannot characterize a world—any sort of world—without qualities. Subtract all qualitative content from your thoughts about things, and there will be no things left. Try to imagine a tree without color or visible form, without sound in a breeze, without the smell of sap and leaf, without felt solidity, and the tree will have ceased betraying any sign of its existence. If you are inclined to redeem the situation with talk of molecules or subatomic particles, try to characterize *those* without appealing to qualities!

It's fine to say, "We get from the qualitative world to the realities of hard science by dealing only with what can be quantified." But the phrase "what can be quantified" is puzzling, since it has no meaning if we cannot say anything significant about the "what" we are quantifying. Given a set of quantities, we have to know what they are quantities *of* if we are to know anything at all about the actually existent world. And how do we characterize a "what" without qualities?

You can, then, begin to see what a vanishing, ghostly world we bequeath to the child. But, of course, scientists do in fact rely on their awareness of qualities. Otherwise, the world would have completely disappeared and they would have nothing to explain. It's just that the discipline of their science does not explicitly recognize the sense world in its own terms—the qualitative terms that pose, not only the child's questions, but also the only questions a truly observation-based science can have. The reason for the omission is clear: if researchers actually reckoned with the qualities they begin with and rely on, they would no longer find themselves theorizing within a pure is-world. This by their own admission, since the whole reason for rejecting qualities in the first place was that they are "contaminated" by the psyche and its values.

A second historical choice, less conscious in its origins, was to proceed by a method of analysis, assigning ultimate explanatory significance to the furthest products of the analysis. The problem here is that one never stops to consider a thing in its own terms. The fiery tree of autumn resolves into root, branch, and leaf, the leaf into cells, the cells into organelles, the organelles into biochemicals ... and so on without end, down to the most remote subatomic entities. "Without end" because there could be no satisfactory end. If understanding must be given in terms of analysis, and if the analysis were ever to stop at some fundamental, unanalyzable thing, then that thing (upon which all else is erected) must, according to our method, stand as an incomprehensible mystery, no more approachable than divine fiat.

[Photo: Karoline Diederich]

Analysis is an essential direction of movement in all scientific cognition. But if it is not counterbalanced by an opposite movement, then we can never say anything about *what is there*—what is presenting itself significantly as this particular thing of this particular sort. We can speak only of the elements it consists of. But this hardly helps, for of these elements in their own right we can again say nothing, but must refer instead to what *they* consist of. We have no place to stop and say, "Behold *this*." By itself alone, the method is a way of never having to face anything. No wonder, then, that neither the evolutionary theorist nor geneticist ever sees in the organism a creature of which we might stop and ask, "Who are you?"

A one-sided method of analysis, in other words, brings us again to a kind of emptiness. And, again, we must say: science is not really empty. The scientist is always recognizing the insistent presence of things in the world—significant wholes—even if the nature of this recognition receives no formal or systematic acknowledgment alongside the analytic cleaving of wholes into parts. After all, you are not likely to set about analyzing a thing if you have not first glimpsed it, at least intuitively, as a significant entity in itself. But your preferred method of analysis does not encourage you to attend to this whole in its own terms. If it did, you might find yourself caught up in something more like a conversation than in the mere manipulation of parts.

A Little Child Shall Lead Them

These historical choices—to reject qualities and to proceed by a one-sided method of analysis—confront scientists with a problem that looms so threateningly near and so incomprehensibly large that ignoring it is almost the only option. If, however, we could get up the courage to face the problem squarely, it might suggest to us that we can never shrink the child's rich cognitive inheritance all the way down to an is-world of mere fact. We can approach this end-point only in modern physics, and we achieve the approach only by depriving our theoretical constructions of their content. The reassuring certainties we enjoy in these constructions are the formal certainties of mathematics. But they alone cannot give us a world. Some of the greatest physicists, in their more child-like, soul-searching moments, have admitted as much. Einstein once remarked that

> As far as the propositions of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.

Another physicist, Sir Arthur Eddington, may have had the same problem in mind when he wrote,

> [Our knowledge of physics] is only an empty shell—a form of symbols. It is knowledge of structural form, and not knowledge of content. All through the physical world runs that unknown content, which must surely be the stuff of our consciousness.

Likewise, a pre-eminent physicist of our own era, Richard Feynman, confessed that "we have no knowledge of what energy *is*"—and this same cognitive darkness overshadows the other key terms of our physics, such as *mass*, *force*, *motion*, *time*, and *space*.

All this forcibly brings the truth home to us: we can hardly claim to have an is-world of fact without value, of object without subject, given that both fact and object have become blanks to us, with their content shoved under our methodological rug. Did we not exclude their content from view precisely because it speaks a language akin to our own interior? So, yes, if we ignore the world's content, we do come nearer to an is-world, but it turns out to be an empty world precisely because we have ignored its content. And this content is exactly what the child sees and puts a name to with his wonderfully innocent and simple observations.

You may think it strange to arrive at puzzles of physics in a discussion of biotechnology and its application to children. How have we gotten so far afield? But in an analytic era with its inevitable fragmentation and intense specialization, recovering a single, unified language for approaching the child means realizing first of all that far afield is not really far afield. The most fateful, scientifically developed "drug" we administer to the child is not some highly specialized biomolecule bathing his neurons, but rather the ambient, scientific world-view saturating his consciousness. And the whole effect of this view, centered as it is in the emptied fact-world of physics, is to rob nature of any congenial content for the child.

In *Beyond Therapy* the President's Council on Bioethics has shown how revealing a second, value-centered language can be. But the decisive question remains whether we can bring the two ways of speaking together in a harmony of meaning. Can we, for example, learn to approach the genome in the spirit of the child's soul-piercing "Why… ?" or the parent's quizzical "Who are you?" Might it be that real breakthroughs in genetics—breakthroughs of understanding rather than of technique—await our ability to look at the organism qualitatively, in its own meaningful terms? And if we do so will we not find the whole speaking through every part, so that the child's genome can, when approached in the right spirit, be discovered as part of the child's—*this* child's—revelation of himself? Finally, is not our receptivity to this revelatory aspect of the human organism a prerequisite for entering into a conversation with the child about his "betterment"? One way or another, we conduct a wide-ranging and gravely significant conversation with every child. If our language remains that of fact and control, then the language itself will dehumanize the child fully as much as any of the biochemical and genetic ministrations that are such natural consequences of the language.

These questions, like those of the child, may seem hopelessly large and impossible, ill-fitted to the science we are comfortable with. But perhaps what makes them discomfiting is our long habit of turning away from them, and our attempt (always unsuccessful) to escape the meaningful and living language adequate for framing them.

If we could transform our dealings with the child into a genuinely two-way conversation, it might prove healing, not only for the child, but for us adults and our science as well. Then the most important thing might not be our perhaps impertinent question, "How can we make you better?" Rather, it might be how the child's innocent simplicity can counterbalance our sophisticated but one-sided adult constructions. If the child does bring a task to the world, part of it may be to help *us* become a little more child-like in facing a value-soaked world—fearless in addressing this world with impossibly large questions, and fearless as well in listening for impossibly large answers.

Genesis of the Gene *(continued from page 8)*

Moss also looks at the "astronomical" complexity of self-maintaining, self-regulating metabolic processes in the cell, noting that genes can neither account for the integration and balance of these dynamic processes nor exist without them. And he also summarizes the ways in which the larger cell regulates the activity of genes through chromatin marking— the chemical modification of DNA. Then he offers a 56-page review of the long and tortuous quest for a genetic understanding of cancer. The upshot of it all is his conclusion that "the stability and intelligibility sought for in idealized genes must be rediscovered in the complex dynamics of process"—process that is always shaped by context.

In sum, Moss wishes to deliver science from the spell of the fairy tale that continues to influence genetic researchers even though its particular elements have been discarded one after another:

> Once upon a time it was believed that something called "genes" were integral units, that each specified a piece of a phenotype, that the phenotype as a whole was the result of the sum of these units, and that evolutionary change was the result of the new genes created by random mutation and differential survival. Once upon a time it was believed that the chromosomal location of genes was irrelevant, that DNA was the citadel of stability, that DNA which didn't code for proteins was biological "junk," and that coding DNA included, as it were, its own instructions for use. Once upon a time it would have stood to reason that the complexity of an organism would be proportional to the number of its unique genetic units.

(continued on page 24)

GENESIS OF THE GENE *(continued from page 23)*

One other note. Moss points out how contemporary biologists repeatedly suggest we must choose between Darwinian evolution, as conventionally understood, and creationism. But this shows a blatant disregard of history. The teleologies of Aristotle and Kant profoundly shaped the history of biological thinking, but neither Aristotle nor Kant was a creationist. "There was for Aristotle no excepionalism, no miracles, or divine interventions." In fact,

> There were no references to external causation in Aristotle's biology at all. Aristotle labored to understand the nature of living beings in terms of the elements and movements from which they were constituted. He found in the organism's adapted form—that is, in its mode of existence and attunement to its environment—the organizing principle of the organism, its final cause or purpose unto itself, the for-the-sake-of which it undergoes its formative processes.

What has happened is that the individual organism's development and maturation—its achievement of a highly organized, complex, adapted form—has ceased to be the central problem of biology demanding explanation. Development is seen rather trivially as "the result of a preset centralized [genetic] program." Attention is then turned to phylogenetic, or evolutionary, issues. In this way the biologist "expels all manner of adaptive agency from within the organism and relocates it in an external force—or as Daniel Dennet prefers to say, an *algorithm* called 'natural selection.' "

This shift, which Moss calls the "phylogenetic turn," conveniently allows the biologist to ignore real organisms as far as possible, and instead to play with the mathematics and logic of genetic "code," mutations, population genetics, and all the rest. In this game, as Moss shows so well, reality is the loser.

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