In Context

Number 7 Spring 2002

The Newsletter of **The Nature Institute**

Dear readers,

On March 2 The Nature Institute's staff, along with many helping hands from the local community, cleaned out our old office and moved everything — furniture, computer equipment, library, and Craig's extensive bone collection (including a 120-pound elephant skull) — to our new office less than a mile away. On March 3 we began the long process of organizing ourselves in our new home. On March 5, with scarcely enough time to finish sweeping out the cobwebs, we welcomed an overflow, standing-room-only crowd for our first, public event in our own space — the beginning of a lecture series by Craig entitled, "The Wisdom of the Animal World." There couldn't have been a more heart-warming and house-warming occasion.

So now we have a place of our own. It's remarkable to experience the difference a rooted sense of place makes — almost before you've had a chance to put those roots down! Like the human heart described elsewhere in this issue, our building becomes a living center; people near and far stream into this center for a variety of activities, and at the same time we continually find ourselves moving outward in order to engage a larger community. The rootedness whose promise excites us is a dynamic rootedness, made stronger by the weaving together of these comings and goings — just as the transpiration and environmental exchange through its leaves enable the plant to put its roots down.

In this, we believe, there's warning against trying to become a successful *institution* or *establishment* in any static sense. A true place is always being made, else it ceases to exist except as a museum piece. Not that we don't stop occasionally to consider, with wonder and thanksgiving, how quickly and far The Nature Institute has come. It's fair to say that each year since our founding the new developments have outstripped any expectations we might have had at the year's beginning. It's hard to avoid asking ourselves sometimes, "What's going on here, and why have we been so fortunate?"

A president of Shell Oil was once asked how it felt at the top of his company. He replied, "It's like sitting on the back of a huge brontosaurus and watching where he's going." Sensing forces at work larger than one's own small self can certainly be healthy, even if those forces are blind market forces. We are grateful, however, that the carrying power behind The Nature Institute is not blind. Rather, it is the power of conviction and hope and community evidenced in the in-streaming and out-streaming whose focus warms our new place and already makes us feel at home.

All of which means, of course, that you who participate in and support and maintain an interest in the work of The Nature Institute play a decisive role in making this the kind of place it is. We certainly would like it to be a welcoming place, so if you find yourself in the area, we hope you will get in touch and arrange a visit. By so doing you will add your own gesture to the ever-expanding definition of the Institute and thereby account for some of the new rootlets pushing into the depths of the earth from this time and place.

Craig Holdrege *Steve Talbott*

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The Nature Institute

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Of Ideas and Essences

You will recall that Craig and I had a feature article ("Sowing Technology") in the July/August *Sierra* — a special issue of that magazine dealing with biotechnology. Subsequently a *Sierra* reader, Kerry Knudsen, wrote a letter to the editor suggesting that part of the environmental movement "is developing from a cultural romanticism into an eco-mysticism." This trend is evidenced by an "essentialist philosophy" — an "unscientific and idealist philosophy that is irrational because it is based on an essence of Nature, a typological Nature, which does not exist" (Knudsen 2001).

It's a safe bet that Knudsen's concern about essentialism was fueled by Craig's and my reference to the "nature" of particular organisms and by comments such as this:

> Instead of a coherent whole expressing an organic unity through every aspect of [an organism's] being, the engineers hand us a bag of separate traits. (Holdrege and Talbott 2001, p. 36)

Only a grasp of the integral unity of the organism (we were saying) can enable us to recognize whether an engineered trait would be harmonious and consistent with the organism, or else arbitrary and clashing.

Since the charge of essentialism seems to be a standard occupational hazard for the Goethean scientist, we should try to understand what lies behind it. And the first thing we notice is that those who raise the alarm about essentialism seem to be preoccupied by old debates between science and religion. In particular, they assume that anyone speaking of the "nature" or "unity of being" or "integral wholeness" of the organism must be arguing for something like the metaphysical "essence" that was supposed to constitute each created kind of *Genesis*. This essence was unchanging and eternal — and therefore was unacceptable to the evolutionist, whose kinds (species) certainly are not unchanging.

But this has little relevance to what Craig and I wrote in *Sierra*. Our remarks arose from the context of Goethean science, and here (with extreme brevity) is one way to summarize the relevant aspects of this context:

** The Goethean researcher is interested in observable phenomena, and has no desire to press behind the phenomena to some sort of metaphysical essence.

** The Goethean researcher who speaks of the nature of an organism is referring to its inner unity of being — "inner" because this unity is conceptual.

** "Conceptual" does not mean subjective. When one struggles to conceive the nature of the organism, one is struggling to find the concepts (the ideas, the interior being) that *belong to* the organism and are, as formal cause, *generative* of its unity. (This, however, can hardly make much sense so long as one is bound by our culture's normal rendering of terms such as "concept," "cause," and "idea.")

** There is no reason to take the observed unity of the organism as unchanging or incapable of evolution. The nature of an organism just is what it is (what it is observed to be), and if it evolves with time, this can be seen as part of its dynamic aspect. The potential for continually transformed expression is, after all, intrinsic to any truly vital idea.

Machine and Organism

A mechanically literate individual can often look at a machine and, by considering the various parts and the way they are articulated together, grasp the basic functional idea of the machine. The use of the term "idea" in this case is hardly controversial. The idea can be derived from observation and is objectively describable. It really does characterize the machine; our understanding of the machine would not be complete without our apprehension, through thinking, of its idea.

In his commentaries on Goethe's scientific writings, Rudolf Steiner (2000, pp. 43-44ff.) points out that the idea of the machine is impressed upon it from without by the designer. The machine and its idea are wholly explicable in terms of parts relating to each other in an external manner. Of course, a part may present itself to immediate observation as a "black box" concealing its internal operations. But in this case our full grasp of the machine's functional idea depends upon our breaking open the box and finding subparts that *do* relate externally.

The organism, Steiner goes on to say, is a different matter. Its overall functioning cannot be understood through the external, machine-like relations of its parts, nor is its idea impressed upon the organism from without, by a designer. Rather, the idea works generatively from within so that each part comes into being as an expression of the whole.

Coleridge was approaching the same set of distinctions when he said: whatever is organized from without is mechanical; whatever is "mechanized" from within is organic (1848, p. 42n1).

And, again, Peter Kindlmann, a professor of engineering design at Yale University, has written, "My own very practical work in electronics design over more than thirty years has ingrained in me a modular approach." This entails "partitioning a larger whole into functional modules, each described by an input/output 'cause and effect' behavior." There you see the machine conceived as a collection of parts (modules) with clearly defined external relations.

But, Kindlmann continues, "nature does not 'design' this way." Instead, it offers

> a total fusion of function and form that we are right to admire aspiringly, but can seldom take as a direct lesson [for engineering]. A blade of grass is a totally integrated system of structure, fluid transport and chemical reactor. (Kindlmann 2001)

In a "totally integrated system" where the functional idea informs every part, making it an expression of the whole, it becomes impossible to speak of separate parts without some falseness. The part, when isolated from its whole and conceived *merely* as a part related externally to other parts, is no longer the same part. By analogy, a word conceived in isolation based on its dictionary definition is not the same as the word incorporated into a meaningful text; in the latter case, the word is informed (and therefore transformed) by the meaning of the text as a whole.

Looking for the Idea

The philosopher of science, Lindley Darden, writes that

> neither the theory of natural selection nor the Mendelian theory of the gene could have been formulated had organisms been viewed as having "essences" rather than as being composed of independently variable characters [that is, traits].... (Darden 1992, p. 42)

By all means, let us be done with metaphysical essences. But this need not force us to the mechanical view implicit in Darden's "independently variable characters" and in the reigning conception of the gene. The parts of a machine can be independent of each other, relating only via external cause and effect, but the parts of an organism cannot. If geneticists had kept this more clearly in mind, they would not now be reeling from the string of revelations showing that genes do not "cause" traits. Everything now being discovered in genetics testifies to the fact that what goes on with the genes cannot be separated from what goes on with the rest of the organism (Holdrege and Wirz 2001).

Those who want to escape machine models often try to do so by *complicating* things. They try to overcome the isolation of the part by allowing *all* the parts to affect each other. They invoke feedback loops and call on some sort of "systems theory." These steps may indeed help us design more sophisticated machines. But they buy us little advantage in approaching the organism if we continue to think of all the new, complex relations in the same old mechanical, external, cause-and-effect fashion.

The alternative is to seek the unity of the organism in its *inner* nature, its governing idea. You cannot simply dismiss this as a hankering for metaphysical essences. It is, of course, possible to keep repeating, "I don't see any such governing idea — there is no such thing in nature." You could, indeed, say this about the externally imposed idea of a machine — for example, a kitchen blender — and the only response one could offer would be, "Please, look again."

The same is true of the organism, where the idea works in a rather different and less immediately obvious fashion. But the critic should at least recognize that we are saying, "Here, look again" — and not asking for belief in some sort of metaphysical entity. *SLT*

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Seeing the Rainforest

The following are some notes drawn from the rainforest sections of Andreas Suchantke's book, Eco-Geography: What We See When We Look at Landscapes *(Great Barrington MA: Lindisfarne, 2001).*

When Andreas Suchantke walks through the Amazonian or African rainforest, he senses an entire lifeworld straining upward, seeking the light — almost, you might say, excarnating. The ecosystem has substantially detached itself from the earth, so that the walker finds himself traversing the forest's root zone. Giant, buttressing roots splay out from high up on tree trunks; the trees "seem to be standing on the earth rather than rooted in it. And, indeed, underground the roots hug the surface so closely that here and there they reemerge, coiling over the surface like great snakes" (p. 39). Everything you see immediately around you is root-like: "the hanging ropes of the lianas are scarcely distinguishable from the ubiquitous strangler fig and epiphyte tendrils, which are actually roots" (p. 40). (Epiphytes are plants growing non-parasitically upon other plants.)

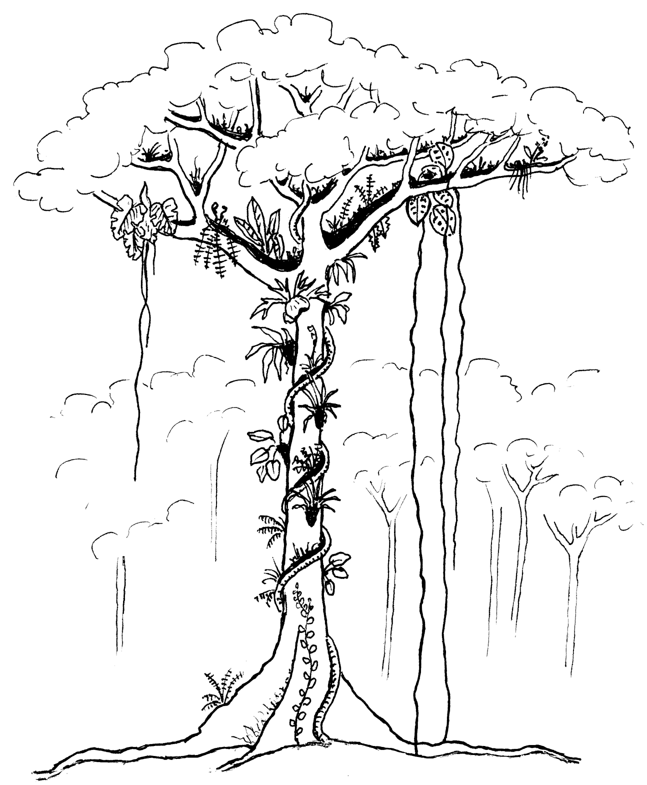
Remove the thin layer of leaf debris on the forest floor, and you find an equally thin layer of rhizome-rich humus, which, if scratched away, reveals the sterile red soil immediately beneath. In the rainforest, Suchantke points out, the region of germination occurs less in the mineral-poor soil than upon it. The cycling of all important minerals occurs largely above ground. "Leaf litter and deadwood immediately fall prey to fungi, which live in such close symbiotic association with the shallow root systems of the trees that they prevent the nutrient cycles from dipping any lower and feed all decomposition products straight back into the upward nutrient stream of their host plants" (p. 112). Whatever does get into the ground is washed away by the heavy rains. "This explains why a tree can sprout only if the seed lands in the rotting remains of a fallen one" (p. 42).

Because of the continual loss of nutrients from the soil through leaching, the Amazonian rainforest would eventually face extinction if it were not for an unexpected nourishment borne on tradewinds from the northeast: mineral dust from the great sand storms of the Sahara desert.

> The Earth's "death pole" [represented by the desert] is quite literally a key element in keeping the "vegetative pole" alive. This is a truly astonishing example of ecological interdependence. Here two of the Earth's large-scale ecosystems, geographically separate and widely differing in function, are seen to be so attuned to each other that their behavior can only be compared to that of organs within an organism. (p. 112)

Accordingly, the trees on Brazil's east coast (nearest to the Sahara) are the most heavily laden with epiphytes — especially bromeliads, which lack roots and are therefore wholly dependent upon wind-borne minerals.

The curious "detachment" of the rainforest's root zone from the soil has implications for modern practice. When a tropical rainforest is cleared by burning, the mineral ash provides an immediate shot of fertility for the new crops, but the benefit is short-lived. The sun quickly burns up any remaining organic matter and the soluble minerals are leached out of the soil, leaving only insoluble iron and aluminum compounds that sometimes harden into a rock-like crust. The land is ruined. Unlike in a temperate forest, "to destroy the world above ground *is to destroy everything*" (p. 43).



A Separate World in the Sun. If the root layer of the rainforest is displaced upward, so, too, is the herbaceous layer. In a temperate forest the green herbs and flowers lie immediately above ground. But to see these in the rainforest you have to look *upward* to the "hanging gardens" in the forest canopy.

There you will find all manner of epiphytes accumulating on branches, "together with a full complement of mites, springtails, and even earthworms" (see illustration on previous page). Speaking of the African forest, Suchantke writes,

> Ants, exclusively ground-dwellers in temperate forests, here prefer to build their nests in branches that stick out a little above the forest canopy. Many species of termites follow their example. With the grazing mammals the pattern is the same. Few are found on the ground, for example duiker, alone or in pairs, or the rare Bongo antelope, while large troupes of colobus monkeys swing through the high branches. Herbivorous apes are a characteristic phenomenon of tropical rainforests, and not only in Africa. In South Asia langurs (*Presbytis*) fill this role, in South America howler monkeys, as well as sloths. Particularly striking also is the fact that in both their mode of life and their physiology there are parallels between these inhabitants of the treetop meadows and the ruminants. (p. 42)

There is abundant bird life, too, high in the canopy. And "the birds share the scene with many species of frogs, which breed their tadpoles in the miniature ponds that form in the rosettes of bromeliads" (p. 110). In sum: whereas in temperate forests the layer richest in life processes and diversity of species is in or just above the ground, the tropical rainforests produce a corresponding layer in the canopy, high above ground level.

An Intense Monotony of Green. There is in all this, Suchantke notes, a remarkable paradox: "The earth's most luxuriant vegetation grows on the most infertile of soils" (p. 111). Just how luxuriant is brought home when you realize that, while rainforests account for only 3 percent of the earth's land surface, they contain almost one-third (29 percent) of terrestrial plant biomass. This mass includes a tremendous quantity of carbon (now being released into the atmosphere with the destruction of the forests) and also acts as a "gigantic saturated sponge" for water. The root systems catch much of the daily rainfall, and absorb the snow melt coming out of the mountains. The Amazon catchment area alone contains nearly one-fifth (18 percent) of all the fresh water flowing into the earth's oceans. The enormous quantity of water held by the biomass and released steadily into the atmosphere through transpiration has the same moderating effect as a large body of water, damping temperature extremes and keeping the air moist (pp. 96-97).

The vegetative lushness of the rainforest can present itself to the traveler as depressingly one-dimensional. The green leaf prevails — so much so that one can walk for hours without any change of scenery. "Finding a blossom provides very welcome relief for senses saturated by the endless monochrome of the lush foliage" (p. 100). Most blossoms, however, occur in the epiphytic layer overhead, close to the light. And even here, careful inspection reveals that the brightly colored parts are often sepals or bracts, while the blossoms themselves remain small and inconspicuous:

> The blossom itself cannot attain its full expression; it is drawn down into the vegetative leaves and "swallowed." It would seem that blossoms cannot compete with the vegetative vitality of the lower leaves; many trees only blossom once they have shed their leaves!

Some visitors find this unquenchable vegetative force oppressive. "Even scientists who have come to do research on the rainforest have been known to develop such a phobia against it that no power on earth would induce them to visit it a second time. They have the feeling of being trapped, smothered by its rampant vitality" (p. 108).

> The oppressive feeling of being hemmed in that we experience in the rainforest comes not from any lack of space, but from being cut off from the light and enveloped in a vegetative realm of intense, mute, unconscious growth. Subjective as such an impression might be, it points to a real, objective danger to which anyone from more temperate parts who stays for any length of time in a rainforest is prey. The brooding closeness of the atmosphere, which persists even at night, and the eternally repeated daily alternation between dizzying heat and torrential rain dull the mind and smother all activity. A slow, inexorable fall into inertia sets in, leading ultimately to a complete disintegration of personality. Conrad's "Mistah Kurtz" is not the only one to have suffered this fate. Not for nothing are many areas of tropical West Africa called "the grave of Europeans." (p. 40)

Suchantke relates the vegetative intensity of the rainforest to the relative scarcity of higher animal forms in the understory of the forest. In higher animals there begins to form an interior "reflective" space that is opposite to the vegetative pole — a space where growth forces are stopped and turned inward, toward sentience and consciousness. And, in any case, the protein-poor forests could not support an extensive, high-level food chain. It required the light-filled savannas to make possible the great herds of mammals evident on the African plains.

Clearing the Forest. European culture, Suchantke writes, would have been unthinkable without the clearing of the forests and the beginnings of agriculture.

> Although it may be "politically incorrect" to say so, we should not be deceived by the modern city-dwellers' romantic attitudes. There is a strong desire to "go back to nature" and the forest is made the idealized focus of this longing, but the fact remains that the forest, in its natural state, provides no adequate basis for human culture of any scale, and has always been alive with dangers of one kind or another. (This earlier experience is reflected in myths and fairy tales, where the forest is always a hostile place, foreboding and full of demons and wild animals; in the forest you are likely to lose your way.) The clearing of the forest was the legitimate *outward* expression of an *inner* need human beings had to make the landscape their own, to tame the power of wild nature and set their cultural stamp on the land.

But the healthy impulse in all this gave way (in Europe as elsewhere) to ecological devastation, and Suchantke now worries that the biosphere itself may not be able to survive the current wholesale destruction of the world's forests. His own aim is to *understand* the forests as a necessary preliminary for a wiser human engagement with them — an engagement that would bring out their ancient virtues and help them to evolve in directions consistent with their own "striving."

With this in view, he points to a few promising ventures in rainforest-human partnership. And he speaks of much more in this book as well, including savannas and deserts, the Great Rift Valleys of Africa and elsewhere, the ecology of New Zealand, and the role of "juvenilization" in evolution. The book is a stimulating addition to the growing literature of a new, qualitative science. *SLT*

Small Manipulation—Big Effect

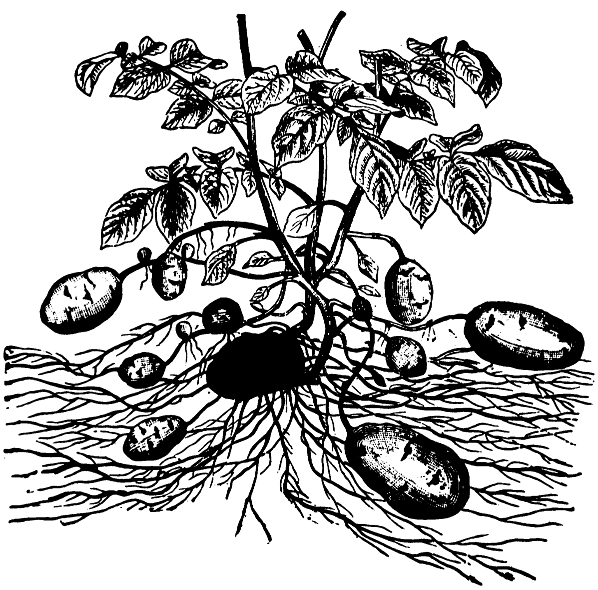
The slogan we've been hearing so insistently from biotech industry representatives over the past several years assures us there is "substantial equivalence" between genetically engineered and non-engineered crops. The slogan's endless repetition has obscured a remarkable fact: it is unclear whether anyone making this claim has ever bothered to *look* at the two types of plant in a disciplined way in order to ascertain what immediately visible differences there might be.

"Almost Like Different Varieties"

But now The Nature Institute's affiliate researcher, Johannes Wirz, is helping to remedy this oversight. By growing genetically modified and non-modified potatoes under controlled conditions, his team in Switzerland has produced startling results. Observation of plants with and without added genes showed such dramatic differences in leaf morphology and development that, in Johannes' view, the plants might well be mistaken for different varieties.

The project began when Pia Malnoe, a molecular geneticist at the Eidgenössische Research Institute in Changins, suggested a qualitative and holistic assessment of the genetically modified potatoes she had developed. Johannes, who is a molecular biologist on the staff of the Research Laboratory in Dornach, Switzerland, eagerly took up her suggestion. The subsequent study brought together molecular biologists, breeders, and Goethean researchers — whose differing expectations and world views, Johannes says, demanded open-mindedness and a good measure of conflict preparedness from all the participants. The study was carried out under both field and greenhouse conditions.

The potato variety in the experiment was "Bintje." Two genetically modified lines developed from Bintje — "Ala 20" and "Visco 2" — were grown, along with unmodified plants. Visco contains a mistletoe gene intended to provide resistance to leaf rot, while Ala was engineered to produce a poisonous metabolic product in the presence of a fungi infection, leading to the death of infected cells (and thereby providing resistance to the fungus).



Comparisons of the leaf sequences during the entire cycle of plant growth showed substantial differences. For example, the Ala plants had leaves that were more delicately formed, with stronger differentiation of the parts of the leaf, compared to the control plants. The Visco plants had strikingly rounded leaflets and much smaller leaves marked by a more uniform size and shape throughout the growth cycle.

Johannes and his colleagues supplemented and verified these observations with quantitative measures of leaf area, leaf perimeter, and so on. They also took measures of plant height and potato yield, both of which differed significantly between control and genetically modified lines.

Dirty Hands (in More Ways Than One)

Johannes, citing the work of Jochen Bockemühl at the Goetheanum in Dornach, contends that plants react as a whole to introduced genes, much as they react to external conditions such as drought or sunlight. The potato project suggests, in his opinion, that intensive, qualitative work is necessarily a part of any full assessment of molecular-genetic processes in the plant. Morphological methods are a proper complement to analytic methods.

Johannes is also aware that even growing these previously developed, genetically modified plants is problematic. There are many risks — a fact we dare not forget. But he cites the view of a co-worker, Hajio Knijpenga, that "we have to get our hands dirty." There may be no other way to bring to light the full implications of the dominant, engineering stance toward the plant world.

(The foregoing is mostly drawn from a preliminary report on the first year of the ongoing potato project, written by Johannes Wirz and Ruth Richter, and published in *Anthroposophie Weltweit*, January, 2002. Translation help provided by Henrike Holdrege.) SLT

A New Home

Sometimes things just fall into place — and on this occasion the timing couldn't have been better. We knew we had a space problem, since the growing demand for our educational program would require larger facilities. In fact, we didn't even have room to convene our full board of directors, and our students had no comfortable place to study and work. The "library" doubled as a storage room and senior researcher's office.

But before we had much time to worry about all this — and soon after we heard that our existing office might not be available much longer — we learned of a 2000-square-foot house for sale on five acres of land bordering the fields of Hawthorne Valley Farm. The forest and wetland reserve (where Craig has done much of his skunk cabbage observation) is only a ten-minute walk away, as is Indian Valley, a beautiful section of the farm with woods, stream, and pasture where we often conduct nature studies. The house is likewise within easy walking distance of the hamlet of Harlemville, where Hawthorne Valley School and the Visiting Students Program are located — as is the farm store, whose delicatessen has been known to sustain us through especially intense periods of work. We hope to create a trail from the farm center to the wetland, with the Institute property a key link between the two. We could hardly imagine a more ideal location.

We began renting the house in March. Our staff, a moving van, and a generous-hearted group of local students and community members were more than enough to underwrite a smooth transition to the new place. The house, built in 1987, is in good shape, which enabled us to move right in (with the aid of a couple of sponges, sandpaper, and a few gallons of paint). We are now in the midst of renovations to make the building an appropriate public facility; for example, we are adding new steps, a deck railing, and a wheelchair ramp.

The house — whose property includes a field and mixed deciduous forest, as well as a yard, garden, and grape arbor — already has become a vibrant center for our research and educational work. We welcomed over fifty people into our lecture room for each evening of Craig's March course on "The Wisdom of the Animal World." Then Waldorf high school biology teachers from around the country met in the same space to work on the theme, "Metamorphosis." We've also hosted smaller, more intimate gatherings — for example, our full staff enjoyed a stimulating roundtable conversation with environmental activist Andrew Kimbrell and board members Douglas Sloan and Langdon Winner. We're seeing how our new home helps us to make human connections.

The house offers adequate space for our offices, and also for the library, which houses our book collection and provides a setting for quiet study and small meetings. The basement can become a workroom and storage/display area for our biological collection. This will allow us to do more research with this collection and give students much easier access to it as well. In our previous office, the collection was boxed up in a walk-in closet.

So, yes, things do seem to have fallen into place. We feel fortunate that this kind of "luck" has guided us from the beginning. It's not something one can always count on, but sure is nice when it happens!

Purchasing the property — a capital campaign. Since affordable property in Harlemville is a rare find, this is an opportune moment for us to take a further step and acquire a long-term home for The Nature Institute. The owners, Nature Institute Friends Annelien and Christoph Meier, would very much like to see the Institute permanently settled in the house. They had planned to sell the property immediately, but hearing of our interest, they gave us a one-year lease and thereby time to raise funds to purchase the house under very reasonable conditions.

We are now embarking upon a $250,000 capital campaign. In the first year our goal is to raise $90,000, which would secure this valuable property and allow for necessary renovations. Given what we would gain from such a long-term home for The Nature Institute, this is a relatively modest sum. But raising it will nonetheless require from us an intensive and broad-based effort. Given the enthusiasm we have seen both in our own staff and in the considerable number of visitors we have already been able to serve in this new center, we are optimistic about seeing rapid progress toward the campaign's goal.

Please consider helping in one of the following ways:

- Become a major donor to the capital campaign (contributions of $1,000 or greater).
- Make a pledge for donating according to an installment plan.
- Double your annual gift — half toward the capital campaign and half to meet the second year of the $90,000 challenge grant from European foundations.
- Tell others about the work of The Nature Institute.
- Let us know of your contacts with individuals or foundations that might be interested in supporting our work.
- Do you have an idea for a fundraising event?

If you have any other suggestions, please let us know. An envelope is enclosed.

The Institute Working

Our activities over the past year (since we last reported them at any length) have been far too numerous to summarize adequately in a brief space. Here, however, are a few glimpses into the public life of The Nature Institute:

Genetic engineering: battle for the organism and consumer rights. Craig has been extremely busy giving talks, workshops, and interviews about the risks and misunderstandings inherent in our society's mad race to re-engineer the organism. (In one 21-day period he gave eight lectures, several of them about genetic engineering.) His presentations have been sponsored, for example, by a regional library association, Waldorf schools, a Community Supported Agriculture (CSA) group, and an educational center in Toronto. Perhaps the most intriguing invitation came from the Bar Association of New York City, which put Craig on a panel along with a representatives from the biotech industry, the U.S. Environmental Protection Agency, and the Food and Drug Administration.

The Bar Association meeting was held in January. Craig addressed the industry and government contention that genetically engineered food is "substantially equivalent" to non-engineered food and therefore requires no labeling. The extreme unpredictability and variability of the organism's response to introduced genes (verified in countless genetic experiments) argues against any casual assumption of substantial equivalence. And even if one does assume such equivalence, consumers would still have a right to know about the processes through which their food is produced — just as we can know, through FDA-required labeling, whether the orange juice we drink is made from concentrate or not.

A workshop for doctors. In January Craig delivered a talk on "Qualitative Science" to about twenty-five doctors practicing "anthroposophically extended medicine." Then, for the same doctors, he co-taught a workshop in practical observation of internal organs — lung, kidney, liver, and heart, all from sheep.

The response was gratifying. One doctor expressed "renewed awe at the small cosmos of organs" we carry within our bodies. Another wrote, "Craig Holdrege seems like a doorway to a new world." And a third told Craig, "You are inappropriately modest about your knowledge base versus doctors! Where it's true we know what to do for a patient in the Emergency Room with a heart attack and you don't, on the other hand we tend to have sacrificed philosophic/scientific depth for practical knowledge."

Probing the technological mind. Among the many pieces Steve has written for The Nature Institute's online newsletter, NetFuture, two may particularly interest readers of *In Context*. "The Deceiving Virtues of Technology" looks at Homer's *Odyssey* and sees in the various contrivings and devisings of Odysseus the birth of the modern individual and the roots of technology. But more recent history reveals major shifts in the character and tendencies of technology, so that our challenge today is nearly opposite to the one Odysseus faced: the technology that helped him become a self-conscious individual threatens us, if we are not alert, with the loss of selfhood. This essay was first delivered as a keynote address at the Cognitive Technology 2001 conference at Warwick University, U.K. It is available at www.netfuture.org/2001/Nov1501_125.html.

The second essay, "Ecological Conversation," attempts to sketch the place of the human being within an endangered biosphere. Is it necessarily repugnant and "anthropocentric" to speak of the special responsibilities we bear for the future of the natural world? This piece attempts to show what is involved in a respectful conversation between humans and nature. See www.netfuture.org/2002/Jan1002_127.html.

Steve has also written (for the journal, *Worldviews*, vol. 5, pp. 105-10) a review of *Goethe's Way of Science*, a SUNY Press book edited by David Seamon and Arthur Zajonc. The review is available on our website (www.netfuture.org/ni/misc/pub/stevet/goethes_way.html). His essay, "Beyond the Algorithmic Mind," was published in *Cognitive Technology: Instruments of Mind* (Berlin: Springer, 2001), pp. 190-202. And during July of last year, he taught a one-week course, "Technology and Humanity: Does the Future Compute?" at the Rudolf Steiner Institute, Waterville, Maine.

NetFuture continues to receive broad recognition. Following Steve's announcement in the newsletter that he was severely cutting back on email use, the *New York Times* (September 26, 2001) ran a feature on the challenge of email, noting Steve's position and quoting his explanation for his decision. And *Yes!* magazine, in its "Techno-Resources" section (Fall, 2001), cited six people as "Interesting Thinkers." Steve was one of the six, and the citation acknowledged both NetFuture and his "brilliant 1995 book called *The Future Does Not Compute*." Further, our Advisory Board member, Langdon Winner of Rensselaer Polytechnic Institute, was another one of the six!

Goethean science and a new relation to nature. Craig's four-part lecture series on "The Wisdom of the Animal World," mentioned below in the note about Nature Institute courses, was only one event among several in our continuing effort to characterize a new kind of science. Craig also gave a March talk on "Metamorphosis and Metamorphic Thinking" to a group of Waldorf biology teachers at the Institute. In January he traveled to Waukesha, Wisconsin, to give a talk and workshop, "Understanding Nature as a Participatory Dialogue." And in November he considered "Morality, Theory, and the Future of Science" in a talk at the annual meeting of the Science Section of the Anthroposophical Society in Pasadena, California.

Up and coming. The German publisher, Bertelsmann, is preparing a book about the future of the information society, and has asked a number of observers from Europe and America for contributions. Steve will provide a chapter entitled "The Counter-Information Revolution." His aim is to show that information, as we commonly conceive it, leads us directly away from qualitative engagement with the world. He will sketch out what it takes to get from information to a qualitative science. The chapter is given this epigraph: "The world is not an informational system, but a meaningful text."

By the time you read this, Craig and Steve, along with the Institute's affiliate researcher, Ron Brady, and board member, Douglas Sloan, will have attended a symposium bringing together David Abram (author of *The Spell of the Sensuous*), some of the scholars interested in Abram's work and in phenomenology generally, and some of the authors and educators interested in Goethean science. The aim is to explore the relation between our differing, but perhaps complementary, approaches to the question, How can we re-enliven our relations with the natural world — the world that Abram refers to as the more-than-human world? The symposium was co-sponsored by The Nature Institute and Douglas Sloan's Center for the Study of the Spiritual Foundations of Education at Columbia Teacher's College (with financial support from the Fetzer Institute).

Craig has received a grant to travel to Africa for two weeks in August. In Botswana's national parks he expects to observe some of the animals he has studied — elephant, giraffe, lion, and zebra. We have extracted a promise from Craig to give a public talk and slide show when he gets back.

Nature Institute Courses

The good news is that The Nature Institute has begun offering courses, talks, and workshops at our new home. The bad news (well, sort of) is that the summer course, "Coming Alive to Nature: Practicing the Goethean Approach to Science and Nature Study," is nearly full as of this writing. It may be completely full by the time you read this, but you can call us or check our web site to make sure. The dates are June 30 – July 6.

Course work for participants will include plant studies and observations in the field; painting and drawing; exercises to enliven thinking; and discussion of the significance of a Goethean approach. Craig Holdrege, Henrike Holdrege, and Martina Müller will be the teachers. No prior experience with Goethean science is necessary.

Our inaugural course, held last March, was a four-part lecture series by Craig entitled, "The Wisdom of the Animal World." The evening presentations were heavily attended and well-received. After a general introduction to the animal kingdom in its relation to the mineral and plant worlds, Craig offered detailed characterizations of the elephant, giraffe, and sloth. For those attending, there were numerous revelations — for example, that the giraffe has a short neck!

Or, at least, it may appear that way, depending on how you look at the giraffe:

When you consider the animal as a whole, with its strong tendency toward vertical extension throughout its body, you find that the neck, relative to the rest of the animal, can indeed be seen as short. Most other grazers and browsers can easily reach down to the ground with their heads, as when they drink. The giraffe's neck is so "short" that the animal must splay its front legs in an awkward-looking manner in order to bring its mouth to ground level. This kind of perspective is all too easily lost when the giraffe's neck is isolated from the rest of the organism and treated, as is so often the case, as a textbook example of the adaptation of the isolated part.

How to stay informed about future offerings. We expect to continue scheduling educational sessions at the Institute. For example, about the time you receive this issue of *In Context*, Craig will be conducting a series of botanical walks through the local countryside. In the future we will post all public events on our web site, so if you have web access you might want to check the site periodically. But we will also make the best use we can of other ways to notify you of forthcoming events. And you can always feel free to give us a call.

Student Life

This past winter The Nature Institute's adult students embarked on a diverse, twelve-week program focusing on Goethe's morphology and science writings, together with field observations of native tree and animal species near Hawthorne Valley Farm. They also studied skeletons in the Institute's newly liberated biological collection (no longer kept hidden in a closet), gained an introduction to projective geometry under Henrike Holdrege's guidance, and, as a bonus, were able to attend Craig's March lecture series on "The Wisdom of the Animal World".

The course included five people, in addition to Craig and Henrike:

Sue Davidoff and Allan Kaplan live in Capetown, South Africa, where they are organizational and educational consultants. They have devoted three months of their sabbatical to the study of Goethean methodology, and hope to apply this to their work in the social sector — primarily in non-first world countries.

Kirsti Hills Johnes from Norway has lived and worked in Camphill communities worldwide for thirty years. She sees Goethean studies as significant for her interactions with special-needs people.

Having had previous experience in the mainstream of science and engineering, Paul Salanki (from Ontario) attended England's Schumacher College to complete a M.Sc. in Holistic Science. He came to the Nature Institute last winter to pursue a science founded more directly upon the development of awareness and perception. Speaking of his study at the Institute, he notes that "there are few places in the world today where such opportunities exist."

Heather Thoma is continuing the studies she began with the Institute in the spring of 2001. She is aiming for strengthened practical experience with the Goethean way of seeing, and wants to find a bridge between ecological observation, architecture, and human movement.

In late March Jonathan Talbott returned to join us. He is in his last term of study at Evergreen State College in Washington and will fulfill his final graduation requirements by pursuing independent study here at the Institute. Trained as an animal tracker and wilderness "survivalist," Jonathan wants to deepen his understanding of Goethean methods while also working on the epistemological issues at the foundations of contemporary science. He studied here for the first time during the 1999/2000 academic year.

Just before going to press, we were joined by a second Jonathan—Jonathan Willby—who will study at the Institute until mid-June.

Staff News

We are extremely pleased that Heather Thoma has joined us as our capable and dynamic Outreach and Development Coordinator. She will assist us with administration and fundraising, while also helping to organize our courses and education projects.

Heather spent time as a student with us in the spring of 2001, observing, drawing and mapping native species in the wetlands, and assisting with the trailbuilding projects there. Earlier she had completed a Masters in Holistic Science at Schumacher College in Devon, U.K., where she learned about Goethean Science through her thesis work with Margaret Colquhoun at the Pishwanton Project in Scotland. Prior to that she spent ten years doing Education and Outreach work at several environmental non-profit organizations, facilitating connections between interdisciplinary science educators and community groups. She has also spent time with the International Wildlife Film Festival and the Clark Fork Coalition in Missoula, Montana, and with Friends of the River and The Institute for Food and Development Policy in northern California.

Heather is excited to be here with The Nature Institute, offering her organizational experience while continuing to develop her practice of Goethean science through working with Craig and Henrike Holdrege.

Meanwhile, Jessica Hamilton, our former office assistant, has moved on to work with a new initiative in our region. We wish her well in her new endeavors.

Thank You!

Thanks to all of you, we successfully met the $90,000 matching-grant challenge from the group of European foundations. Actually, we came in significantly above the target by the December 31 deadline. The beautiful thing about this challenge grant is that it is repeated during this year and the next, giving us a tremendous opportunity to establish The Nature Institute on solid ground. Of course, we do have to meet the challenge again during these next two years! But the word of the moment is one of deep gratitude for your support.

Those who have contributed money, goods, or services to The Nature Institute (or its online publication, NetFuture) between October, 2001, and the end of March, 2002:

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Thanks to the dedicated crew of volunteers who helped us move The Institute in March! — Pam Avery, Gavin Blankenship, Mark Bolevice, Ben Dalton, Matt Davis, Charlie Doheny, James Ferris, Susie Goetz, Sheila Golden, Dan Haldeman, Jesse Haldeman, Christina Holdrege, Martin Holdrege, Seth James, Paul Salanki, Christopher Wetmore.

Also, special thanks to Paul Salanki, who has been helping us to get situated in our new home. He did all the wiring for the telephone and computer network and is building steps and railings to bring the building up to safety code. It's hard to imagine how we would have managed this transition without Paul's help.

The Dynamic Heart and Circulation

Craig Holdrege

This essay is a substantially shortened version of Craig's introduction to a book called "The Dynamic Heart and Circulation," of which he is the editor. Many of the supporting references have been removed from the text. The book will be published later this year and is aimed at teachers, health professionals, and anyone interested in learning about a Goethean approach to the human being. To order the book, contact AWSNA Publications (916-961-0927 or www.awsna.org).

The liver is a chemical factory. The kidney is a waste treatment plant. The heart is a pump. The brain is a computer.

If we lived in a more poetic age, we might say, "the heart is a rose." But a mind at home in the mechanical world of cause and effect can hardly avoid seeing the heart as a pump circulating the blood through the body.

The damaging thing about mechanical models is that they tend to be exclusive. High school or college students don't usually learn "the heart has some functions that we can interpret in terms of a pressure pump." Rather, they learn "the heart is a pump." Mechanical metaphors in science all too often become fixed and literal, losing their vibrancy and openness. This makes them easier and clearer to apply – and also less faithful to life.

The Fluid Heart

The circulatory system is dynamic. While the brain rests firmly and still in its protective casings, the circulatory system lives in rhythmic movement, mediating extremes. Most of the heart, as an organ of movement, consists of muscle fibers (myocardium). These fibers are joined in bands that "present an exceedingly intricate interlacement" (*Gray's Anatomy*).

The outer muscle fibers begin at the upper part of the heart and sweep down in counterclockwise curves to the tip (apex) of the heart (see figures 1 and 2). There they loop around and form the so-called heart vortex (*vortex cordis*, see figure 1, middle drawing). Those fibers that begin at the front (ventral side) of the heart enter the heart vortex at the back (dorsal side) of the heart while those that begin at the back sweep around to the front. These outer fibers loop around each other, creating the vortex pattern, and then continue into the inside of the muscular wall and spiral back upward. Some of these fibers radiate into the papillary muscles that move the atrio-ventricular valves.

Fibers that lie deeper at the top of the ventricles spiral down – in contrast to the superficial fibers – clockwise. These fibers coil in more tightly and form nearly horizontal loops around the body of the ventricles before they sweep upward again to the top of the heart.

The best way to form a picture of this complex fiber arrangement is to study figure 2 and then try to recreate the spiraling with your hands. With repeated effort you begin to get a sense of the heart's dynamic structure, which the English anatomist J. Bell Pettrigrew described as "exceedingly simple in principle but wonderfully complicated in detail."

Fig.1: The heart muscle fibers in the ventricles. a) viewed from the front (ventral), b) viewed from below; note the vortex formed by the fibers (*vortex cordis*), c) viewed from from behind; the superficial fibers are partially removed to show the deeper muscles. [after 1]

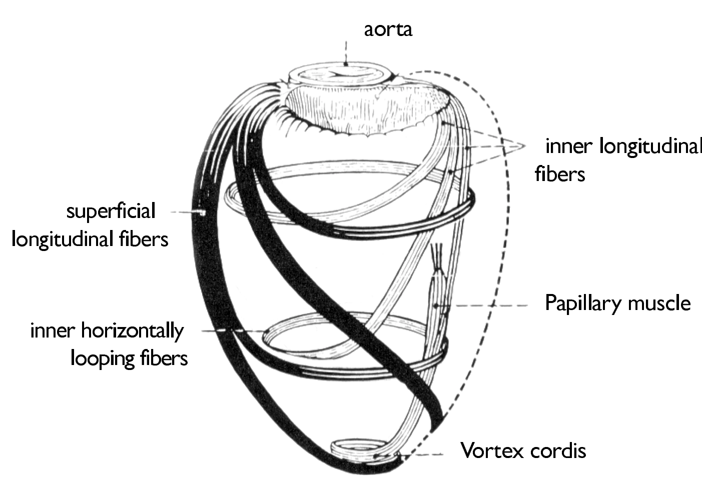

Fig. 2: Schematic representation of the spiraling heart fibers in the left ventricle. See text for description. [after 1]

Muscle consists of about 75% water. The spiraling and looping pattern of the heart fibers, including the beautiful heart vortex, is an image of fluid movement. The blood streaming through the heart also creates loops and vortices. Like the fibers of the heart, this movement is very complex and intricate. In a sense, what the blood does as a fluid has become formed in the muscular structure of the heart (see figure 3).

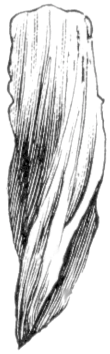

Fig. 3 : A cast of the left ventricle of a deer.

The direction of blood flow is radically altered by the heart. Venous blood enters the right side of the heart through the superior and inferior caval veins, which are vertically oriented (see Figures 4 and 5). From the right atrium the blood streams down into the right ventricle and then back upward into the pulmonary artery, which immediately branches horizontally to the right and left to enter the lungs.

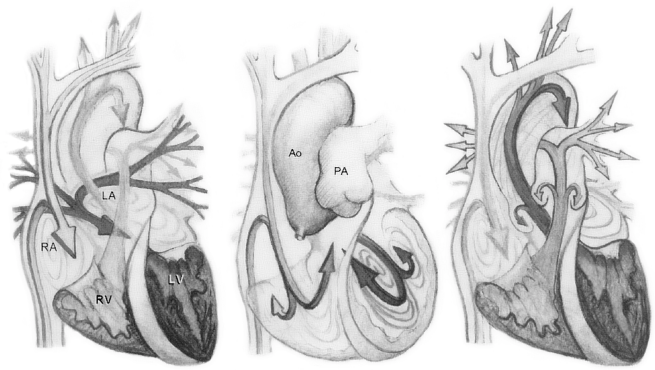

Fig. 4: Changes in blood flow direction through the heart, viewed from the front. Systole has been shown twice to show inflowing and outflowing blood. RA, right atrium; RV, right ventricle; LA, left atrium; LV, left ventricle; Ao, aorta; PA, pulmonary artery. (Drawings by P. Kilner; reprinted by permission. See [3].)

In contrast, the blood that enters the left side of the heart comes horizontally from the pulmonary veins. From the left atrium it flows downward into the left ventricle and loops upward into the ascending aorta. At the aortic arch three arteries ascend into the head and arms, while the vertically descending aorta serves the rest of the body.

So the right side of the heart brings vertically flowing blood into the horizontal and the left side of the heart brings horizontally flowing blood into the vertical. This change in orientation is clearly evident in the drawing of the cross that is formed by the caval veins and the pulmonary veins (Figure 5).

The streams of blood entering the right atrium from the superior and inferior caval veins do not collide, but turn forward and rotate clockwise, forming a vortex. The blood streaming into the left atrium also forms a vortex, but it turns counterclockwise. When the atrio-ventricular valves open, the blood streams into the relaxed ventricles, again rotating, forming vortices that redirect the flow of blood. Momentarily the blood ceases its flow and then the semilunar valves (which separate the ventricles from the outgoing arteries) open and the blood streams into the pulmonary artery and the aorta.

The coiling, looping heart fibers create contractions that mirror and facilitate this streaming, looping blood flow unique to each chamber. During systole (contraction) the heart moves downward and oscillates slightly to the sides and also rotates around its own axis. During diastole (relaxation) it moves upward and rotates back in the opposite direction[2, 4]. Only the heart's interwoven spiraling muscle fibers can produce this kind of complex motion.

We see that blood flow, the form of the heart, the pattern of its fibers, and the motion of the heartbeat are intimately entwined. We can't think of one without the others. When we go back to the origin of the blood and the heart in embryonic development, it is no simple matter to say what came first. Early in its development the heart begins to form loops that redirect blood flow. But before the heart has developed walls (septa) separating the four chambers from each other, the blood already flows in two distinct "currents" through the heart. The blood flowing through the right and left sides of the heart do not mix, but stream and loop past each other, just as two currents in a body of water. In the "still water zone" between the two currents, the septum dividing the two chambers forms [1]. Thus the movement of the blood shapes the heart, just as the looping heart redirects the flow of blood.

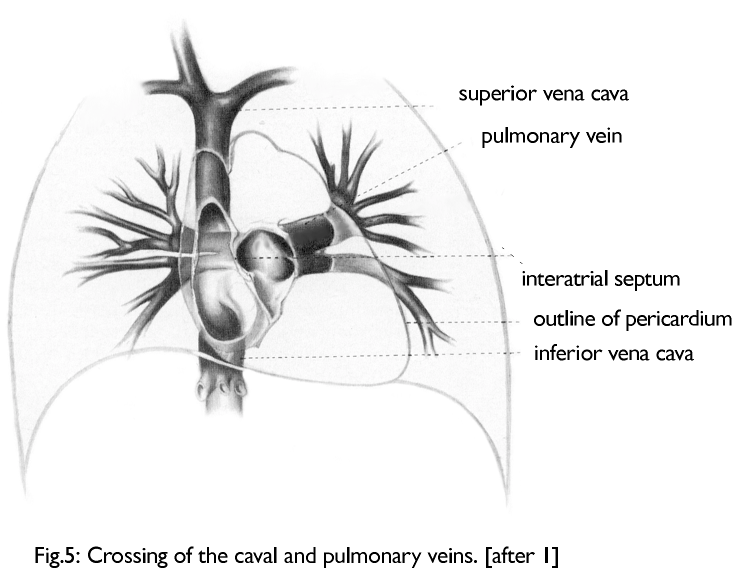

Fig.5: Crossing of the caval and pulmonary veins. [after 1]

Pulsing Interplay

The heart is the center of the circulatory system. It connects the upper and lower parts of the body as well as, through the pulmonary circulation, the outer (air) with the inner. The heart is continually adapting its activity to the needs and state of the body and person as a whole.

In strenuous activity, for example, the heart expands more in the diastolic phase (when it receives blood) and increases its beating rate, allowing more blood to pass through the heart and into the lungs and muscles. But the heart is not simply pushing this blood into the body. The lungs take in up to three times the amount of oxygen during exercise, not only because of the increased diffusing capacity of oxygen, but because both lung alveoli (where diffusion occurs) and the lung capillaries dilate, letting more blood pass through the lungs. Similarly, in the muscles the blood vessels actively dilate.

If, over an extended period of time, an organ needs more oxygen, it stimulates, via growth factors, the blood vessels in the organ to grow. This is another example of how the impulse to change and adapt comes from the periphery. The whole circulatory system, from center to periphery, is involved in getting more blood into the tissues that need it.

The blood moving through the body is continually changing. After we've eaten, for instance, the blood passes through the intestines and takes up nutrients. The blood then enters the liver, which draws out nutrients. The liver also detoxifies the blood, removing, for example, bacteria or alcohol. In each organ something unique to that organ happens to the blood. In the brain large amounts of sugar and oxygen leave the blood. The kidneys remove metabolic waste products and water, but also secrete hormones that regulate the production of red blood cells. The blood is truly a special fluid in its ability to take in and give off substances that it moves through the body. It is in unceasing change and thereby helps the body maintain its physiological balance and coherence.

Changes in the blood's pressure, viscosity, warmth, and biochemical composition are communicated to the heart by means of the nervous system, hormones, and heart and blood vessel sensory receptors. The heart therefore exists as a perceptive center for the body via the circulation. Steiner spoke of the heart as a sense organ for the organism, enabling it to perceive what transpires in the upper and lower poles of the body [5].

The heart does not just perceive what comes to it via the blood. It also alters its activity – and not only to circulate more or less blood. For example, the heart secretes a hormone in response to the changing consistency of blood. If the blood is too viscous, the heart secretes this hormone (natriuretic peptide) into the blood, and the hormone stimulates the kidneys to secrete more water into the blood.

One further feature of the interplay of heart and peripheral circulation we shouldn't overlook is the maintenance of body warmth. Only the warm-blooded mammals and birds have completely four-chambered hearts. The internal differentiation of the heart corresponds to the organism's ability to maintain a high constant body temperature despite radically fluctuating inner and outer conditions. The beating heart muscle itself is a source of warmth for the blood, while the peripheral circulation can expand and contract to give off or contain warmth.

Into the Soul

Here are some English words and expressions relating to the heart:

Heartless	Have a heart
Hearty	Lose heart
Heartrending	Heavy heart
Heartbreaking	Warmhearted
Heartache	Coldhearted
Fainthearted	Hardhearted
Lighthearted	Heart sick (sick at heart)
Heartsore (sore hearted)	Search your heart
Wholehearted	Put your heart at rest
Heart-to-heart	Near to my heart
Take heart	You are all heart
Take that to heart	Heartfelt

The feelings associated with these expressions are often deep (heart sick, heart-to-heart) and span polarities (cold- and warm-hearted; faint- and light-hearted). What comes from the heart is authentic and whole. It's one thing to search your brain for something or to put your mind to something and a very different matter to search your heart for something or put your heart into it. The heart is literally in-dividual; it is unity and when that unity loses its center or begins to dissolve, it's, well, heartrending.

The quality of warmth is central to the heart. Someone who is heartless is cold. When we have a heartfelt concern, soul warmth streams out from us. When we take heart, warmth enkindles our courage. (Etymologically, "courage" means "heart.") And when we gesture to someone to take heart, we emphatically raise up our arm and ball up the fist in front of our chest. Taking heart means gathering at our center and from there expanding into the world through our actions.

Not only the heart moves between the polarities of contraction (systole) and expansion (diastole). Rhythmic movement between poles, and mediating and balancing between extremes, characterizes the circulatory system as a whole. The blood gathers in the heart and then flows out into the periphery, changing and exchanging with this periphery, and then moving back to the center.

When we've grasped the circulatory system qualitatively in this way, it's not surprising to discover its intimate connection to our inner life of feeling. Feelings of awe and love allow us to flow out into the world. We connect, give and learn from the world and bring the fruits of this interaction back to a center. We experience satisfaction and contentment. Our joy leads us back into the world. Or we experience fear, anger, or even hate. We draw back into ourselves when such feelings capture us, and the healthy oscillation of the soul between inside and outside, between self and other, is disturbed. Just as we can become completely isolated through hate, so also we can lose ourselves in unceasing rapture.

The healthy life of the soul depends, as does the circulation, on continual movement, on the ability to flow out and gather in. Or we can speak in terms of the other middle system in our body, the respiratory system: we need the rhythm between breathing out and breathing in.

Our soul life and physiology are inseparable. It is well known how stress (which means we are inwardly driven and contracted with little inner breathing room – our soul can't oscillate) has its physiological correlate in hypertension, where the blood, like the soul, is under abnormally high pressure. A Swedish study found that women who lived alone, had very few friends, and also no one to call on if they needed help, tended to have heart rates that varied little over the course of the day. Such low variation in heart rates is correlated with heart disease and early death. Less socially isolated individuals have a more varied heart rate.

The path to health involves seeing bodily processes as an expression or outer aspect of what we are inwardly.

Conclusion

Mechanical models may be helpful to understand partial functions of an organ or system, but when they become exclusive, the partial truth becomes falsehood. We end up making the heart much *less* than it really is. The image is that of a central power center that forces blood through the body and thereby maintains the body. This is, if you will, an egocentric view of the heart as the forceful doer. The pump just keeps on working until it wears out – or, as in the case of the artificial heart, keeps beating even when the person has died.

Mr. Robert Tools was the first patient to receive the AbioCor artificial heart. After the operation in July, 2001, Mr. Tools recovered quite well and was able to leave the hospital. He suffered a stroke on November 11th. Patients with an artificial heart are always susceptible to strokes, because the blood more easily clots when it comes in contact with the artificial material of the valves. Normally a patient receives blood thinners to prevent clot-formation, but this was not possible in Mr. Tools' case, since he had a tendency to bleed internally.

After the stroke, Dr. Laman Gray, who carried out the surgery, reported that Tools' condition "is probably a little better than a person with a [real] heart, since we don't have to worry about the heart itself." Gray went on to comment about another patient who had received the AbioCor heart. This patient was making slow progress, due to a high fever that may have damaged his organs. But, as the reporter paraphrases Gray, "Mr. Christerson's [artificial] heart has been working well."

On November 30, Mr. Tools died due to internal bleeding. But, as the *Los Angeles Times* reported, " 'Tools' death in no way means the experiment failed,' said Dr. Mehmet Oz …. Indeed, Tools' doctors noted that the heart continued to beat flawlessly even as he died." Here we see the mechanism enthroned in a sad separation from the person. The pump still continues to beat as if nothing had changed, while the person dies. And as long as you focus on the mechanism, and the pump continues to work, the experiment cannot be called a failure.

Very different is the view of the living, dynamic heart and circulation. Here we see give and take, and continual change and adaptation through interactions. We see a dynamic, perceptive center that maintains coherence and integrity. From birth till death, the living heart shares in our life as ensouled beings.

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The Lure of Complexity (Part 2)

Steve Talbott

(This is the second part of a two-part essay. The first part appeared in our Fall, 2001 issue and is also available on the web: http://www.netfuture.org/ni/ic/ic6/complexity.html.)

Anyone who lives in an earthquake zone knows that mild earthquakes are much more common than powerful, devastating ones. What you might not expect, however, is that a simple, straight-line mathematical relationship known as a "power law" tells you what percentage of earthquakes will exceed any given energy. Even more surprisingly, you can derive the same sort of law showing what percentage of cities will be larger than a given size. Or what percentage of fjords in Norway will exceed a given length. Other power laws occur when you look at word-usage patterns in texts, global temperature variations, the occurrence of traffic jams, stock market performance, and (as discussed in part 1) avalanches in artificially constructed sand piles.

In each of these domains any attempt at causal analysis leads you to the complex, nearly unanalyzable interplay of countless factors. (Try to tabulate all the reasons why individuals migrate to and from any particular city!) And yet, in every case this interplay yields an elegant, straight-line power law. This is the kind of thing that appeals to so many complexity theorists, convincing them that they are on the track of a grand, unified theory of nearly everything.

Seeking Universality

A planet in motion, obeying Newton's laws, does not present a picture of complexity. By contrast, the geological, biological, and evolutionary realities of a landscape (such as a fjord or region of earthquake faults) *are* complex. This, at least, is the thought Per Bak expresses when he says, "we do not live in a simple, boring world consisting only of planets orbiting other planets, regular infinite crystals, and simple gases or liquids." He goes on: "Crystals and gases and orbiting planets are not complex, but landscapes are" (Bak 1996, pp. 4–5).

Bak, who is a pioneer of complexity theory, rejoices in the challenges of the landscape. But note the slight oddity here. A planet is, after all, the bearer of its landscapes, so it must be at least as complex as any one of those landscapes. Only when we think away all the planet's rich detail, reconceiving it abstractly as little more than a mathematical point in Newtonian motion, does its complexity fall from view. We should keep in mind that "boring" simplicity characterizes a way of theorizing about phenomena, not the phenomena themselves.

And the irony is that, in embracing landscapes and other complex phenomena, complexity theorists such as Bak rely on their own abstract simplifications, along with a fierce resolve to "shear away detail." So they end up merely repeating, on this new front, the astronomer's sacrifice of the world's fullness. Where celestial mechanics reduces the planet to a locus for interaction of a few simple mathematical laws, these researchers now reduce the landscape to a locus for interaction of a few — rather different and more statistical — mathematical laws. The landscapes that, in their qualitative and particular reality, are so invisible to the astronomer plotting a planet's Newtonian trajectory in space seem to be nearly as invisible to the complexity theorist looking for deep, context-free truths. All too often the study of complexity begins to look like an abandonment of the phenomena the researchers originally set out to investigate.

Bak wants a general theory of life so profound that it "cannot have any specific reference to actual species" — a theory that doesn't get sidetracked by "utterly accidental details ... such as the emergence of humans" (Bak 1996, p. 10). Likewise, speaking of the various power laws, he observes that "since these phenomena [that is, statistical patterns] appear everywhere, they cannot depend on any specific detail whatever." And again: theorists who are going after fundamental principles must "avoid the specific details, such as the next earthquake in California." Rather,

> Our strategy is to strip the problem of all the flesh until we are left with the naked backbone and no further reduction is possible. We try to discard variables that we deem irrelevant. In this process we are guided by intuition. In the final analysis, the quality of the model relies on its ability to reproduce the behavior of what it is modeling. (Bak 1996, p. 42)

But, just as Bak refers to "phenomena" when he is really speaking only of statistical patterns, so, too, the "behavior" he alludes to here is hardly the behavior of any particular thing. The particulars — such as the individual character of the fault line that will produce California's next earthquake — have been ruled out of the picture in advance. So the behavior at issue is, again, a matter of highly abstract, statistical generalities.

What seems never to occur to Bak and many of his fellow researchers is that the grand unifying theory they are stalking may be grand in scale, and may be unifying, but for this very reason promises to be more or less trivial. Don't get me wrong, however. There are doubtless interesting ways to elucidate the power laws we can abstract from diverse phenomena. It's just that the act of abstraction here has been so severe — so many aspects of the phenomena we were looking at have been left out — that our discoveries, while interesting in their own right, will tell us almost nothing about these particular phenomena. The scholar who is seeking to understand the population growth of Cairo is much better advised to explore the relevant cultural, social, political, economic, geographic, and ecological realities bearing on this one place than to dwell on the elegance of a straight-line graph showing the frequency of occurrence of cities with different population levels. It's not clear who among students of particular phenomena *will* find much use, or much revelation, in that graph.

Explanations that do not depend on specific details will fail to elucidate those details. If, at the outset of our investigations, we strip away every concrete particular we can, then we will hardly arrive at any profound understanding of concrete, particular phenomena. But what else is there to understand? It was the whole concern of the key figures of the Scientific Revolution to shun the abstract cerebrations of the medieval schoolmen and open their eyes to the world around them. Should science reject this stance now, preferring (in Bak's words) "to free ourselves from seeing things the way they are"?

The problem with a scientific method based on maximum generalization and abstraction is that the more it succeeds — that is, the more general and abstract its results become — the shallower they tend to be. They tell us less and less about the particular contexts we wish to understand.

Look at it this way. If you let X represent anything at all and let 1 stand for "exists" and 0 for "does not exist," then it is true to say of every existent thing (every X) in the universe: "X = 1". By the standard of generality, abstraction, and precision, this must be just about the deepest truth of all. And, perhaps in some sense worthy of meditation, it really is. But as a scientific statement it is vacuous. Its vacuity is directly related to its generality. Precisely because it tries to tell us something about everything, it doesn't tell us much about anything in particular.

In our drive toward generality and abstraction, we end up with what we ask for. If, for example, we are determined to reckon only with what is generally true of both living organisms and systems of inanimate, mineral objects, we will end up seeing only the inanimate, mineral aspects of living organisms. We will get a theory that "connects" diverse things, but in the process loses the things we are connecting.

Flight from Phenomena

The abandonment of detail by complexity theorists sometimes begins to look like an outright abandonment of phenomena. In the first part of this article I mentioned Stuart Kauffman's pot of symbol strings. A symbol string is just an ordered group of zeroes and ones — for example:

011
101011
11100

Kauffman asks us to imagine these strings floating around rather like molecules in a pot of liquid, interacting with each other according to a set of "grammar rules." That is, when strings "collide," zeroes and ones may be appended to a string, or deleted, or changed (drawing as necessary upon a reservoir of available digits). As the grammar rules are applied to the colliding strings, the latter may "evolve" in interesting ways.

Now, you may well wonder just what sort of pot this is. How do numbers interact in a pot? Kauffman describes the process almost as if it were a matter of physics — a matter of real materials obeying real laws. He speaks (albeit in quotation marks) of "enzymes" and "substrates" and "strings" that "collide." And he considers his strings to be *models:*

> Bear in mind that we can consider our strings as models of molecules, models of goods and services in an economy, perhaps even models of cultural memes such as fashions, roles, and ideas. (Kauffman 1995, p. 287)

Yet Kauffman shows no sign of reckoning with the stubborn realities of an actual model that works. What excites him is an abstract set of purely logical relations. Yes, his excitement quite evidently arises because he imagines these relations to be applicable to real phenomena; but he is not so much engaged in the study of the phenomena as in the elaboration of his logical scheme.

Among complexity theorists there is often a strange disregard of the distinction between abstract thought structures and real-world phenomena, including real models. But there is, after all, a radical difference between a purely notional pot of symbol strings, conceived as a set of logical relations, and any actual embodiment of these relations. You can see this difference even if the embodiment takes form only as a computer simulation, where the zeroes and ones are translated into electrical patterns in silicon and light patterns on a screen.

Once you have such embodiment, your thought experiment comes under constraints that were absent from the purely abstract logical relations. The abstract relations just are what they are — eternally, you might say — but the embodiment is an entirely different matter. To begin with, a computer simulation of the symbol pot can be sustained only because a massive technical infrastructure is in place and because engineers have carefully designed the simulation hardware and software. And even once it is up and running, the simulation might take an unexpected turn due to an electrical power failure, or I might spill coffee into the computer's circuitry, or a bug in the supporting software might supervene, or a giant meteor might strike the earth, or the hardware might (and over time certainly will) succumb to normal wear and tear. Contingencies of this sort are exactly what make the difference between the purity of logic and the reality of the world.

This is the kind of reflection that seems wholly irrelevant to a person enamoured of disembodied abstractions. But it is exactly what should matter to anyone who, like Kauffman, takes the abstractions as key to understanding the evolution of real (embodied) life forms.

This point is worth pressing further.

Physics or Fancy?

You may have heard of the Game of Life. It divides your computer screen into a fine-meshed rectangular grid wherein each tiny cell can be either bright or dark, on or off, "alive" or "dead." The idea is to start with an initial configuration of bright or live cells and then, with each tick of the clock, see how the configuration changes as the software applies these simple rules:

** If exactly two of a cell's eight immediate neighbors are alive at the clock tick ending one interval, the cell will remain in its current state (alive or dead) during the next interval.

** If exactly three of a cell's immediate neighbors are alive, the cell will be alive during the next interval regardless of its current state.

** And in all other cases — that is, if less than two or more than three of the neighbors are alive — the cell will be dead during the next interval.

You can, then, think of a cell as dying from loneliness if too few of its neighbors are alive, and dying from overcrowding if too many of them are alive.

Now, what interested the early students of this game in the 1960s was the fact that, given well-selected initial configurations, remarkable patterns are produced. A "glider" composed of lit cells might sail serenely across the screen. A "glider gun" might produce an endless series of gliders. Another entity might swallow up any glider that makes contact with it, while itself remaining intact. There are static patterns, blinking patterns, rotating patterns, and forms that can evolve and even reproduce themselves in endlessly fascinating ways.

What is still more remarkable is the conclusion some researchers eventually drew from all this. Full of excitement as they watched their enchanted screens, they began to suspect that they were being initiated into the deepest secrets of biological evolution, of reproduction, and of life itself. (The complexity discipline known as Artificial Life grew out of this work.)

Referring to the Game of Life and the three-part law governing its performance, philosopher Daniel Dennett has remarked that "the entire physics of the Life world is captured in that single, unexceptionable law" (Dennett 1995, p. 167). Moreover, "our powers of prediction [regarding the Life world] are perfect: there is no noise, no uncertainty, no probability less than one" (Dennett 1991, p. 38).

But, as we have seen, the "unexceptionable law" is hardly a law of physics, and it is a little odd to talk about our "powers of prediction" where only thought relations are in view. If, on the other hand, we really are talking about a physical machine equipped to represent the thought relations in some embodied form — a machine whose activity we might now venture to predict — then the problems of a sustainable power supply, spilled coffee, and all the rest cannot be avoided. What we have, contrary to Dennett, is noise, no certainty, and no probability equal to one.

It is not that brilliant thinkers such as Dennett would fail to recognize this obvious truth. It's just that the truth doesn't seem to count for much in their thinking. The "something else" that enables us to talk about the phenomenal world instead of the pure thought relations of an assemblage of abstractions draws no particular attention from them.

What's happening here is that the world has been reconceived as a machine, the machine has been reconceived as a pure abstraction (for example, as software — see Talbott 2000), and the theorists, taking up their stance within this realm of abstraction, merrily spin out new thought relations to "explain" the world. But since their method has instructed them to avoid the real world as far as possible by shearing away detail, they remain mostly in a kind of abstract never-neverland. The rules of the Game of Life do not explain what I see on my computer screen even when I am running the Game of Life. Any such explanation would have to reckon with power supplies, programmers, and a great deal else.

The Consequences of Abandoning the World

I have restricted myself here largely to the problem of generality and abstraction. However, I should offer at least these exceedingly brief remarks about some of the other complexity themes I alluded to in Part 1.

Reductionism. The claim by some complexity researchers to have moved "beyond reductionism" is not justified by the facts. The decisive and damaging act of reduction within conventional science has always been the reduction, in thought, of the qualitative world of phenomena to abstract, machine-like models devoid of qualities. Complexity theorists seem at least as committed to this reduction as any other scientists. It is true that many of these theorists want to grant "irreducible" status to higher-level orders of reality such as economics, animal behavior, and human thinking. But this hardly makes much difference if the concepts available for dealing with these realities are as machine-like and as qualitatively emptied as the concepts previously applied to atoms and photons.

Holism. There can be no holism without the qualities that complexity researchers strip from the world. It is the nature of qualities to interpenetrate one another, and only through such mutual interpenetration can a whole express itself through each of its parts. Without qualities, there are featureless "particles" side by side in changing arrangements, but nothing to make an integral unity of them — nothing to give the assemblage the sort of distinctive, expressive character enabling us to recognize a whole. Where theorists do speak of wholes, you will find that either their terms do not justify such speaking, or else they have surreptitiously imported qualitative considerations without acknowledging them and without giving them a proper place in their method.

The literature of complexity presents us with countless references to wholes that are "more than the sum of their parts." But those who speak this way don't seem to take their own words seriously. If they did, they would be forced to grant that the whole — the "something more than the sum" — remains even after all the parts have been removed. They would, for example, strive to grasp the generative idea, the productive unity, of the rose — the unity that expresses itself through root, leaf, and flower but is by no means a mere collection (sum) of roots, leaves, and flowers. (See "Of Ideas and Essences" in this issue.)

Disciplinary convergence. The loss of any foundation for holism within complexity studies suggests that the hope for meaningful disciplinary convergence is probably misplaced. Confusion on this point results from a failure to see the double aspect of abstract generality. It is true, on the one hand, that we can homogenize many disciplines by seeing only their projections upon the same abstract grid. In this way, chemistry, biochemistry, genetics, botany, zoology, evolutionary theory, and cosmology have increasingly come to be dominated by the same sort of remote, non-experiencable "entities" — particles, atoms, molecules, genes — that first colonized the physicists' imagination.

But the interdisciplinary unity being sought here, as I have been arguing, is an emptied unity — the unity that comes from the one-sided urge to strip away differences and refuse to consider them. The study of cities and of earthquakes—or the study of plants and of minerals—become the "same" studies.

By contrast, a true unity arises when we recognize differences while at the same time bringing *those very differences* into meaningful relationship — an essentially qualitative undertaking. We would not see the expressive unity of *Hamlet* if we turned away from the uniqueness of each character, looking only for what they had in common. There would be nothing significant left to bring into unity.

So the other tendency of abstract generality — and this is what has driven the fragmentation of science from the beginning — is to rob the various disciplines of the distinctive elements through which they might have entered into muscular relationship. An increasingly featureless commonality replaces mutual illumination and complementation. One is left with no scientific tools for relating the world's different phenomena to each other (as opposed to obscuring their differences), so compartmentalism remains a major affliction. How meaningfully can Artificial Life investigators, on the one hand, and naturalists observing living frogs and trees, on the other, relate their separate undertakings?

Emergence. When your scientific work repeatedly brings you up against vaguely conceived "emergent" phenomena — phenomena that seem to arise from out of nowhere — you might reasonably wonder whether your models and explanatory mechanisms have omitted something important. While most complexity theorists seem undisturbed by this thought, I have been suggesting above that the omission has in fact been as radical as it could possibly be: what the models tend to leave out is the phenomenal world as such, with all its contingencies and with all its causal, or generative, powers. To these investigators, therefore, *all* actual phenomena are likely to appear emergent simply because all phenomena present a qualitative fullness that has intentionally been stripped from the theoretical apparatus employed to explain them.

What the situation requires is a fundamental reconsideration of method. Most importantly, this means a reconsideration of the founding decision within science to ignore qualities, since it turns out that to ignore qualities is to ignore the world. There is no way to get from the sheer abstractions of complexity theory back to the world of phenomena, except by re-introducing qualities "through the back door" when no one is looking — and then exclaiming about the "emergent" wonders that arise. It would be much more sound scientifically to face qualities up front, wrestling through to an understanding of their proper place in the scientific enterprise.

Looking for the Positive

I have left a huge amount out of my cursory survey, and this is the place to acknowledge the fact. I have said nothing, for example, about the promise of chaos theory (about which I hope to write in the future). And I have not noted that some investigators, such as the Nobel prize-winning chemist, Ilya Prigogine, avoid at least some of the excesses dominating the field. (See Grégoire and Prigogine 1989; Prigogine and Stengers 1984.)

Let me conclude, then, on a somewhat more balanced note. It is certainly arguable — as I have indeed argued — that the tools complexity researchers bring to their work are even more severely constrained, more one-sidedly abstract and quantitative, less tolerant of qualities, less relevant to the richness of the world given through observation, than was the case with much of the science they are trying to reform.

But it is also true that the students of complexity really are seeking a better science. Their desire to overcome narrow compartmentalization is genuine, and this means they are acknowledging broader contexts — they are actually *seeing* nature's diversity — at least long enough to wheel out the heavy artillery of abstraction with which they proceed to level the newly acknowledged landscape. Moreover, the hunger for "emergent" realities surely reflects a sense that we need to reckon scientifically with a larger reality than the traditional "hard" sciences have addressed. Researchers looking at earthquake faults or economic transactions or the population growth of cities no longer accept the charge that they are on secondary scientific ground whenever they speak, not of particles, but of the phenomena they can actually observe.

This willingness to observe, for purposes of explanation, a much fuller world is the main hope of complexity work. The problem, as we have seen, is that the kinds of explanation employed immediately obscure the fuller world the researchers are straining toward. This, of course, is where Goethean scientists can play a helpful role by demonstrating the possibilities of a qualitative science that honors the phenomena in all their richness.

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