In Context

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The Newsletter of **The Nature Institute**

#25

Dear Friends,

Observation is central to everything we do at The Nature Institute. In all of our research and educational work we strive to refine our capacities of observation. On the one hand this means turning with an open awareness toward the phenomena of the sense world. On the other hand it means observing human thought processes so that we become more sensitive to the way our thoughts interpenetrate with experience. How often do we attend to our abstract notions more than to the things themselves! Such abstractions can cut us off from the deeper roots of understanding and at the same time can shape our thinking and actions in ways that become destructive.

This issue of *In Context* encompasses these complementary aspects of our work. The feature article by Georg Maier—extracted from a chapter of his forthcoming book, *An Optics of Visual Experience*—is perhaps most noteworthy for its calm spirit of exact observation. The subject—what sort of world does a mirror space present us with? what are its qualities and its principles of coherence?—may seem almost banal topics. But our little excerpt hints at the value of carefully attending to phenomena for their own sake. Maier's work reminds us that, however "commonplace" the subject matter, a well-trained receptivity can bring new insights and render the matter less common than our inattention may have led us to imagine. Surely this lesson bears upon our busy times in which we all too easily overlook and ignore—and therefore do not take seriously—what is right in front of us. What could be more urgent than to meet events in the world with a quietness and depth of mind bent on absolute fidelity to the truth of experience? Meier's work is an invitation to discovery through disciplined perceiving.

At the other pole—observing contemporary thought processes—our opening article focuses on the field of biological engineering. It reveals a realm of human ideas and manipulation that is deeply unsettling. The very nature of the living organism is being made into a subject for both trivial gaming and commercialized re-engineering. As the examples in the article show, the relation with the living world has become so disconnected that it is dissolving into a kind of chaos where everything is imagined to be possible and where projects need only to be imagined as possible in order to be attempted. In their starkness these ambitions and efforts reveal how important it is to move in a different direction—to anchor human thought and action in concrete perception and experience.

And between those two articles, we come upon the brilliant and currently overlooked twentieth-century cell biologist, Paul Weiss, who combined clear, precise observation of the organism with equally clear thinking. His prominent achievements during the middle two-thirds of the last century can serve as a beacon for those trying honestly to follow the lead of the many surprising biological findings of the still young twenty-first century. He combined the most rigorous scientific observation with a profound respect for the character of the living organism. We consider both Weiss and Maier to be among the guiding lights for our own work at The Nature Institute.

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The Nature Institute

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Biological Engineering for Fun and Profit

In the July, 2007 issue of *New York Review of Books*, physicist Freeman Dyson heralded a coming era of "user-friendly" genetic engineering kits. At that time the first step, according to this high-profile scientist, had already occurred: genetically modified tropical fish with new and brilliant colors had appeared in pet stores. Still to come, he prophesied, were do-it-yourself kits enabling gardeners to "breed" new roses and orchids, and animal lovers to create previously unknown varieties of pigeons, parrots, lizards, and snakes, not to mention dogs and cats. "Designing genomes," Dyson claimed, "will be a personal thing, a new art form as creative as painting or sculpture." Then the final step in the "domestication of biotechnology" will be biotech games

> designed like computer games for children down to kindergarten age but played with real eggs and seeds rather than with images on a screen. Playing such games, kids will acquire an intimate feeling for the organisms that they are growing. The winner could be the kid with the prickliest cactus, or the kid whose egg hatches the cutest dinosaur.

Dyson acknowledged that these games "will be messy and possibly dangerous," but this concern hardly vitiated his enthusiasm, and he seemed to have little doubt about the scientific precision of the underlying procedures, at least when performed by knowledgeable adults. "Guided by a precise understanding of genes and genomes instead of by trial and error, we can within a few years modify plants so as to give them improved yield, improved nutritive value, and improved resistance to pests and diseases."

So far as that "precise understanding," is concerned, the interested reader should refer to The Nature Institute's http://nontarget.org website. Few biologists today who actually work at trying to understand the organism at the molecular level (as opposed to physicists writing outside their field) would make the claim of precision. After all, if our knowledge was at all precise, we ought (according to the doctrine of molecular determination of the organism) to have "conquered" cancer long ago—or at least to have figured out what the problem is. But, in any case, lack of understanding has never been an obstacle to those who view the natural world as a playground for unrestrained manipulation. And nothing has happened during the less than four years since Dyson's article was published to suggest that his prediction of widespread manipulation for fun and profit was incorrect.

Take, for example, Ingmar Riedel-Kruse, a bioengineer who asked himself why there shouldn't be video games using live microbes. He and his colleagues developed a game console that, according to *Science* magazine, "nudges paramecia around a microfluidic chamber with chemical gradients or mild electric fields." Games include Ciliaball, a soccerlike entertainment, and Pond Pong, "in which two players bat the microbes back and forth by releasing chemicals from a needle tip." A microscope camera projects the fun onto the game window.

That might seem fairly innocuous, since the organisms are not actually genetically engineered. If you yearn for the deeper joy of re-making organisms in order to satisfy your own artistic whimsy, you can only envy the poet, Christian Bök, who was given the privilege of devoting some $16,000 to the realization of his dream. He chose to create an organism with inserted DNA that, according to an arbitrary mapping scheme in his own mind, encoded some of his poetry. "I hope," he told the journal *Nature*, "to be among the first poets to make a work of art out of such a burgeoning technology."

Then there is Meredith Patterson, "a computer programmer turned biohacker by night," according to a December, 2008 article in *The Times* of London. "In her San Francisco dining room Ms. Patterson is currently attempting to rewire the DNA of yoghurt bacteria so that they will glow green to signal the presence of melamine, the chemical that infamously turned Chinese-made baby milk formula into poison." This illustrates how easily playing with the molecular processes in organisms can be hitched to "socially redeeming" causes.

Can it also be hitched to some very, very bad accidents? It doesn't seem to matter. "The growth in popularity of biohacking seems unstoppable," writes *The Times*. And when a reporter put the question of terrorist opportunities to Ms. Patterson, she shrugged, "A terrorist doesn't need to go to the DIYbio [Do It Yourself Biology] community. They can just enroll in their local college."

As for those socially redeeming aspects, few would question the cause, if not the proposed solution, that empassions

Adam Shriver, a doctoral student in philosophy/neuroscience/psychology at Washington University. He is concerned about the pain that veal calves and gestating sows suffer as a result of their unnatural diets and feedlot conditions. And so, in a *New York Times* Op-Ed piece (Feb. 19, 2010), he urged that the animals be genetically engineered to remove the awareness of pain. "If we cannot avoid factory farms altogether, the least we can do is eliminate the unpleasantness of pain in the animals that must live and die on them. It would be far better than doing nothing at all."

Shriver's proposal was directed at the professional research community. But there are now various organizations, such as BioCurious and DIYbio, whose aim, in part at least, is to encourage the general public to indulge their taste for imposing their own fantasies upon other organisms. There's also an International Genetically Engineered Machine competition for undergraduates. The sponsoring organization writes: "Student teams are given a kit of biological parts at the beginning of the summer from the Registry of Standard Biological Parts. Working at their own schools over the summer, they use these parts and new parts of their own design to build biological systems and operate them in living cells."

By now the trend has, it seems, accelerated altogether beyond control—if control was ever even possible. And while professional researchers in molecular biology have some ethics guidelines and protocols for preventing the unwanted release of engineered organisms into the environment, the same is hardly true of do-it-yourselfers laboring away in their kitchens.

What can one say in response to this chaotic mixture of noble aspirations, utter pettiness, hell-bent recklessness, and cavalier experimental curiosity—all marked by an apparently total disinterest in the living organisms being manipulated? Nothing much, I'm afraid, in just a few words. Perhaps you, like me, are rendered temporarily speechless by the kind of thing described above. There is, however, at least this: it all says something about why an organization such as The Nature Institute is needed in today's world! (Beyond that, I do hope before long to post a major essay on our website, which I've written for a book on bioethics to be published by the Hastings Center.)

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A Modest Champion of the Whole Organism

Whenever I hear it said that "the whole is greater than the sum of its parts," I find myself wondering (rather uncharitably, perhaps) whether the speaker has any more understanding than I do of what the words might actually mean—or whether (as it often sounds to my ears) the cliché is merely an expression of feel-good, more holistic-than-thou sentiment. Why, if the thought is so important, do we almost never hear its meaning spelled out—or at least not spelled out in a way that makes much sense?

I readily grant that I, too, have always believed the phrase to conceal something important, despite my inability to do justice to its meaning. One offhand remark that stimulated my thought on the matter came from physicist Arthur Zajonc a few years ago, when he said something roughly to this effect:

> If people really believe a whole is greater than the sum of its parts, we should ask them to identify the "greater" reality that remains to be recognized once all the parts have been summed up.

I did in fact occasionally pose that question to others, but without promising result. While I had my own vague intuition of the matter, it never gained the clarity I would have liked.

You can imagine my delight, therefore, when I encountered a straightforward and decidedly non-clichéd interpretation of the phrase from a leading cell biologist of the twentieth century — an interpretation proffered in reassuringly dry, matter-of-fact language unlikely ever to become the clarion call of a New Age. In fact, the author of the interpretation often put his meaning into a mathematical formula—one surely never destined for the fame of $E=mc^2$, but perhaps fully as important once we realize its implications for our understanding of living organisms:

$$V_S < (v_a + v_b + v_c + \ldots v_n)$$

Don't worry, however. There's no need to consider the formula here. The whole matter can be explained without a formula, and with clear examples. For those interested, I'll save the explanation of the formula itself (which will require all of a sentence or two) for later.

Paul Weiss, Scientist of Distinction

Shortly after his student days in Vienna, where he studied mechanical engineering, physics, and biology, Paul Alfred Weiss met the man who would become a founder of general systems theory. It was in the early 1920s. As Weiss tells the story: "A sparkling Viennese student, a little more than three years my junior, approached me for a meeting—Ludwig von Bertalanffy. We met in coffeehouses and 'milked' each other. I soon found that his thinking and mine moved on the same wave-length—his coming from philosophical speculation, mine from logical evaluation of practical experience" (1977).

At the other end of his life, in the 1970s, Weiss found himself in association with the likes of Arthur Koestler, editor of the book, *Beyond Reductionism* (to which Weiss had contributed a chapter), and the Frensham Group, which included ethologist Konrad Lorenz, psychologist Jean Piaget, developmental biologist C. H. Waddington, chemist and philosopher Michael Polanyi, neurophysiologist John Eccles, and other notable researchers seeking a broad philosophical and interdisciplinary understanding of the living world.

In light of these connections, what is remarkable about Weiss' life is the degree to which he pursued his wide understanding without ever taking up, or even showing much interest in, philosophy as such. Throughout his long career he remained a scientist's scientist, rigorous, focused on practical research, and with a mathematical cast of mind. As he himself put the matter with regard to Bertalanffy, "And so it remained for half a century, each of us hewing his separate path according to his predilection. That is, I kept on as the empirical experimental explorer, interpreter, and integrator, for whom the 'system' concept remained simply a silent intellectual guide and helper in the conceptual ordering of experience, while he, more given to extrapolations and broad generalizations, and bent on encompassing the cosmos of human knowledge, made the theory [general systems theory] itself and the applicability of it to many areas of human affairs his prime concern" (1977).

However, all profound observation must be at least implicitly open to the widest possible realms of thought, and Weiss was nothing if not a profound observer. His objection to much of the science he encountered in his day centered on what he found to be an uncomfortable constriction of observation and understanding by abstraction, machine-like linear notions of cause and effect, and the ignoring of context.

In his doctoral thesis of 1922, Weiss studied the response of butterflies to light and gravity. He argued, according to his biographer, that "the nervous system cannot be reduced to a rigid tropistic machine, but that the elementary steps in behavior are subordinated to the state of the whole," a view he later found fruitful in his studies of the vertebrate nervous system (Overton undated; quotations below are from this source unless otherwise indicated). He subsequently experimented with limb transplantation in newts and other organisms. While doing this work at a clinic in Bier, Austria, he discovered a frog with two extra limbs at the nearby Hungarian railway station. The limbs were fully functional, confirming some of his own experimental findings. "The frog was featured in his European lectures and the idea of the 'natural experiment' became a teaching device and later found its way into his text and teaching lectures."

Weiss went on to engage in a wide range of research, but he never found himself too far from questions relating to the development and functioning of the nervous system, and to embryology and organismal development in general. He would eventually write a leading textbook, *Principles of Development*, along with many other books and numerous technical papers. In 1930 he came to the United States, where he spent many years at the University of Chicago. In 1947 he was elected to the National Academy of Sciences, and in 1954 he became one of the first professors at the new Rockefeller University in New York, where he directed a laboratory specializing in wound healing, cancer, and development and repair of the nervous system. During World War II, he worked on techniques for nerve regeneration, some of which were later applied in Army and Navy hospitals. He would eventually serve as visiting professor at ten universities, and become dean of the graduate school of biomedical sciences at the University of Texas.

Once, when asked why he worked so hard, he "was overheard to reply that his reason for wishing to be a good embryologist was that by doing so he might repay the United States for what it had done for him."

Weiss always emphasized the importance of language, devoting lectures to the changing meaning of embryological terms over time, or the differences in usage among contemporary investigators. He originated terms such as "neurobiology" and "developmental biology" as part of an effort to overcome the compartmentalization and fragmentation of the life sciences. He worried that, in his words, "While scientific workers are more and more constrained into narrower and narrower confines in which to pursue their specialties, science as a whole cannot develop into a healthy and proportionate organism unless specialists will leave their burrows on periodic occasions and meet on common ground."

Finally, much like E. S. Russell of an earlier generation (see *In Context* #22), Weiss objected to the dominance of gene-centered explanation long before such complaints were widely considered respectable. "What is misleading in the term 'genetic determination'," he wrote, "is that it conveys the notion that the development of an organism is simply the mechanical product of a bundle of linear 'cause-effect' chain reactions, reeling off in rigid sequence according to a minutely predesigned plan of clockwork precision. That notion, reinforced by the anthropomorphic language that endows genes with the powers of 'dictation' and 'control', rests on a basic misconception of the nature of biological processes in general and of developmental dynamics in particular" (1973). And again:

"A 'cause' (or gene) is something *without* which some 'effect' (or character) which you expect *fails* to occur, while something else occurs instead. To turn the sum of such negative statements around and fashion from them a positive doctrine of of plenipotency (of causes or genes) seems to me a reprehensible somersault of logic" (1973).

Weiss' contributions have, in recent decades, been largely overlooked amid the intense enthusiasms and one-sided technical developments of the era of molecular biology. But if I am not mistaken, there is now a growing opportunity for his voice to be heard. Perhaps the reaction of an Italian molecular biologist, after reading a paper in which I mentioned Weiss, is a pointer to the future: "I went on Google Scholar to download relevant articles of Dr. Weiss. Wow! I spent more than three hours reading very clear and neat scientific prose underlining exactly the same problems we are facing today."

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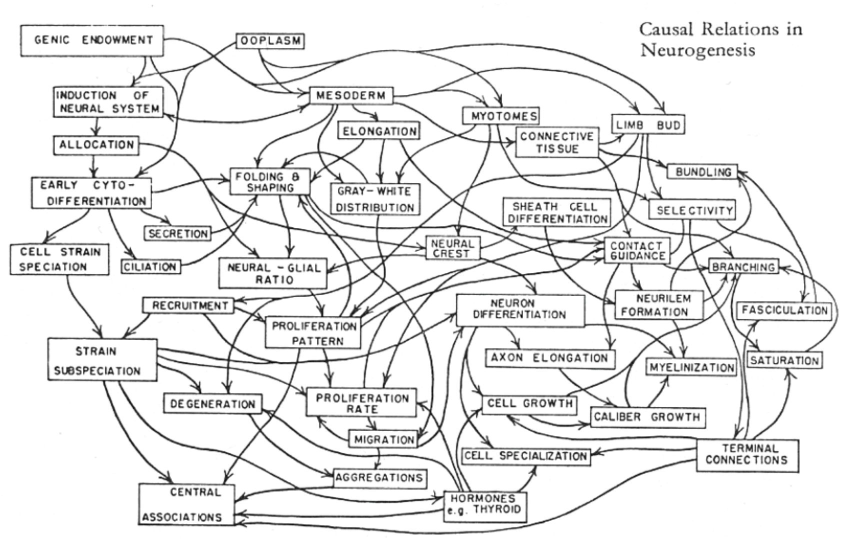
Of Contexts and Coordination



Causal Relations in Neurogenesis

Paul Weiss, born in Austria in 1898, began his research in the early 1920s and migrated to the U.S. in 1930, where he spent most of his distinguished, several-decades' long research career—a career capped by receipt of the National Medal of Science from President Jimmy Carter. (See the accompanying box for biographical details.) Throughout his career he devoted a great deal of time to the observation of embryonic development and the behavior of cells both *in vivo* and in tissue cultures, often using techniques he himself pioneered. Interested in cell differentiation, morphology, and the development of patterns, especially at the cellular level, he elucidated the ways in which physics and chemistry play out in specific processes. He even developed mathematical models for some of these processes.

As prolific and important as these contributions were, Weiss was convinced by his observations almost from the beginning that the usual machine-like explanations of living processes were grossly inadequate to capture what was going on—and could easily be shown to be inadequate as soon as one took the larger context into account. That context was seething dynamism. "In contrast to a machine," he wrote later in life, "the cell interior is heaving and churning all the time; the positions of granules or other details in the pictures, therefore, denote just momentary way stations, and the different shapes of sacs or tubules signify only the degree of their filling at the moment" (1973).

He liked to point out how misleading are the pictures of stable cellular structures we see in textbooks; in reality, even the two-dimensional surfaces and cellular membranes, the three-dimensional cytoskeleton, and various fiber systems are subject to more or less continuous dissolution and reconstitution. Particular structures are only snapshots of flow. Life is a dynamic process, he would say, and "the elements of a process can be only elementary *processes*, and not elementary *particles* or any other static units" (1962).

Not only are there countless processes vital to life in every cell of the body, but these processes, in addition to having their own apparent goals, are in cooperative interdependence, or in tension, or in some cases in a kind of opposition to each other. But the sum total of interactions, for all their differing natures and tendencies, "hold together" in a striking way. "The only thing that remains predictable amidst the erratic stirring of the molecular population of the cytoplasm and its substructures is the overall pattern of dynamics which keeps the component activities in definable bounds of orderly restraints" (1973). The context, in other words, possesses a certain stability amidst all the surging movements of the part-processes with their varying degrees of freedom.

This principle of the rule of the context over its part-processes holds at all scales, not only at that of the cell. In order to appreciate what it means to achieve a reliable and stable overall result from myriad part-processes, consider the accompanying figure, showing (in an extremely simplified way) some of the interdependencies and interactions during the development of a mature nervous system from a fertilized egg.

Weiss liked to point out that no two limb buds in a developing embryo are ever exactly the same; the formative cells (mesenchyme cells) are growing and moving in a different way in each specific case. Yet the end result of their growth is a "standard," fully formed limb of the right sort. More dramatically, the same cell group in a limb bud can form the asymmetric pattern of a right limb or, if transplanted to the opposite side, the contrary pattern of left-handed asymmetry (1971).

Clearly, the molecular substances (including the genes) in those cells at the beginning of the process are not by themselves determining the outcome of growth. Beside its full complement of "genetic information," each cell needs additional "topical information" derived from the structure of the collective mass. How otherwise, Weiss asks, could any unit know just what scrap of information to put to work at its particular station in order to conform to the total harmonious program design? Left solely to their own devices, individual cells and their entrapped genomes would be no more capable of producing a harmonious pattern of development than a piano with a full keyboard could render a tune without a player (1973).

In sum, "overall regularity in the gross is attained and maintained not as a mechanical result and a reflection of a corresponding underlying regularity of rigidly stereotyped behavior of the component elements down to the smallest detail, but on the contrary, in spite of a high degree of vagrancy among the latter. The individual component does not 'know' where and in what specialty it will end up until it has been well on its way and given a defining 'cue'" (1973).

Returning to the "churning" sea of protoplasm mentioned earlier: it is remarkable that, not only must all the cellular processes and features support each other in a cooperative way despite their individual divergent tendencies, but this cooperation must occur in an extremely fluid context without tight compartmentalization or mechanical linkages (1963): "Small molecules go in and out, macromolecules break down and are replaced, particles lose and gain macromolecular constituents, divide and merge, and all parts move at one time or another, unpredictably, so that it is safe to state that at no time in the history of a given cell, much less in comparable stages of different cells, will precisely the same constellation of parts ever recur . . . Although the individual members of the molecular and particulate population have a large number of degrees of freedom of behavior in random directions, the population as a whole is a system which restrains those degrees of freedom in such a manner that their joint behavior converges upon a nonrandom resultant, keeping the state of the population as a whole relatively invariant" (1962). This "nonrandom resultant" is exactly what we lose sight of when we study the members of a population as separate entities.

All this, then, provides an explanation of the formula given above. Put very simply, this is what the formula says: the variability of a cell as a whole is less than the sum of the variabilities of its component parts. (Weiss actually uses the more technical and mathematical term, *variance*.) The same principle works at many levels, from organelles, to cells, to tissues and organs, to organisms—and even to the collection of organisms within an ecological setting. In the case of the cell, according to Weiss, the formula "represents an 'operational' description of what it is that makes the cell as a unity 'more than the sum of its parts'. In order that this formula be satisfied, one must evidently postulate that the component processes, when operating in the common integral system, are *interdependent* in such a manner that as any one of them strays off the norm in one direction, this entails an automatic counteraction of the others" (1963).

So it's a bit ironic: the whole is *more* than the sum of its parts because it varies *less* than would be suggested by a consideration of all the separate part-processes. A principle of coordination works from the whole into the parts, from the larger context into the subcontexts.

Of course, answering one question often raises additional questions. Weiss characterizes a relation between the whole and its parts that gives reasonable meaning to "The whole is greater than the sum of its parts," but this leaves us wondering about the nature of a whole that is able to achieve such coordination of its parts. The issues are subtle, and subject to a great deal of confusion in today's scientific environment. They cannot be treated here, but I have dealt with them at length in Talbott 2010 and 2011, and you will find all the related papers at http://natureinstitute.org/txt/st/mqual.

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Talks, Workshops, Courses

Events at the Institute

Goethean Explorations of Light and Color, with Henrike Holdrege. Over four Saturdays we explored the visual world through various observations and experiments. We worked with human vision, atmospheric and prismatic colors, afterimages, colored shadows, and the mixing of colors through darkening and lightening. The workshop, which aimed to demonstrate the practice of Goethean phenomenology, was designed for artists and others interested in the subject. It was offered in The Nature Institute's spring program and was part of the Free Columbia Art Course.

Nine teachers and two parents came to the Institute for a weekend in March on ***Mathematics Alive—Geometry for Middle School Teachers and Parents.*** The workshop was led by Henrike Holdrege and Rebecca Soloway, a teacher from the Garden City, New York Waldorf School. The participants engaged in a variety of activities. As one teacher commented, "*the feeling of being challenged, and yet having the tools to find my way was a good experience. I put my students in that position every day! I look forward to bringing these subjects in the coming years.*" The two evenings of the course we spent mainly outside observing the clear night sky, which included the experience of observing the largest full moon in years as it rose over the eastern horizon.

Farmers Course: see separate article.

Participants in the farmers course.

Other Events

- Monday Nights with the Stars, with Henrike Holdrege — Spring 2011
- Winter Wildlife Tracking, with Michael Pewtherer and Jonathan Talbott

Out and About

In March, Craig gave a talk at Allegheny College entitled "Tending the Roots of Sustainability: Education and Our Responsibility to Children and the Earth." In a follow-up workshop, Craig guided participants through plant observation exercises as a model for nature-based exploratory learning that can be adapted to other areas of science teaching.

Also in March, Craig taught a half-day workshop at the Pfeiffer Center on how to understand plants and animals in a holistic way. The workshop was for participants in a year-long Saturday course on Biodynamic Gardening and Farming.

In April, Craig traveled to Kassel, Germany, to the Institute for Waldorf Edcuation, where he taught a course on Evolution for high school teachers.

In early May, Craig traveled to Nova Scotia to give a talk sponsored by the Anthroposophical Group of Nova Scotia entitled "Truth, Beauty and Goodness: Pathways to a Living Understanding of Nature." He also delivered the keynote address at a conference on "Waldorf Education as Environmental Education." He spoke about "Reconnecting with Nature."

In August, Craig and Henrike will travel to South Africa to collaborate with the Proteus Initiative (www.proteusinitiative.org), which employs "an understanding and practices first developed for seeing into living processes within the world of nature" and seeks to "enable a new way of engaging with social and developmental phenomena: a way which may work effectively with social complexity." The Nature Institute's relationship with the Initiative's founders, Allan Kaplan and Sue Davidoff, dates back to the winter of 2001-2002, when they came to The Nature Institute in order to work for three months with Craig and Henrike.

Widely experienced as international consultants to social organizations and communities, Allan and Sue wanted to bring the qualitative and phenomenological methods associated with Goethean science to bear upon their own work. Inspired by their time here, they returned to South Africa and worked toward the fulfillment of a double hope: to create the

Proteus Initiative as a vehicle for applying Goethean methods to social contexts where they are almost unknown; and to establish a wilderness retreat that would not only preserve a valuable and breathtakingly beautiful landscape for posterity, but also provide a site for some of their conferences and workshops. Craig and Henrike will teach part of the Initiative's series of workshops entitled "Towards a Thinking Which Is as Alive as Its Subject Matter." The aim of the series is to bring an ecological awareness to social process, and a social sensibility to environmental concerns. While each workshop is different, all will attempt to bring our social and ecological strivings together within the broad framing of a Goethean phenomenology, deepening our practice and our thinking towards a genuinely holistic and living response to our world.

A Place-based Environmental Science Curriculum

This past fall and winter Craig participated in the development of an environmental science curriculum for grades 6 – 8 at the Detroit Waldorf School. The school's question was: Could a curriculum be developed that weaves together a phenomenological approach to science, environmental and social justice awareness, and service learning opportunities? The school felt that such a curriculum—which could be modified for other learning settings, such as urban summer camps—would be "an essential contribution that we could make to our community, especially to demonstrate to our young people how they can be instrumental in understanding and acting upon locally significant environmental issues. The central approach is to study topics around which the students can become passionate and can also fit into their understanding of the world at their age."

Candyce Sweda, who has been involved in the school and other Detroit community activities for many years, approached Craig, Michael D'Aleo, and Gary Banks (both Waldorf teachers and scientists with a passion for environmental topics) to develop this curriculum. This was an intensive and rewarding collaboration. Each of us developed one area for all three grades and then the group worked together to create coherent courses: Michael focused on energy and transportation, Gary on substances and cycles (e.g. water, air, carbon), while Craig developed ideas for teaching about and experiencing plants, food, and agriculture. The challenge was to craft a curriculum that would involve firsthand student experiences and not just transferral of information. Moreover, it was important that this curriculum be place-based so that the students could learn about the environment in and around Detroit and also be involved in community activities such as river monitoring and urban gardening. Detroit is a city that faces special challenges, having lost over one million residents since 1950 (when its population was nearly two million; now it has about 790,000 residents). It is a vast urban landscape marked by many signs of decay, and yet many grassroots and innovative initiatives are taking hold to change this landscape. The school, with this curriculum and the hope that it can bear fruits within the broader community, wants to contribute to the current of change. Craig felt it an honor to be part of this effort.

This work was supported by a grant from the Community Foundation for Southeast Michigan to the Detroit Waldorf School. The curriculum was presented at a meeting on January 22, 2011. The complete curriculum and a CD of the public presentations can be purchased by contacting: Candyce Sweda, Detroit Waldorf School, 2555 Burns, Detroit, MI 48214; or email csweda@ibl.org. Craig's curricular outline for the topic of "Plant and Human Interactions" can be found at: http://natureinstitute.org/txt/ch/envir_cur2011.htm.

Credere Grant in Goethean Phenomenology

This year The Nature Institute sponsored a $1,000 grant in Goethean Phenomenology. The funds were donated to the Credere Fund of the organization, Think OutWord, which has a number of grant programs. The Goethean Phenomenology grant program was newly instituted this year.

The grant committee awarded the 2011 grant to Joao Felipe Toni for his project "Goethean Phenomenology as Environmental Education in the Brazilian 'Restinga' Biome." This study will investigate and elaborate activities for students utilizing the Goethean phenomenological method in botanical research of the native species and the landscape of a biome of Brazil called Restinga. The Flora of Restinga has about 142 families and over 1500 species. During his month-long fieldwork, Joao Felipe will engage in rigorous observation, data collection, artistic exercises and contemplative reflection upon the plant life along the Morro das Almas's Trail in Cardoso Island State Park in the State of São Paulo, Brazil. This project is a case study to demonstrate the relevance of the history and the philosophy of biology and the Goethean phenomenological method for high school science teaching, and for elucidating the nature of science.

For more information about the Credere Fund or to donate to support next year's grants, visit http://thinkoutword.org/grants.html.

Understanding Qualities in Nature

A Basis for the Agriculture of the Future

Twenty-one farmers, gardeners, apprentices, and individuals interested in food and agricultural issues participated in The Nature Institute's weeklong intensive. Most of the participants spent the following week at Hawthorne Valley Farm learning more specifically about the view of agriculture and life that informs biodynamic agriculture, with an emphasis this year on animal husbandry.

On the first evening each person introduced him or herself, and through the brief presentations both the diversity of the group and the intensity of each person's search were evident. Many of the participants were in transition, some about to begin their life as farmers or apprentices, others looking to find a new farming or gardening situation that would allow their ideals to be more fully realized. Their search for a deeper understanding of nature and a way of farming that integrates human activity into the larger web of life imbued the course with a quality of openness, connectedness, and wakefulness that was remarkable.

The course at the Institute included many practical activities: each morning began with explorations and experiences that let us form qualitative concepts of earth (solids), water (fluids), air (gases), and warmth. We then worked to understand the way-of-being of animals and how we can learn to "read" form and function through observing and comparing bones. These sessions culminated in a consideration of the interconnected and yet distinct nature of plants, animals, and human beings within the context of agriculture. The evenings were dedicated to astronomy—working to understand the movements of stars and planets in the course of a day and year. Here are some comments from participants:

After working at a fast pace on farms for several years, [I found] the course to be a blessing and introduction to a whole new way of interaction with the natural world. I'll take the skills I've learned into my daily work, and I'm sure it will enhance that work.

Each [course activity] informed the others, bringing thought to practical application and into different contexts. There was also a gradual development that almost snuck up to culminate in such a way that was difficult to predict. Brought me to a new vision of realizing our freedoms and responsibilities as human beings and inspired me to explore and develop my own capacities.

I will see the world I am so closely working with, with brand new eyes. Eyes more like a child seeing things for what they really are before me, and not for what I have been told they are. I feel small in this large world, which is a good feeling. I am in awe of the power and enormity of nature.

This week will serve me to better educate apprentices on our farm, using real-life phenomena to convey and speak directly to them during their time learning.

I really enjoyed the hands-on activities as you allowed the four elements to show us how they worked rather than just explaining or portraying them.

I have taken comparative vertebrate anatomy courses in the past – but never like this! A whole different experience! I really enjoyed the stimulating discussions facilitated by Craig as well as the students in the course. The Socratic approach to learning enriched us all!

A New Brochure

We have recently completed a new brochure that provides an overview of The Nature Institute, including our mission, programs, and research activities. If you would like a brochure or have ideas for placing additional brochures where they might find interested readers, please contact us!

Building Expansion Update

As you know, we started our building expansion capital campaign in the fall. We began with the $150,000 leadership gift from the Seyhan Ege Trust and our goal was to raise an additional $225,000. Our request for support met a generous response from individual donors and foundations—not at all something we take for granted in times where finances are tight. We have received gifts and pledges totaling $200,000 so far, and we are currently working to raise the final $25,000. 115 individuals have given explicitly to the building project while another 150 people have given unspecified gifts or gifts to support the work that will go on in our facilities—our core research and education work. *Thank you for this generosity of spirit and the monetary gifts that flow from it!* Now this money can flow, directly and indirectly, to the many hundreds of people who will contribute to the project through their work and their building products.

We would like to express our warmest thanks to Heide Zajonc, who helped us plan and carry out the capital campaign; we can hardly imagine what we would have done without her able advice and active commitment to make the project happen.

During the fall and winter a building committee met regularly to finalize the design. We would like to thank Jon McAlice (design), Chris Hoppe (engineering and plans) and David Gardiner (a local builder who will be the general contractor) for working together in such a collegial and fruitful way with Henrike and Craig to move the project ahead.

We'll keep you informed. You can expect to hear more in the fall.

Elevation Sketch — View from the southwest

Thank You !

Donations from individuals, grants from foundations, and people who volunteer make the work of The Nature Institute possible. From October 1, 2010 to March 31, 2011 we received donations, grants and volunteer services from the following individuals and organizations. This includes all the donations and grants we have received for our building expansion project:

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Mirror Images

Georg Maier

The following article is excerpted from Chapter 3 of An Optics of Visual Experience*, by Georg Maier. The text has been abridged and adapted for* In Context. *See the box on next page and the end of the article for further information.*

When we see a rock in the landscape we feel sure that it is "really there!" Seeing is usually experienced almost like touching. Sight helps us to orient ourselves in our surroundings when we set off toward an as yet distant goal, just as it lets us attend to our activities right here where we are. Thus seeing is generally thought to simply be our ability to keep an eye on objects.

Any attempt to use mirror images to orient ourselves in a similar way will lead to confusion. They do not seem to correspond to our other perceptions of bodies with respect to their location. They offer "extra," "indirect" views, and as long as we are not clear about what we mean here by "indirect," we will justifiably claim that they are unreal for us.

In the following considerations the object that is mirrored will be referred to as the prototype. Our main task will be to understand the lawful relationships between mirror images and their prototypes.

Mirror Images in a Quiet Pond

It is worthwhile to study reflections in quite some detail in a moderately-sized pond. Memorable key experiences can be gained in such a situation. If the pond is small and sheltered from wind, its surface will normally be quiet. We need this quiet for the time being, until we are ready to deal with the glistening, quivering, and confusing array of stretching and shrinking images—the visible motion of the water's surface.

One of the first impressions of reflections in a pond might be the unfamiliar sight of brightness shining up from below. The colors of the sky and the clouds, or the shining of the sun are repeated, though somewhat dulled, in the depths below. In fact, the water does not need to be deep in order to give a "deep-reaching" mirror image. We can often notice the remarkable repetition of forms, by which the images seen in the water adjoin the surrounding scenery. At the far bank there may be reeds. Their mirror image continues directly downward. The mirror images below and the sources of the images above show remarkable similarity. Many details of the images below can be found above as well. Are these two classes of images the same? Or better: What are their differences?

Does the mirror image have any *reality*? If we stick our head under water, the mirror image disappears. What we perceived in the water as mirror image cannot be found there as a tangible object. All we find there is wetness. But are only those things real that can be grasped or at least touched? As we deal with mirror images, we are reminded that everything visual is given in images, which consist of intangible brightness, darkness, and colors. Certainly a mirror image is real enough that we can encounter something new within it, something with which we can grapple, something which we can attempt to understand.

Distinctness. Not everything is mirrored as clearly as the plants on the opposite bank of the pond. If we step up to the water's edge, we can look straight down. In this case the mirror image is rather like a delicate veil lying over the view into the water. In this respect it resembles shadows. These, too, superimpose themselves over the forms and colors of a scene. As we move back from the bank, the pale, translucent mirror image gains strength. The further we look out, the clearer the image becomes—and at the far bank the mirror image and that which is mirrored fuse into one another. As we squat down and our eyes are brought closer and closer to the water's surface, the mirror image is pulled toward us across the surface of the pond. As we shall see, the mirror image thereby becomes more and more symmetrical to what we perceive directly above the water on the far side of the pond.

An Invitation to Look

It is a remarkable fact, in the words of physicist Martin Wagenschein, that "physical acoustics only contains what remains of sound, and of music, for someone who is deaf." Similarly, in a conventional physics-based understanding of a tree, for example, "some of its structure and geometry remain, but color, smell, three-dimensionality, and the rustling of its leaves are missing" (http://natureinstitute.org/txt/mw/save_phenomena.htm).

Not so in Georg Maier's phenomenological physics. He wants us to turn to the phenomenal world, perceive it carefully and wakefully in its variations and relations, and take what thus appears seriously as part of reality. Maier's physics is a call to enter with openness into the concrete phenomena and to hold back with all our tendencies to transcend experience in favor of conceptual abstractions and models. The insights that arise are subtle and deep.

In this excerpt from his *An Optics of Visual Experience*, Maier leads us into phenomena related to mirroring—images we see through a pond's quiet surface or in a mirror hanging on a wall. He calls the reader's attention to seemingly simple phenomena and their relations to one another. By moving carefully from observation to observation—and we need to make those observations ourselves—he shows how a world reveals itself when we take the time and care to actually observe what can be seen but is so easily overlooked. Maier's work is an invitation to perceive the appearances of the world. In this excerpt we get to know mirror images not as "mere reflections" of a more real world of "actual things," but rather as a coherent realm of phenomena that has its own special qualities. When—to use an example from the text—an upright stick is placed between a burning candle and a mirror, the images of both, along with the shadow that the stick casts, can be seen in the mirror. But that is not all, the mirror image of the candle is also a source of illumination and the mirror image of the stick now casts a shadow out into the space in front of the mirror! This is utterly surprising and leads us to recognize that "mirror space," as Maier calls it, has its own efficacy. It is not a space that we can enter with our bodies, but as a visually experienced space it does have effects on the space we live in as embodied beings.

An Optics of Visual Experience is not an easy read since it only points to what we readers need to discover for ourselves. Used as a guide to careful and systematic study it can open us to phenomena—of illumination, shadows, reflection, and much more—that are part of the structure and dynamics of the visual world we live in but that we are not normally aware of. The result of the effort is a wakeful awareness of being part of a richly nuanced and deep world.

Maier earned a Ph.D. in physics in 1960, and then spent about seven years doing nuclear-based research, particularly in the field of neutron optics. As he writes,

> I entered a profession with its own specific approach to the world — a profession requiring intelligence and a talent for inventing logically well-formed connections between abstract ideas. Only gradually did I become more open to present appearance, learning to trust it right into the sphere of personal decisions. If at first I had to devote myself fully to abstraction, it was in order to develop later a contrasting appreciation for the specific and unique appearance. (*Being On Earth,* Chapter 5, p.1; http://natureinstitute.org/txt/gm/boe)

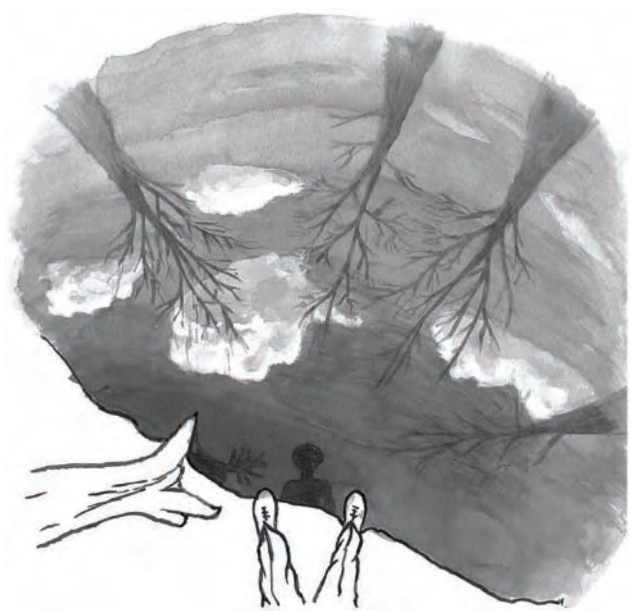
From 1969 to 1998 he worked at the Research Institute of the Goetheanum in Dornach, Switzerland, pursuing phenomenological, experience-based physics. Now retired, he continues his researches in Dornach, where he lives. *In Context* readers can learn more about Georg Maier and his approach to science in *Being on Earth*, which Maier wrote together with his colleagues Stephen Edelglass and Ron Brady (http://natureinstitute.org/txt/gm/boe).

Craig Holdrege

Mirror Space

There are two extreme types of reflections: Glancing reflections, for example those of the irises on the opposite bank, are such that mirror image and prototype meet one another directly and become a pair. The mirror image appears as a folded-down repetition of the prototype.

However, if we look at the mirroring surface straight on, that is, at a right angle, we see only images for which there are no corresponding prototypes in our direct view. Our own countenance appears as a mirror image. When we look down to the edge of the bank, we see prototypes that show us their one side while they expose their other side to the mirroring surface. [As a result, if there is a low, bushy plant near our feet, we look *directly* at the upper surfaces of the leaves, but in the reflected image we see the undersides of the leaves—ed.] In the background close to the image of our face we see mirror images of prototypes which are currently behind (or above) us, and are thus hidden from our direct view. In this way the perpendicular view toward the mirror separates mirror image and prototype, while they appear together as twins in glancing reflection.



What points upward in the prototypes (such as a tree) points downward in the mirror image. This reversal is particularly impressive when there are many upright lines in the mirrored scenery. Imagine standing at the edge of a pond in the woods. Now lean forward and look at your own mirror image below. From all around, the mirror images of the surrounding trees are pointing like spokes toward a center—and this center is the mirror image of your own face. Looking down with one eye, you see the mirror image of this same eye exactly below it. With your head looking down and your body bent over, you see a sight which would otherwise only be given in the exceptional view of facing yourself from underneath and looking *straight up*. The direction toward the zenith is marked by the mirror image of your eye, and all vertical tree trunks are pointing in this direction.

Between these two extremes (glancing reflection and perpendicular view into the mirror) a new aspect is added to the direct view of an object. If the direct view is a side view, for example, then the mirror image shows us a view of the object which could only be given from comparatively further below. By offering a new, second view, the mirror image facilitates a *spatial understanding* of the situation at hand.

The mirror image seen in the pond is not a fixed pattern on the water surface. With every movement we make, the image changes. Here in the realm of mirror images we are dealing with proximity and distance. As we look down into the mirror image, we are looking *through* the water's surface into a *space* underneath it. All the laws of vision in three dimensions can be found to apply in this space! As we walk along the shore of the pond or lake, the direction of our view into this *mirror space* changes, just as it does in the space of direct vision we are accustomed to. In mirror space, too, unmoving things remain in their proper place, and while we ourselves move about in our space up here, down in mirror space new views of them arise constantly in familiar fashion. The space down below is inexorably connected with our space up here, the water surface serving as an invisible seam between both spaces. The question is only: What is the spatial arrangement of the things below the surface of the water? This refers, of course, to things *seen* in the mirror space "behind the surface of the water," not to tangible things in the water. In all the descriptions here it is tacitly assumed that there is no wind, and no insects or fishes to disturb the quiet and unmoving water surface.

We see our own eye vertically below ourselves when we look into the water. Other people looking at us from elsewhere around the pond see our form not only directly but also a second time in the space below, but there it is standing on its head, reversed, or, in other words, *mirrored*. In terms of spatial measure this means that our mirror image appears to be just as far below the water surface as we appear to be above it. In fact the entire mirror space below is structured according to this principle as the visual world continues below the plane of reflection. Thus, both spaces are totally symmetrical in relation to the mirror plane.

While the spaces *themselves* are symmetrical, the fact that we are situated in prototype space leads to an asymmetry between our view down into mirror space and the direct view we have of the scene in prototype space. This asymmetry has been taken

into account by artists who developed landscape painting. While their paintings still show errors in the rendering of perspective, they obviously attempted to reproduce spatial relationships on their canvasses. Let us look at the painting of Saint Christopher by *Konrad Witz*, painted around 1435. We will occupy ourselves with his rendering of the scenery on the far shore and its reflection. To facilitate this, the outlines of several objects and their mirror images have been highlighted in outline. Near the water we see a monk. Behind him is a chapel, and the tip of its steeple is in front of the steep hill. All of this is also depicted by the artist in the mirror image, albeit distorted. But why does he show the tip of the reflected steeple as reaching above the outline of the hill? Did we not notice in the direct view that the chapel is actually not that far up? And where is the cliff with the jagged crown?

Well, the artist has depicted this quite correctly. The painter's position is *above the seam* between the upper world and the mirrored world. Because of his elevation above the water, his direct view of the landscape across from him will differ from the mirror image of that landscape, which appears as seen from a different perspective. To better understand this, let us compare the relationship of foreground and background above and below the water's surface as we bend down and lower our head closer and closer to the mirroring plane:

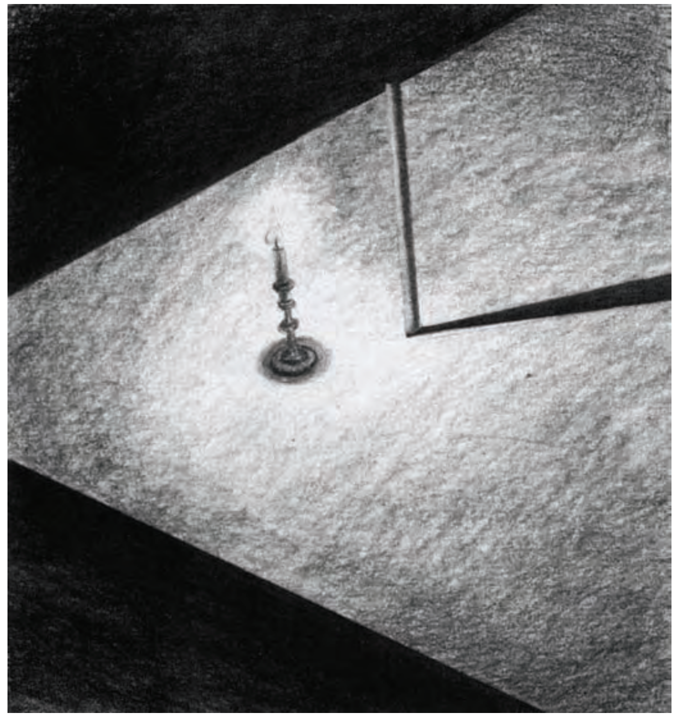
In the direct view, the higher our position, the more the background appears raised up in relation to the foreground: The hillside appears higher than the steeple, as is the case in the direct view in the painting. As we bend down, the background of course *moves along with us*. It descends in relation to the foreground, and the steeple begins to rise above the hillside.

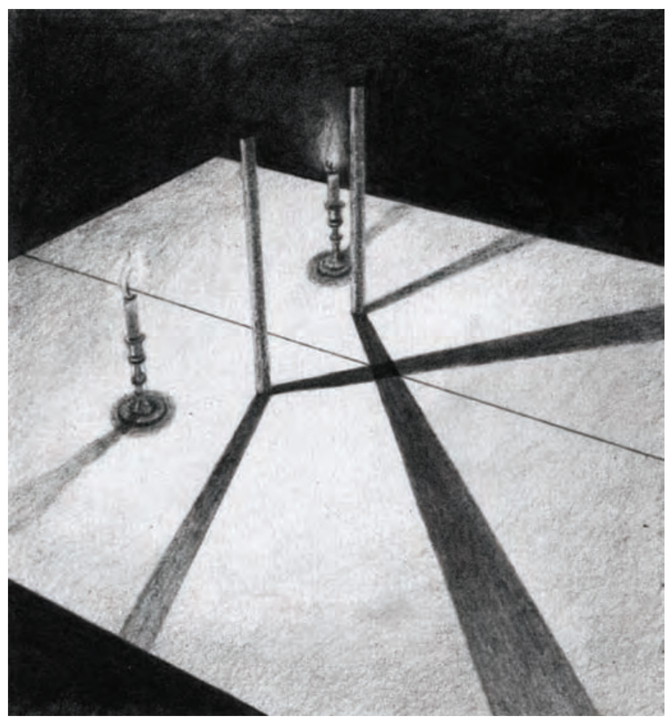
Now, what happens in the mirror image? We have just seen that, as we rise in the upper space, the background rises with us in our direct view of the scene. At the same time, however, our perspective into the lower space becomes equivalent to a "view from the depths," whereby objects directly on the shore are seen raised up against the sky. From our raised position, therefore, the steeple in the mirror image extends above the hillside as is correctly shown in the painting. As we bend down, however, the background of the mirror image rises up in relation to the foreground. The result is that, as we approach the mirror plane, the views into both spaces become more and more similar, and hence the mirror image looks more and more like the direct view.

We can state this in a different way: Our view into mirror space must be exactly the same view of the landscape that the fellow we see below us (our own mirror image, that is) would see when looking up into prototype space from his position down there.

The view seen by the "person in the depths" is indicated when we turn *Claude Monet's* picture, "The Painter's Boat," upside down and observe the mirror image of the boat: this mirror image shows us the boat as it would look when seen from below.

Mirror Space as an Optically Real Continuation of Space





All plane mirrors offer a view into a mirrored space. The mirror plane is the invisible seam between the two spaces. By using solid metallic mirrors, we can move the mirror plane out of the horizontal (the orientation of the water in the pond) and make it vertical, for example by hanging a mirror on a wall. Even a small mirror acts like a window into an adjacent room. The frame of this window limits our field of vision; however we can move around in front of the "opening" and survey the width and breadth of the "room next door."

So far we have dealt only with the view into mirror space. How shining and shadow are mirrored is nicely demonstrated by the following experiment devised by Fritz Julius:

On a table with a white surface stands a candle in a candlestick in an otherwise dark room. Beside it stands an opaque column which casts a shadow (see upper figure). Behind both we place a vertical surface covered by a white cloth (not shown). The shadow of the column will be cast both on the table, as in the figure, and also on the cloth. When the cloth is removed, we see that it was covering a mirror, as in the illustration below. Now let us first try to imagine what we would *expect* to see when the cloth has been removed. One might assume that the mirror would show the mirror image of the scene we saw before the cloth had been taken away: the mirror would simply reproduce what is in front of it, the candle and the column would be mirrored, and a single shadow would reach from both the column and its mirrored image just up to the mirror plane. But in reality quite a different scene appears: all the shadows appear that can be created by *both* visible candle flames as they shine on the two columns and on the candles themselves. These shadows just continue from the space in front of the mirror into the space behind it. Where the shadows cross, a particularly dark area arises. For this area, both flames are hidden by the two shadow-casting columns.

A light in mirror space is indeed optically effective. It illuminates both spaces. In the same way, opaque objects in mirror space are just as effective in casting shadows as their prototypes in front of the mirror. They can cast shadows that extend into the space in front of the mirror, just as those in prototype space cast shadows into mirror space.

The action of the plane mirror is rendered completely understandable by applying the concept of *mirror space*. Mirror space is a direct, immediate summary of the relevant empirical experience. We can see it with our eyes. We have also convinced ourselves that mirror space is optically real, even though it depends on the conditions of the reflecting plane.

An Optics of Visual Experience *(forthcoming in 2011) will be available from Adonis Press, 321 Rodman Road, Hillsdale, New York 12529; tel. 518-325-1100; http://www.adonispress.org. The book is softcover, 232 pages, and costs $35. Translated from the German by Henry Saphir and John Barnes.*

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