Biomimicry Newsletter

Biomimicry Guild Update

Winter and spring have been very busy for the Guild - here are highlights of some of the places we have visited. Janine presented *Learning From Nature* at the prestigious TED (Technology, Entertainment, Design) Conference in February. There was a lot of interest from the high powered and influential audience, leading to interest in the database among other generous offers. Jay Harman presented his work as well. John Todd introduced Janine at the University of Vermont in February where she spoke at the University lecture series. This was followed by the *Sustainability in the Inland Northwest* conference in Boise, Idaho. Next was the Savannah Georgia *Interior Design Educators Council* at the Savannah College of Art and Design. Both Dayna (workshop) and Janine (keynote) attended the American Society of Interior Designers annual conference in mid-March.

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In April, Janine will speak in Sarasota, Florida, sponsored by the Economic Development Organization. Three hundred business and non-profit representatives will be meeting on applying Biomimicry to sustainable economic development for Sarasota. A luncheon with key representatives will raise funds to bring in Dayna for a four-day workshop at Moat Marine Laboratory later in 2005. Coming up is the Biomimicry Workshop at La Cusinga, Costa Rica (April 29 - May 5) where both Janine and Dayna will train a new group of architects and interested folks in the ways of Biomimicry.

As well, discussions are underway with NASA on providing Biomimicry education to their engineers. Dayna has been retained by Interface to work on product development, and is working with other Fortune 500 companies on a number of projects. David Hammond has been placed with a leading product manufacturer, successfully launching a referral service for biologists in the commercial sector through the Biomimicry Guild. Another BaDT training will take place May 30-June 3 in North Carolina. The US Green Building Council is cross-marketing our course in Costa Rica. I continue to work with product manufacturers on potential research assignments for the Guild.

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The highlight was Janine's visit with Prince Charles at Balmoral Castle in January. Prince Charles and Janine met early for tea, worked through dinner and stayed up late into the night. They picked up their discussion at breakfast the next morning, resulting in Prince Charles delaying a BBC interview for almost 2 hours. I know Janine will share more about this incredible exchange.

As the Biomimicry Guild grows, it is becoming important to formalize the business. Plans are underway to move the Guild to Montana from a legal perspective, creating a business support structure. The non-profit will also be based in Montana. Progress has been measured to ensure that the correct structure and controls are in place. I will continue to work with Janine and Dayna on unique projects and development initiatives. All in all, it has been a busy season!

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Database Update

Work on the joint Biomimicry Guild/Rocky Mountain Institute project to build a prototype database of nature's strategies that could help solve engineering and design challenges (see the May 2004 Newsletter) is at a critical stage. The final report for this phase of development will be presented shortly to the funder.

The scope of the database has expanded greatly since the original idea of a simple Filemaker application linked to a web interface. Implementation on a more advanced database engine and the developers' experience with Web-based interaction has resulted in an application that will be able support multi-user Web access in a scalable and flexible fashion. The database has evolved to become not only a method of accessing knowledge but also a tool to support collaboration.

The database allows practitioners to find ideas and information on a broad range of subjects relating to architecture, design, and engineering, both for inspiration and to help solve specific problems. The database provides the ability to find information through a full-text search engine as well as through browsing hierarchical category schemes. The remarkable part of the browse function is that there will be not just one category scheme, but several (each tailored to a different discipline or perspective), and users will be able to create their own category schemes for organizing the data. By combining information from multiple disciplines (for example, biology and material science) in one place, the database will help break down traditional barriers between designers and researchers, and between researchers in different fields. Through promoting multidisciplinary sharing of data, the database could also lead to whole new biomimetic inventions.

The database supports collaboration by helping practitioners search for experts in the field based on expertise, interests and even geographic location. These experts could provide detailed information or consultation, potentially leading to ongoing partnerships. The database also supports collaboration by providing space for comments on every record in the database, so that discussions can develop from new insights that users have, rather than normal journals where communication is mostly one-way. To be effective, collaboration requires a high degree of collective organization, structuring data and supporting efficient retrieval; the database allows individuals to do this by creating their own ontologies. These ontologies can be shared with others. This feature not only aids collaboration but also continually improves the usefulness of the information by identifying and communicating new relationships between data elements.

At this point, the database is a 'proof of concept', sufficient to demonstrate the concept but lacking functionality that would support widespread access. Additional effort will also be required to make the system more robust, as well as cleanse and organize the content. With the proper funding, a beta version of the database could be released in a few months, and a fully functional version might be released in as little as a year. For more information, please contact:

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Curriculum Update

The K-12 curriculum project is progressing well. An informal relationship has been established with five private school teachers in the San Francisco Bay Area, covering grades 1 through 12. A number of programs are being tested. In one of them, various artifacts (ostrich egg, crab claw, peacock feather, Morpho butterfly, deer spine) are brought into the class - the students are asked to identify as many functions that the object performs as possible. Students are consistently surprised at how apparently simple objects can fill multiple roles. For example, the deer spine combines stability, flexibility, protection and attachment points for muscles. The ostrich egg provides controlled gas exchange and the ability to withstand

external forces, yet is easy to break from the inside due to the triangular plates that make up the shell.
A grade 1 teacher is looking for ways to incorporate Biomimicry into the study of tide pools and the systems of the human body, contrasting natural systems with those designed by humans. Two grade 11 classes (environmental studies and biology) have been given the challenge to rebuild a city in a sustainable fashion. By investigating the organisms that live naturally in the area and imagining that they are having a conversation with those organisms, the students are developing an appreciation for the habitat, the organisms that inhabit it, and the kinds of activities that are suitable for that habitat.

Work is underway with the teachers to weave Biomimicry into course work throughout the school year. A grant proposal is being developed to support the existing work and expand it to include additional teachers. The grant would support developing a series of one-day professional development workshops in the fall, to 'teach the teachers' and help them incorporate Biomimicry into their lesson plans. This would lead to more extensive 3-7 day summer workshops that would create a Biomimicry curriculum unit and build a network of teachers proficient in teaching the subject. Eventually, a widely available curriculum can be developed, along with expansion to other geographic areas.

To support curriculum planning, a website is planned that would act as a storehouse of lessons, themes, questions, and activities based on practical experience and results. The website could act as a catalog providing links to content standards, environment centers and organizations working in related areas. It could also capture information on educational research, showing the critical roles of creative problem-solving and design in effective teaching and learning; roles that are at the very core of Biomimicry. The website could include discussion groups, allowing teachers to interact with their colleagues, students and researchers to collaborate and form connections that cross traditional boundaries. By fostering an interactive and mutually supportive community of people interested in promoting Biomimicry in schools, the website will help turn ideas into implementable actions.

One of the challenges facing education is the increased focus on federal standards and the move towards 'test-oriented' teaching. The high mandatory workload on teachers and students makes introducing additional material difficult. The initial focus of the Biomimicry K-12 Project has been on the private school system, where

teachers have more leeway. Once the core concepts have been developed and tested, they will be validated in the public school system. One of our strengths is a strong teacher-centered approach, which should serve as a welcome antidote to the current mandated curricula.

The ability of Biomimicry to teach science, design, art, math, and engineering in a truly multidisciplinary and deep fashion shows great promise in helping students understand and take ownership of the traditional course material. By motivating and inspiring both the students and the teachers, Biomimicry will improve the both the efficiency and the effectiveness of teaching and learning.

To learn more, or to get involved with the project, please feel free to contact me.

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Sure, No Problem

In the last Biomimicry Newsletter, I proposed the notion of nature's design methodology, and the possibility of mimicking it. To entertain this notion, we need not believe in some intention on behalf of nature; we must simply recognize the existence of patterns associated with the processes of evolution, and examine them. Although I refer to 'nature's methodology' for succinctness and lack of a better term, I am in fact referring to these patterns of evolution. Yet even though patterns may certainly be identified, this methodology is extremely broad - being applied to the design of forms, processes, and systems across spatial and temporal scales. To take a more focused look, I would like to specifically examine nature's methodology for problem-solving.

Beforehand, it would be prudent to identify the meaning of a problem in nature. For purposes of this article, and since we are discussing Biomimicry, I will define a 'natural problem' as that which defies or impedes the Biomimicry principles - themselves based on successful, or non-problematic, natural systems:

- Nature runs on sunlight.
- Nature uses only the energy it needs.
- Nature fits form to function.
- Nature recycles everything.
- Nature rewards cooperation.
- Nature banks on diversity.
- Nature demands local expertise.
- Nature curbs excesses from within.
- Nature taps the power of limits.

Something impeding an ecosystem's ability to recycle everything, for example, would constitute a 'natural problem.' And 'natural problems' do appear to occur. The proliferation of photosynthesizing Cyanobacteria, to whom we are indebted for the oxygenation of the planet's early atmosphere, would have satisfied this definition of a 'natural problem' - considering that mechanisms for recycling oxygen had not yet developed. Similarly, our retina's neural apparatus is located in front of our photoreceptors, requiring light to pass through it in order to reach them - not necessarily what you would call fitting form to function, since this arrangement malfunctions as a blind spot and renders sight less efficient in general, although its form endures.

But, viewing problems in this isolated fashion can be misleading. Although the oxygenation of the atmosphere may have been considered polluting and problematic at the time, the majority of life on earth is now dependent on oxygen. Likewise, the arrangement of cells in our retina may actually be a way of providing photoreceptors with sufficient quantities of oxygen and nutrients and protecting them from light-induced injury. Identifying 'natural problems' becomes a matter of magnification - what appears to be problematic at a discrete juncture in space-time may prove otherwise when viewed systemically, in spatial and temporal context.

And, zooming out to the juncture of carbon-based life (because it is meaningful to us), context is exactly the basis of how problems implicating carbon-based life were averted throughout evolution. Nature's methodology operates contextually - designing systems that change through time, not individual components that remain fixed. Although individual components may appear problematic in isolation, they are rendered unproblematic in spatial and temporal context. So, it is not that problems - or impediments to the Biomimicry principles - do not exist

in nature, it is that they are nullified by their participation within systems (spatial context) and do not persist (temporal context). There can be no such things as problems that endure unresolved (even if kept on "life support," as might be argued of many human-designed systems, their "life support" systems invariably fail). Would-be problems are resolved by virtue of context, being eliminated or transformed into solutions. Whatever cannot be recycled simply ceases to exist, or becomes a resource for some emergent vital process. As the Permaculture adage goes, the problem isn't an excess of slugs, but a deficiency of ducks. This suggests a need for caution when we mimic individual components (or forms) as they may not be optimal individually. Or, it challenges us to similarly emphasize systems and processes over forms in our practice of Biomimicry.

So, what patterns associated with maneuvering around potential problems can we identify in the process of evolution? I will describe three aspects of nature's design methodology which, in my opinion, contribute to this capacity: interconnected webs (spatial context), feedback loops and modular design (temporal context). Interconnected webs of life ensure that essential functions are performed by multiple components, cultivating resilience within the natural system, and provide a mechanism of checks and balances, preventing potential problems from becoming fatal. Because oxygen was being produced in enormous quantity, multiple organisms that required it and could transform it into a compound necessary to other forms of life co-evolved. And since oxygen is now a critical component of our atmosphere, there are multiple organisms producing it. One might wonder where the checks and balances for our own polluting practices lie; they do exist, but at a larger scale than our behaviors acknowledge.

Positive feedback loops promote successful phenomena whereas negative feedback loops thwart problematic ones. Natural selection is an obvious example - better-adapted organisms reproduce more successfully, promoting their adaptation, and lesser-adapted ones do not, thwarting the persistence of their mal-adaptation. If a 'natural problem' arises and cannot be transformed into a solution, its host simply ceases to be. If nature had failed to develop a mechanism for recycling oxygen, Cyanobacteria (along with other prokaryotes) would have likely gone extinct. Conversely, considering that the neural apparatus of most invertebrate eyes is located behind their photoreceptors, we may suppose that if the opposite arrangement in vertebrate eyes was not compensated by the rest of the sensory system or did not serve some critical function, it would have failed to become a part of vertebrate physiology. In fact, it is argued that this arrangement

does serve a critical function - but, as with oxygen-dependent forms of life, it is debatable whether this is a case of necessity as a mother of invention, and the vertebrates needed this arrangement to become better adapted, or of invention as a mother of necessity, and vertebrates adapted to need this arrangement. Then again, co-evolution is a chicken-and-egg game of circular causality, in which invention and necessity are alternating generations.

Finally, nature's designs are never final. Considering that 'natural problems' are defined by context and that context may change, nature practices modular design so that her designs may adapt to changing contexts. Given that its concentration in our atmosphere was increasing without feeding vital processes, oxygen was becoming a pollutant. However, nature's methodology was flexible enough to alleviate the situation. Building blocks combined in creative ways, evolved organisms which successfully fed from oxygen and transformed it back into compounds useful to fellow organisms.

How may we as aspiring Biomimics incorporate these three aspects in our own design methodologies? The U.S. governmental structure exhibits the kind of checks and balances nature employs to foster resilience and prevent anarchistic autonomy. This mechanism may be mimicked in both physical and non-physical structures; for instance, by using diverse support mechanisms in an architectural structure, and distributing decision-making capabilities in a social one. We may establish positive and negative feedback loops by soliciting user feedback and allowing users to dictate the persistence or elimination of design features. On a larger scale, we may more conscientiously guide the 'Invisible Hand,' the economic analog to natural selection. It is purported that this hand is impartial, being formed by the collective preference of consumers. However, if the context in which the 'Invisible Hand' operates is modified, through policies providing financial incentives for sustainable goods and services, for example, the criteria determining that which succeeds - or, is non-problematic - changes as well. These changes in criteria will be supported by the positive and negative feedback loops, such as economic indicators and consumer reports, already active in the marketplace. Designing for adaptability may involve rendering a design capable of changing during its life cycle - as with a dynamic course curriculum, which perpetually adapts according to students' needs and preferences, or rendering the design conducive to feeding some other process at the end of its life cycle - as with the use of biodegradable materials.

This is an initial and brief effort to examine and learn from nature's problem-solving methodology. However, this topic merits more discussion than I alone can offer, and I encourage interested readers to respond.

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Biomimetics Course at OCAD

As part of a progressive campaign to be a leading design institution, the Ontario College of Art and Design approached Professor Bruce Hinds and myself, Nima Motamedi, to develop and deliver a course on Biomimicry.

We were poised with a very compelling design problem: create a course on Biomimicry for designers. We approached this course the way we would approach any design problem. We began by outlining our goals and what we expected to accomplish. From the onset we realized that for a course on Biomimicry to succeed in design, it would need to have three things.

First, we would have to pool in as many guest speakers as we could to teach us about basic sciences, biological principles, and other topics lacking in our design education.

Secondly, we would need to tailor the course to meet the expectations and needs of design students as well as to match their level of scientific knowledge and understanding.

Lastly, we wanted to connect our course with other institutions teaching Biomimetics. From the very beginning, we have been in close contact with Professor Sue Redding from the California College of Arts and Professor Elva Rubio at the University of Chicago, and Norbert Hoeller editor of the Biomimicry newsletter, all of whom use Biomimicry in their design philosophies. We hope to forge a network between other design and academic institutions involved in Biomimicry so we can all benefit from each other's support and experience.

We have been attracting small attention in and around Toronto thanks to exposure in a small article in the Globe and Mail newspaper. And the Ontario Science Centre has also expressed interest in our course and we are currently discussing ways to align our efforts to create biomimetic content for one of their upcoming exhibits.

Most importantly of all however, OCAD has informed us that they want to double their Biomimetic content next year by offering another section on our course. This is very uplifting news because it means that we can educate twice as many students as this semester, and that a major Canadian design institution is taking our practice seriously. This is a testament to all the hard work and effort everyone made in the Biomimicry community. It truly is an exciting time to be a biomimetic designer!

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Ontario Science Centre "Agents of Change"

The OSC has embarked on a C$40M refit of 30% (about 30,000 sq ft) of the existing exhibit space. At the same time, the OSC has taken on a new mandate to encourage innovation amongst youth. They are specifically targeting teenagers, partly because teens are traditionally under-served by science centers, partly because material developed for teens can be of interest to both preteens and youth in their early 20s. The first phase of the refit, the Weston Family Innovation Centre Phase 1 is being launched now, with the last phase scheduled for completion in spring 2006.

With the support of the OSC leadership, the 'Agents of Change' team developed a new model that encourages 'co-creation' and a deeper understanding of science on the part of visitors. To support this model and the required cultural changes, the team has developed a new language:

- pilots, rather than prototypes (not asking questions about how something should work, but rather 'why should people care')
- participants, rather than visitors
- experience, rather than exhibits

Many of these changes have already been put in place. Testing of concepts are now done early and often. Diverse groups from both within and outside the OSC are brought in during development, not only to tap their ideas, but also to 'reconnect' them with the important things the OSC is doing. Risk-taking is being encouraged, partly by forcing ideas to be actualized early through testing. Collaboration is key - rather than being owned by individuals or small teams, ideas are now seen as coming out of the interaction between many individuals. There is a recognition that the user experience is paramount, and participants own their own experiences.

The OSC has applied these ideas to the Challenge Zone where new concepts and processes can be tested. Small groups are brought in to work on real problems, under both time and resource constraints. Actually building and testing something is key. At the same time, risk taking is encouraged - perfection is not as important as the learning experience and being creative. OSC facilitators work with the groups to ensure that everyone is able to contribute, and also to introduce new constraints if the problems become too easy.

The OSC is very interested in incorporating Biomimicry into the Material World area. A number of approaches are being explored with the help of Dayna, Dr. Julian Vincent, Jeremy Eddy, PAX Scientific and students of the Biomimicry course at OCAD. The principles and processes behind Biomimicry are also being shared with other parts of the 'Agents of Change' initiative. For example, the Citizen Science area could allow participants to become involved in both the research and application of Biomimicry, helping them see the value of nature's innovation as well as the importance of developing truly sustainable solutions.

A discussion group that includes additional information is available at http://www.thinkcycle.org/tc-bboard/message-threaded?message_id=54294&forum_id=54184

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Upcoming Events

Our spring Biomimicry and Design course will be offered April 29th through May 5th in La Cusinga Lodge on the Pacific Coast near Uvita, Costa Rica. Join instructors Dayna Baumeister and Janine Benyus for this exciting, hands-on, interactive course for students and professional architects, engineers, and designers interested in bringing nature's strategies and solutions to the design table. You will have an opportunity to solve a design challenge by asking "what would nature do here?"; brainstorm with biologists; learn from local plants, animals, and ecosystems and become acquainted with life's inherently sustainable design principles; and how to incorporate bio-inspired design techniques in your own organization. For details on the course and to register, see http://www.biomimicry.net/cr.htm (deadline for registration is April 1).

The 2005 Biologists at the Design Table (BaDT) training will by held May 30th through June 3rd at Blue Jay Point Park, north of Raleigh, North Carolina. Join Janine Benyus, author of *Biomimicry: Innovation Inspired by Nature*, and Dayna Baumeister, PhD biologist and Education Director of the Biomimicry Guild, for an eye-opening, five-day intensive course to train biologists interested in applying biomimicry to design. For details on the course, see http://www.biomimicry.net/BaDT.html.

Alexis Karolides, John Carmody and the Biomimicry Guild have been developing a course for the University of Minnesota to apply Biomimicry to the teaching of design. Alexis and Dayna submitted a funding proposal to the AIA Latrobe Fellowship, but did not make the short-list. They are now looking for other potential funders. The plan is to have biology students train with Dayna, then work with architects to improve the practice of sustainable design in architecture.

Members Corner

Emily Hunter - I met Janine for the first time in 1997, through one of those fortuitous events that change our lives. The Biomimicry book was at the "blue line stage", where the publisher has laid out the book and the author has one chance to make minor corrections before the book goes to press. Wes Jackson had worked with Janine earlier, and agreed to read the proofs. Unfortunately, Wes Jackson and his team were working on a large USDA grant that was consuming all of his time.

I had been working for the Land Institute for a few months developing programs for the various Land Institute sites and staying at the Lumberyard residence in Matfield Green. Wes sent Janine to Matfield Green until he was able to free up time. Janine showed up on my doorstep full of energy about Biomimicry, but also looking for help in reviewing the book. Tom Armstrong (retired from the Parks service and keenly interested in the history of technology, Elaine Shey-Jones, two Land Institute interns and I read through the book and talked with Janine over many days. We were moved to tears by the last chapter, not only by the power of the idea, but also Janine's willingness to entrust her book to strangers. Janine referred to this time as an eddy in the rush to publish - a wonderful and totally unexpected time in everyone's life that lead to enduring bonds of friendship.

Wes Jackson suggested the notion of 'popularizing' Biomimicry (later renamed to 'naturalizing') such that in 35 years, everyone would understand the concept of Biomimicry. Plans were made for a conference in conjunction with the book launch, along with a Biomimicry curriculum. I had founded a small non-profit called Living Education with some other people from Naropa and was able to use it as the vehicle to obtain funding for the first Gathering in Patagonia, Arizona. Here the initial diagrams of the evolving Biomimicry landscape were developed, along with the strategy to naturalize Biomimicry.

Developing a Biomimicry documentary was also a topic at the first Gathering. David Springbett and Paul Lang of IconMedia arranged for Janine to meet with the Canadian Broadcasting Corporation in Toronto. Agreement was reached for a three session broadcast, if funding could be obtained. Funding provided to be a challenge - although Biomimicry was compatible with the mandates of a number of key funding organizations, their grant programs tended to be more narrowly focused. In the end, the CBC funded a two segment program - Paul Lang became the producer and co-director with David Springbett. IconMedia and the Biomimicry Guild were allowed access to the material for educational purposes, with costs to be negotiated.

The second Gathering was held in Matfield Green, dedicated to the education and curriculum programs. Two representations from Mid-continent Research for Education and Learning (McREL) attended to help develop a proposal. Although the primary contact at McREL has since left, the current Vice President is still very interested in working with us if we can raise $160K for a pilot program.

My participation in Biomimicry has been a wonderful gift. Not only is Biomimicry one of the few great ideas that will make a major impact on human life, but it also creates the opportunity to develop those luminous tentacles of friendship that enable deep communication and communion.

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Clippings

Up on the roof, algae appetites may transform waste into energy (MIT News Office, August 9, 2004). Algae are able to consume power plant emissions, turning carbon dioxide and other toxins into biomass, while releasing oxygen and nitrogen. Http://web.mit.edu/newsoffice/2004/algae.html

Germany Shines a Beam on the Future of Energy (San Francisco Chronicle, December 20, 2004). A 30-acre solar-power plant in Muhlhausen will generate 10 megawatts of power, making it the largest in the world. The alternative energy producers are guaranteed high rates for the electricity for 20 years. http://www.commondreams.org/headlines04/1220-05.htm

Weeding out Bacteria (Technology Review, December 21, 2004). "Seaweed compounds, called furanones, can stop the bacteria that cause cholera by cutting off the communication systems enabling the disease to spread. The breakthrough has researchers speculating that furanones will likely also work against other bacteria, including those that cause staph infection, food poisoning and tuberculosis -- which are increasingly becoming resistant to some antibiotics." http://www.technologyreview.com/articles/04/12/wo_philipkoski122104.asp

Guiding the Evolution of Things (Technology Review, February, 2005). Angela Belcher, an MIT materials scientist, uses viruses and yeasts to create compounds through a form of self-assembly. "We look at how nature processes materials and then evolve organisms to make new types of materials." http://www.technologyreview.com/articles/05/02/issue/forward_virus.asp

The Tangled Webs They Weave (Technology Review, February 21, 2005). "After 15 years of research, Dr. Randy Lewis, a professor of molecular biology at the University of Wyoming in Laramie, Wyoming, and his team say they have determined the sequence of genes underlying the spider silk protein." Rather than trying to understand how spiders make silk, the focus seems to be on introducing the DNA into other plants or animals, raising a range of ethical questions.
http://www.technologyreview.com/articles/05/02/wo/wo_hoffman022105.asp

Resources

Recent BioInspire newsletters:

- February 2005: Earth's Natural Internet - Healing the planet with mushrooms
- January 2005: What is Deep Ecology?

The Biomimicry Guild Newsletters are now generally available through ThinkCycle at http://www.thinkcycle.org/tc-space/tspace?tspace_id=49344. You do not need to register with ThinkCycle to read the newsletters; however, registered ThinkCycle members can subscribe to get notified automatically of any new newsletters, and can also use the ThinkCycle discussion group. A ThinkCycle Quickstart guide (requires Adobe Reader) is available at:
http://www.thinkcycle.org/tc-notes/show-note?tc_note_id=41609.

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