BioInspired!

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The Biomimicry Institute

Biomimicry Reaching Over 950 Young Students Yearly in Montana *(Sam Stier)*

Nearly one-thousand students in grades K-12 in Western Montana were introduced to biomimicry last fall through the Montana Natural History Center's (MNHC) Visiting Naturalist program. The Biomimicry Institute worked with MNHC to create the curricula for the program, which provides monthly classroom visits by naturalists and two days of outdoor learning from the natural world to fourth and fifth grade children from 45 different classrooms in 18 schools. The program uses exploration and scientific inquiry to engage and encourage the innate curiosity that children have about the natural world. Goals include:

1. Develop the skills of an artist, writer and scientist to explore the natural world
2. Become familiar with the process of scientific inquiry
3. Understand how form relates function in the natural world
4. Develop a relationship with a Naturalist mentor

The curriculum introduces biomimicry to students as part of a unit on adaptations which explores form and function. The biomimicry part of the curriculum begins by having students explore the amount of time it takes them to fasten a shirt with Velcro compared to a shirt with buttons. Group discussion then explores why Velcro is a technology which functions in some ways better than other fasteners. For instance, most fasteners (buttons, zippers, buckles, etc.) require a degree of manual dexterity to operate, Velcro, however, affixes without a great deal of alignment or force, regardless of ambient conditions, and to a wide variety of materials. Likewise, the seeds of burdock plants (*Arctium* spp.), which inspired George de Mestral to invent Velcro in 1941, disperse by attaching to animals with different kinds of fur or hair and which pass by at unpredictable speeds and angles. The burrs also need to attach themselves in a wide range of weather conditions. In other words, the inspiration for a design can be a fundamental driver for both concept innovation as well as the technology's ultimate functionality or performance.

The students then have an opportunity to explore the outdoors in order to create their own nature-inspired inventions, complete with conceptual drawings that they share with the rest of their group. The process starts with each student picking an object that interests them. The students study their specimen with the naked eye as well as through a microscope, and draw it in their journals. Students then develop and draw an invention based on their thoughts about the relationship between the form and the function of the object.

Inside This Issue:

The curriculum will be refined this spring and included in MNHC's ongoing Visiting Naturalist program. To learn more or to find out how to include biomimicry in your educational activities, contact me using the link below.

Sam Stier
K-12 and Non-formal Education Director

Nature's 100 Best *(Norbert Hoeller)*

Can the transition to tomorrow's economy be accelerated by looking to how Nature has solved the functional and sustainability challenges that we face? Can Nature's solutions spur a new economic model that will lead to products and processes supporting a more sustainable way of living while conserving and potentially increasing biodiversity? According to Gunter Pauli of the ZERI Foundation:

> "Steam and coal transformed the 19th century; telecommunications and electronics, the 20th. We are now on the edge of a biologically-based revolution and in some of the inventions showcased under this new initiative will undoubtedly be the business models for the new Googles, Welcomes, Unilevers and General Electrics of the modern age."

The Nature's 100 Best project is a collaboration between the Biomimicry Guild and the Zero Emission Research Initiatives (ZERI), with support of the UN Environment Program (UNEP) and the International Union for the Conservation of Nature (IUCN). Work started in 2007 on building a database using information from peer-reviewed scientific articles from a broad range of international journals.

The list of over 2000 ideas has been pruned based on a wide range of criteria, including:

- pragmatic and application focused
- good chance of success
- potential for significant benefits
- innovation inspired by a deeper understanding of biology
- supports the Life's Principles

A preliminary list of ideas was released in conjunction with the Convention on Biological Diversity held in Bonn, Germany in May 2008. An update was delivered at the October 2008 IUCN World Conservation Congress in Barcelona, Spain.

Three examples from the initial list are highlighted below, followed by an in-depth article on Las Gaviotas.

Norbert Hoeller
With help from Megan Schuknecht,
Robyn Klein and Mark Dorfman

Vaccines Without Refrigeration

In combination with greater cleanliness and antibiotics, vaccines have played a key role in improving health and longevity. In the Western world, we take vaccines for granted. Refrigeration is readily available to keep vaccines within a narrow temperature range from manufacturing to usage. In the developing world, this infrastructure often does not exist. The World Trade Organization has estimated that maintaining the 'cold chain' would cost U$200-300 million annually, a sum that could be used instead to fund vaccine doses and delivery, along with other preventative health care.

Aside from cold, another natural way to preserve organic substances is dehydration. Unfortunately, dehydration can cause damage to the folding structure of proteins, critical to the protein's proper function. A number of species such as the African midge, brine shrimp and the resurrection plant are able to survive dehydration by entering 'anhydrobiosis' – a state in which the organism displays no metabolic activity yet can recover when water becomes available. The 'trick' involves cells generating a sugary substance such as trehalose. Although the exact details are still being studied, the sugars appear to replace water and also form an amorphous glassy matrix that slows protein unfolding.

Dr. Bruce Roser is a pioneer in exploring ways of storing vaccines without refrigeration. Inspired by organisms that undergo anhydrobiosis, he co-founded Cambridge Biostability Limited in 1998 and is actively developing technologies for stabilizing vaccines and other drugs. After mixing the vaccine with water-soluble sugar glasses, the water is removed and the result is formed into microspheres through spray-drying. These microspheres can be mixed with an inert anhydrous liquid and stored for extended periods at ambient temperatures. The combination can be directly injected without requiring that the dry vaccine be reconstituted with water in a sterile environment. Dr. Roser is also exploring how the sugar glass concept could be applied to improve cryopreservation of tissues and organs.

Nature's 100 Best *(continued)*

Anti-Bacterial Strategies

The fight against bacteria is unrelenting. Until the advent of antibiotics, common infections were often fatal. Unfortunately, bacteria continue to evolve and adapt to our counter-measures. As described in the article *Signal Jamming in the Fight Against Bacteria*, bacteria can form biofilms that provide a defense against antibiotics. Chemical signals between bacteria trigger the formation of these biofilms. In a number of cases, these signals also trigger bacteria to enter a virulent stage.

As a result of a chance observation that red algae *Delisea pulchra* appeared to resist underwater fouling, Biosignal Limited was able to identify specific furanones that prevent bacteria from settling on the surface of the algae to form a biofilm. Biosignal has since synthesized a large number of compounds with similar signal-blocking characteristics and is developing a wide range of commercial applications including anti-bacterial coatings for contact lenses and food packaging, microbial corrosion inhibitors in pipelines and biofilm controls for water cooling towers.

The discovery that bacteria have a much more complex 'real-world' life than the free-floating (or planktonic) form typically studied in the lab has far-reaching consequences. It is estimated that from 65% to 75% of infections involve biofilms, requiring large doses of antibiotics. If not all bacteria are killed, they can become resistant, an increasingly worrisome health issue. Interfering with bacterial signaling could also prevent some bacteria (such as cholera) from switching to their virulent state. Outside of the health field, Biosignal estimates that corrosion due to biofilms costs industry U$2 billion annually. Equally important, blocking bacterial signaling does not kill any of the bacteria and thus does not appear to encourage resistance. At least over the last few million years, bacteria appear not to have adapted to *Delisea pulchra*'s defenses.

Dye-Sensitized Solar Cells

Solar energy is the largest source of free energy on Earth. It is estimated that 178,000 terawatts of solar radiation strikes the Earth annually (Biological energy production). Although a portion of that energy is radiated back into space, the solar energy has the potential to provide much of the 12 terawatts of energy that we consume globally each year.

Although solar energy can be used directly, such as in passive solar homes, efficient ways of converting solar energy into forms that can be easily transported and stored are needed before solar energy can displace non-renewable sources. Photovoltaic cells are becoming increasingly important in both centralized and distributed power generation. Most photovoltaic cells use a semiconductor such as silicon, cadmium telluride (CdTe) or copper indium gallium selenide (CIGS). The semiconductor serves two functions: it generates electrons when excited by photons from sunlight (excitation) and maintains an electric field which produces the current flow (conduction).

In contrast, photosynthesis involves a multi-step process involving absorption of light followed by transfer of the captured energy to reaction centers where water and carbon dioxide are converted to oxygen and organic compounds. In 1991, Prof. Michael Graetzel and Prof. Brian O'Reagan (Ecole Polytechnique Fédérale de Lausanne) developed dye-sensitized solar cells that also separate the excitation and conduction operations. Titanium dioxide particles in conjunction with an electrolyte and two conductors act as a conduction layer. The conversion of light to free electrons occurs in a dye layer (often ruthenium-polypyridine) coating the titanium dioxide particles.

Less energy is required in the manufacturing of dye-sensitized solar cells compared to silicon-based cells, significantly reducing the amount of embedded energy and the 'energy pay-back time' (the time required for the cells to produce as much energy as went into their production). Although dye-sensitized solar cells currently are not as efficient as silicon, they utilize cheaper and less toxic chemicals. Lastly, separation of the electron generation and conduction steps allows dye-sensitized solar cells to work at lower light levels. In comparison, the electrons in semiconductor cells can recombine with the 'hole' created during excitation, re-radiating energy instead of producing useful electricity.

Companies like Konarka Technologies and Dyesol continue to work on reducing the cost, improving the conversion efficiency and increasing manufacturing yield. The longevity of dye-sensitized solar cells has been an issue, due to the deterioration of the electrolyte solution which often contains volatile organic solvents. Recent work by Prof. Graetzel and Prof. Zakeeruddin has identified a mixture of three solid salts that can act as an electrolyte with good stability and efficiency (New Efficiency Benchmark For Dye-sensitized Solar Cells).

Plants still have a few tricks to teach us – they combine solar energy capture and transformation into a system that transports the essential nutrients, stores the organic products in a stable state at ambient temperatures and pressures, and can tap these products when the sun does not shine.

The Lessons of Gaviotas

In 1971, Paolo Lugari set out to create a self-sufficient, tropical community on 25,000 acres of *llanos* or savannah in Colombia, sixteen hours by jeep east of Bogotá. In contrast with most other communities that sprang up at that time, Lugari specifically chose an area lacking in natural resources. Torrential rainfall was interspersed with drought. Although the area had been part of the Amazon rainforest thirty thousand years ago, naturally occurring fires during the dry season burned the woodlands and prevented them from regenerating. The soil had been leeched of nutrients and was laced with aluminum. In addition, Colombia had gone through economic decline in spite of its abundant natural resources. Political unrest and the drug trade fed guerrilla and paramilitary factions, further destabilizing the country.

Lugari managed to attract an eclectic band of people from all walks of life, including thesis candidates from universities across Colombia. These "adventurous thinkers" and "pioneer-technicians" came to Gaviotas to study the opportunities and challenges of the region and suggest solutions. In addition to maintaining links with Bogotá and other parts of the world, many stayed on to become valuable members of the community – their stories are a key part of Alan Weisman's **Gaviotas, A Village to Reinvent The World**.

Double-action sleeve pump

In spite of (or perhaps because of) the challenges, the people of Gaviotas developed a wide range of solutions that improved their lives while "fitting in" with the local environment. Examples include locally adapted windmills and double-action sleeve pumps (see http://www.friendsofgaviotas.org/Innovation/Innovation.html for downloadable manuals in Spanish), natural cooling and dehumidification systems, and numerous solar-powered devices for cooking, water purification and refrigeration. A number of these devices were implemented across Colombia, bringing fresh water and improved living conditions to communities in need.

Tapping resin

The most impressive initiative was the reforestation of the savannah with Caribbean pines. Inoculation with the mycorrhiza fungus *Pizolithus tinctorius* allowed the pines to thrive even in the poor soil of the *llanos*. The pines provided a renewable source of resin that could be refined and converted into a wide range of valuable products, bringing income that supported Gaviotas when outside funding from organizations such as the United Nations dried up in the late 1980s.

Biodiversity

Gaviotas intentionally did not treat the pine forest as a monoculture, but allowed natural succession to occur. The pines (which are not fertile in this area) gave native vegetation a foothold, slowly allowing a diverse and vibrant forest ecosystem of nearly 300 native species to establish itself. Over 10,000 hectares (25,000 acres) have been planted to date. The forest has increased local precipitation and helped replenish aquifers, allowing Gaviotas to start a water bottling operation providing pure water to the surrounding region. It has also sequestered more carbon dioxide than had been expected in the topsoil, undergrowth and trees.

Ronald Savitt suggested in his Journal of Macromarketing review of Weisman's book that Gaviotas may not be replicable, since it is not a "thing", a program or even a well-defined philosophy. Weisman describes the challenges of transplanting solutions developed in Gaviotas to other areas. In some cases, simple maintenance procedures were not followed. In others, cultural issues prevented diffusion of the technology. What has not been explored is whether the ***process*** of Gaviotas can be replicated, such as:

- a pragmatic and incremental approach to problem solving, based on listening, innovating, assessing and continually making adjustments
- a reliance on local resources (people, energy and materials) to develop solutions that are locally appropriate
- a holistic, systems-oriented perspective that placed problems and opportunities in a larger context
- a focus on building diversity, expanding resources and creating opportunities at multiple levels, including artistic endeavors
- an emphasis on 'balance', in promoting equality amongst the members of the community and also in how the community interacted with the local environment

Gaviotas has not only survived economic, social, political and environmental turmoil, but has flourished. ZERI is promoting the model of Gaviotas as a way to reforest an additional 6.3 million hectares (15.5 million acres), increasing biodiversity, sequestering carbon dioxide and providing opportunities for the people of Colombia. It will be interesting to see how the grass roots, low cost and localized model of Gaviotas can be adapted to build momentum on such a large scale.

(Images used with the permission of *Friends of Gaviotas*, which has a slideshow of the Gaviotas forest and a number of picture galleries.)

Working the Field of Bio-Inspired Design *(Norbert Hoeller)*

A number of recent contributors to the *BioInspired! Newsletter* have created an informal group to explore ways of advancing the field of bio-inspired design and updating the biomimicry community on progress. Possible subjects include:

- the demonstration of methods and tools, including results achieved
- case studies that explore the 'how' of bio-inspired design, not just the 'what'
- examples of how bio-inspired design can provide insight into the challenges and opportunities facing humanity

The group has identified three actions it plans to undertake:

- Develop a list of journals and conferences covering bio-inspired design, to help academic members of the community get published.
- Write summaries of original published works that provide insight into the 'how' of bio-inspired design.
- Develop a community of interest to explore and discuss a broad variety of issues related to the field.

To collect information for the first action, a template has been prepared and is being tested with an initial group of journal editors and conference organizers. The first set of article summaries supporting the second action follows this article. The group has decided to use the Biomimetics listserv as a pilot venue for the third action. The listserv already supports an active user community in addition to providing a useful communications platform.

If you are interested in participating in any of these initiatives, please contact me through the link below.

Norbert Hoeller
With Nicolas Beck, Peter Fiske, Ashok Goel,
Carlos Alberto Montana Hoyos, Tom McKeag,
Eileen Stephens, Julian Vincent and Marc Weissburg

Hexagonal Surface Micropattern for Dry and Wet Friction

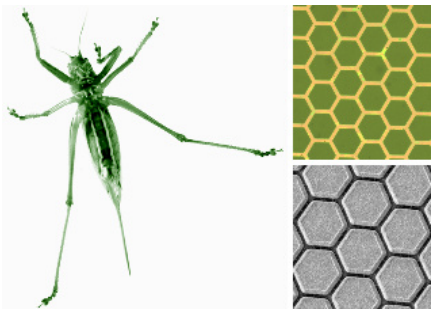
Michael Varenberg, Stanislav N. Gorb; Advanced Materials, 2008, Vol 21 Issue 4, pages 483-486.
http://www3.interscience.wiley.com/journal/121589088/abstract

This paper explores biological contact structures involving smooth foot pads (as found in bush cricket, tree and torrent frogs), in contrast to hairy pads (see *What Beetles Can Teach Us About Adhesion* for examples). In both cases, the pads allow matching of the contact surface with the natural substrate. Smooth pads typically have surface micropatterns such as hexagons, which are believed to increase friction under wet conditions. Due to the challenges of testing biological specimens, an artificial surface with a hexagonal micropattern was tested experimentally.

Under dry conditions, the smooth surface exhibited 'stick-slip' motion, while the patterned surface slid smoothly but still exhibited a comparable friction force. Under wet conditions, the smooth surface experienced a 20-fold reduction in friction force, while the patterned surface quickly recovered from 30-50% of the friction force seen under dry conditions. The channels between the hexagons allowed fluid to escape, re-establishing contact between the surface and the substrate.

The experiments on the artificial surface inspired by biological specimens helped provide support for the hypothesis that micropatterns "may function as a friction-oriented feature, preventing hydroplaning and optimizing the thickness of the fluid film." The greater freedom to manipulate the object under test can lead to a faster understanding of the mechanisms.

The article also pointed out the value in looking across species to help uncover underlying principles. In addition to being the shape that maximizes the number of objects that can be packed in a given space, hexagons provide "the highest possible contact area, maximum lateral stability and isotropy, and longest draining channel length." The research also suggested another approach to solving adhesion and friction issues. The article referenced a tire with improved dry and wet handling through a hexagonal tread pattern that was developed through trial and error.



Bush cricket *Tettigonia viridissima* on a vertical glass surface, close-up of the bioinspired polymer using a light microscope and a scanning electron microscope.

Working the Field of Bio-Inspired Design *(continued)*

A Proposal for Biomimicry as Basis for an Integrative Pedagogy for Sustainable ID

Carlos Alberto Montana Hoyos, Dr. Takahito Saiki; Proceedings of the IDSA 2008 Education Symposium, September 10-13/2008, Phoenix, Arizona; pages 163-172.
http://www.lulu.com/content/3038730

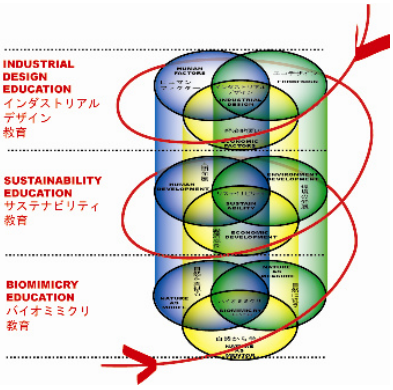
This paper describes an alternative Design for Sustainability teaching approach "based on the integration of biomimicry, human needs analysis and ecodesign analysis tools that integrate social, environmental and economic factors." Biomimicry was chosen because of its sustainability focus, systems approach, and respect for limits (see *Biomimicry in Sustainable Industrial Design Education* for additional details).

Two workshops held in 2006-2008 at the School of Design and Environment at the National University of Singapore tested the method, specifically the strategies:

- "biology to human needs" (biomimetic analysis -> biomimetic solution -> human problem -> eco-analysis -> final proposal)
- "human needs to biology" (human problem -> biomimetic analysis -> biomimetic solution -> eco-analysis -> final proposal)

Qualitative information about the workshops was gathered from students through a questionnaire. In general, students demonstrated a greater awareness of sustainability issues around Industrial Design and an increased ability to develop innovative and sustainable designs inspired by nature. Students reported that the workload was high and the method needed more clarity and simplicity. They found the second strategy ("human needs to biology") more difficult, partly because they were dealing with greater complexity and more constraints. However, this strategy is representative of the challenges that an Industrial Designer would face professionally.

If teaching and practice of biomimicry is to advance, it is critical that "models … be developed, tested, evaluated and refined". By sharing diverse approaches to biomimicry teaching and their results, as a community we can better adapt the methods and discuss improvements, eventually building a toolkit of 'best practices' for teaching and learning biomimicry within different professional contexts.



Learning Spiral of a proposed teaching and learning method for DfS in ID, based on Biomimicry.

Smart Grid – Taking our Cue from Nature

Roman Kulyk, REGEN Energy Inc.
http://www.regenenergy.com/Resources/REGEN_SmartGrid_Whitepaper.pdf

This whitepaper describes how 'smart appliances' can play a part in the sorely needed upgrade of the North American energy grid. In addition to automatically reducing consumption during periods when the local power grid is overloaded, smart appliances could allow customers who are billed based on real-time pricing to shift consumption to periods when electricity is cheaper.

By applying the principles of 'swarm theory' (see The Power of Ants and Bees for background information), REGEN Energy™ has been able to develop a simple and inexpensive EnviroGrid™ controller that communicates wirelessly with its neighbors to minimize peak loads across multiple appliances without impacting users (see Centennial College data analysis report for more details). The controllers can report usage to a central collection point, allowing timely preventative maintenance and further optimization of the system. In the event of grid congestion, they can also reduce overall power consumption by slightly shortening appliance duty cycles, with little or no impact on users.

Rather than emulating a form or function in nature, the EnviroGrid™ controller is an example of applying "deep patterns" or principles from nature to deliver environmental and economic benefits in an elegant and cost-effective manner. The solution is robust, adaptive, requires no centralized control and shows potential for further spin-off applications.

Biomimicry and Design Workshop in Costa Rica

The Biomimicry Guild will be conducting its popular Biomimicry and Design Workshop near Uvita, Costa Rica from April 17-24, 2009. This introductory course is designed for professionals and university students in various fields including architecture, industrial design, the sciences, engineering, community development, city planning, business, landscape architecture, and interior design.

Course participants can expect a rigorous and thorough exploration of the theory and deep principles of biomimicry, along with opportunities for real-world collaborative problem solving using the tools and techniques of the biomimicry methodology. Participants also enjoy a week of learning about biomimicry in the context of virgin Costa Rican rain forest where howler monkeys, fiery-billed aracaris, and many other tropical locals regularly join the group for lessons about local ecology.

The course will be led by Dayna Baumeister, PhD, co-founder of the Biomimicry Guild, and five additional instructors with years of experience teaching biomimicry. The registration form and details about the course, logistics, and cost can be found on the Guild website at http://biomimicryguild.com/costa_ricaworkshop.html. You may also contact me using the link below or 00 +1 406.360.3720 with any questions about the course. Registration ends in early March, so submit your application soon!

Megan Schuknecht
Biologist at the Design Table and
workshop coordinator

Ask the Planet (Cindy Gilbert)

Voice Your Opinion!

This newsletter is the 12th issue under its new look and name, and the 21st including the original *Biomimicry Newsletter.* The last issue went to over 3,200 subscribers. To help improve the newsletter, please take a few minutes to complete the survey using the link below.

The survey has three sections and a total of ten questions, and should take no more than ten minutes to complete. All information will be kept confidential.

The survey will run from March 1st to March 31st. A summary of the results will be published in a future issue of the newsletter.

Thanks!
Norbert Hoeller

http://www.surveymonkey.com/s.aspx?sm=dpYsZhenKDer_2b_2fVQBEmwkQ_3d_3d

Calendar of Public Events

Date	Location	Event
March 3, 2009	Syracuse University, New York	Lecture: Biomimicry: Innovation Inspired by Nature
March 17, 2009	Brentwood, TN	Monthly Meeting Presentation: *Biomimicry* (USGBC – Middle Tennessee)
March 19, 2009	Washington University, St. Louis, MO	Assembly Series Lecture: Biomimicry: Innovation Inspired by Nature
Mar. 31-Apr. 2, 2009	Loughborough University, UK	Fifth International Conference on Bio-Acoustics.
April 17-24, 2009	Uvita, Costa Rica	Biomimicry Guild - Costa Rica Workshop

Date	Location	Event
May 6, 2009	Portland, OR	Conference Lecture: *Biomimicry: Innovation Inspired by Nature (Living Future 09 USGBC – Cascadia Green)*
May 7, 2009	Salt Lake City, Utah	Sustainability Series Lecture: Biomimicry *(Salt Lake City Library)*
July 13-16, 2009	Las Vegas, Nevada (selected conferences)	WORLDCOMP'09 - The 2009 World Congress in Computer Science, Computer Engineering, and Applied Computing
July 27-31, 2009	Edinburg, UK	17th International Conference on Composite Materials

"Biomimicry (from *bios*, meaning life, and *mimesis*, meaning to imitate) is a new science that studies nature's best ideas and then imitates these designs and processes to solve human problems. Studying a leaf to invent a better solar cell is an example. I think of it as "innovation inspired by nature."

The core idea is that nature, imaginative by necessity, has already solved many of the problems we are grappling with. Animals, plants, and microbes are the consummate engineers. They have found what works, what is appropriate, and most important, what lasts here on Earth. This is the real news of biomimicry: After 3.8 billion years of research and development, failures are fossils, and what surrounds us is the secret to survival.

Like the viceroy butterfly imitating the monarch, we humans are imitating the best and brightest organisms in our habitat. We are learning, for instance, how to harness energy like a leaf, grow food like a prairie, build ceramics like an abalone, self-medicate like a chimp, compute like a cell, and run a business like a hickory forest.

The conscious emulation of life's genius is a survival strategy for the human race, a path to a sustainable future. The more our world looks and functions like the natural world, the more likely we are to endure on this home that is ours, but not ours alone."

A Conversation with Janine Benyus

BioInspired! is published quarterly and is posted on a public-access Weblog hosted by TypePad. For those of you familiar with RSS Readers, TypePad supports various feed formats (look for the *Subscribe to this blog's feed* link in the right navigator).

Comments can be posted on the newsletter Weblog. At this time, the TypePad RSS feed does not deliver comments.

If you wish to subscribe to this newsletter, please complete the E-newsletter sign-up form.

Last, but not least, please send any feedback or comments to:

Norbert Hoeller

Clippings, Resources and Events

Four public-access Weblogs hosted on TypePad are now available to share information of interest to the Biomimicry Community.

- Clippings: short articles relating to Biomimicry.
- Resources: pointers to more extensive information.
- Events: workshops and relevant conferences.
- BioInspire: *NEW* Twenty-six issues of John Mlade's monthly magazine published between January 2003 and July 2005

These Weblogs can be monitored with your favorite RSS Reader. Anyone can post comments. Please be aware that TypePad requires an e-mail address and will display this address to people viewing the comment. Each Weblog has a 'sticky' post at the top with suggestions on how to reduce the impact of getting Spammed.

Contributions of clippings, resources and events are greatly appreciated! Please see the note at the top of each Weblog for instructions.

Thanks, Norbert Hoeller

A CALL TO TEACHERS AND STUDENTS OF BIOMIMCRY

If you are integrating biomimicry into your teaching or learning, we want to hear about it! Just fill out the on-page form you'll find on the web at http://sinet.ca/tinc?key=zkJeYXyN&formname=BioEducation. When you're done filling out the information, you simply click on "ok" (lower right) and you're done. Thanks in advance!