Biomimicry Newsletter

Special Costa Rica Workshop Edition

The 2005 Biomimicry and Design workshop was held at La Cusinga Lodge on the Pacific Coast of Costa Rica. The Pacific Coast is ideal for this kind of event - it is the wilder and more pristine side, whereas the Caribbean side is flatter with more agriculture such as banana plantations. The variety of habitats including both primary and secondary forest gave a sense of being truly surrounded by nature. We were also close to the ocean, providing a great view and access for walks along the beach, our inter-tidal tour, and quick dips to "cool off" (the temperature of the Pacific at 9 degrees north of the equator is more like bath water).

The tropical rainforest was simply overwhelming in the variety of plants, animals and adaptations laid before us. We were able to study a troupe of howler monkeys on one of our walks, saw a number of small toucans (for which La Cusinga Lodge is named), and watched the industry of leaf cutter ants. The property included a small river. In contrast to a temperate forest, the riverbanks of tropical forests are not dramatically different from the surrounding forest. There is a surprisingly small amount of comparative literature to help place the tropical rainforest in context for us temperate zone travellers.

Inside

The second habitat we visited was the coral reef. We snorkelled off Isla Ballena (Whale Island) as well as offshore at Punta Uvita. Although Costa Rica is generally not considered to have much marine diversity, we saw a surprising number of fish and other organisms. Unfortunately, the coral reefs have been devastated since the early 1980s due to rising water temperatures attributed to El Niño. The zooxanthelle (algae that live inside the coral) have been dying off, causing the coral to bleach and eventually die. The problem has been aggravated by agricultural runoff and erosion. There is hope that some species of zooxanthelle are adapted to the higher temperature and may re-colonize the coral.

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The Sierpe mangrove is the largest in Central America. For our mangrove kayak tour, we entered about 7 miles upriver from the ocean at a transition zone that included non-mangrove trees. As we travelled down river, we saw the traditional red, white and black mangrove that are adapted to both standing water and high salinity. Our guides were very knowledgeable about the ecosystem and were able to point out many species that we would not have been able to see from the land, such as the large numbers of crabs (the main animals that recycle nutrients in this ecosystem). We saw a wonderful range of wildlife including sloths, monkeys, mangrove hummingbirds, basilisk lizards and crocodiles.

La Cusinga Lodge was a gem - not only was it close to all three habitats (rainforest, coral reef, mangrove swamps), but the staff were very professional. It was a pleasure working with them on the logistics of our training and dietary needs, as well as the mangrove and snorkelling tours. The lodge itself was amazing - we were really impressed with the thoughtfulness with which it was constructed, from the solar hot water panels and hydroelectric power, to the placement of the buildings so that trees did not need to be cut down. The layout was well designed for large groups while keeping the small family atmosphere as though we were staying at someone's home. The owners deserve credit not only for preserving the surrounding forest but also reclaiming and replanting pasturelands. Last, but not least, it was wonderful to see the actual plants that bear the food we eat such as bananas, plantains, starfruit, and cassava root. Would I go back again next year? In a heartbeat.

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Workshop Overview

As Corina described, Costa Rica and La Cusinga are ideal locations for learning Biomimicry 'in context'. After we settled in, Janine presented a whirlwind tour of Biomimicry examples. As always, nature's ingenuity and subtlety was awe-inspiring, from the tubercles on whale fins that reduce drag *and* increase lift, to kelp that stays clean by blocking the signalling mechanism of bacteria. Janine covered a broad range of practical applications in the areas of form, process and ecosystem, including thin-film optics based on the octopus eye, research on how locusts avoid collisions, and the emergence of life-cycle product development where each stage delivers marketable value.

Our official course work started by 'reconnecting with nature'. Although it is easy to intellectually accept the value of nature's designs, you have to experience its brilliance all around us to make the emotional connection. The message was reinforced by walks in the rainforest, kayaking in the mangrove swamps, visits to the inter tidal zone and snorkelling. On the second evening, Jeannette presented an overview of sensory systems from a broad range of species, while Craig regaled us with his research on how bees optimize the problem of finding food and the application to the computer industry, interspersed with his unique rendition of the 'waggle dance'.

Janine and Dayna walked us through the key steps of the Biomimicry methodology: identifying the challenge, biologizing the question, defining the context, finding natural analogies, selecting and refining the top ideas, and finally assessing the 'fitness' of the solutions against nature's sustainability principles. We applied this methodology in developing our own projects, which are described next.

On the way back to San Jose, most of us were able to participate in a field trip at the Certo Cloud Forest, quite a change from the heat and humidity of the rainforest. Costa Rica is certainly a country of contrast and beauty.

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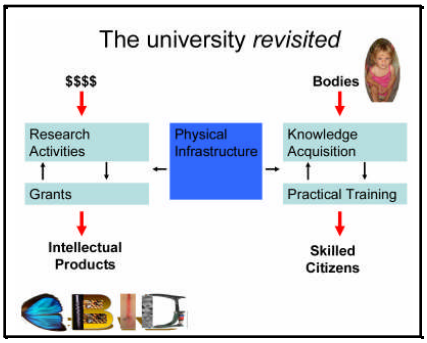
Center for Biologically Inspired Design

The Center for Biologically Inspired Design (CBID) had its roots in meetings initiated by Jeannette to find out what exciting things people were doing at Georgia Tech to combine biology and engineering. When Jeannette, Marc, Mohan and I got together, we discovered that surprisingly many people at Tech had research experiences showing promise for a cross-disciplinary approach - we had an unmistakable sense that we were at the beginning of an exciting era. Meanwhile, Georgia Tech requested proposals for seed funding to develop new interdisciplinary centers - perfect timing!

Our goal at arriving at the Biology and Design workshop was to write a proposal that would communicate a compelling and well thought out vision of a Center that would use biology to design better solutions, and engineering to better understand biology. We floundered for the first day and a half - we found it difficult to articulate what CBID would do and how it would be organized. We were unclear how the center would promote and inspire research in the area of Biomimicry. We began to wonder whether we were just furthering our own research interests and goals, instead of supporting a new field of study.

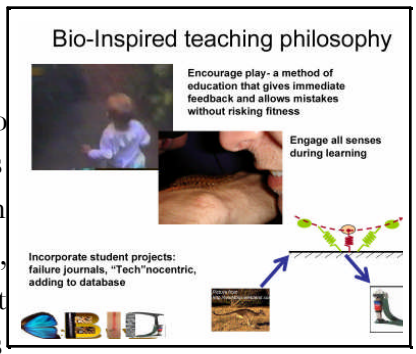
I had originally been sceptical about whether Biomimicry was truly an all-encompassing process. Over lunch, I decided to give Biomimicry a try and biologized the question "What is a university?" It occurred to me that a university takes inputs (students and money), processes and transforms them, and produces specific outputs (trained professionals, knowledge and papers). An ecology would be a comparable biological entity. If Georgia Tech were an ecological system, we would be a new species trying to integrate ourselves into that ecology.



I suggested that we apply concepts from "Ecology, the Ascendent Perspective" by Robert E. Ulanowicz, which states that the maturity of ecological systems is related to the amount of energy and material flowing through an ecosystem, availability of specialized pathways and the orderliness of flows. To be accepted by the Georgia Tech ecology, we need to increase the flow or the internal efficiency. Options include better ways of educating students, new funding, new knowledge outputs, and new programs or tracks for

students interesting in multidisciplinary learning. We realized we had an opportunity to redress the shift towards reductionism by encouraging a more balanced approach emphasizing synthesis.

Although I was the only one familiar with the concepts of Ascendency, the concept of Georgia Tech as an ecosystem and CBID as a new species that thrives by contributing to that ecology broke the stalemate. Marc described invasive species that are destructive and contrasted them with species that develop a niche, bridging the biological viewpoint with the engineering view of Ascendency. We decided to explore the 'niche development' model further.



We got stuck later in the project on how CBID would handle education. Again, biologizing the question as "How do animals learn?" led us to consider biologically inspired teaching. Mammals and many species of other classes learn through play. Play is an immersive way of experimenting, practising and getting instant feedback without risking biological fitness. We believe CBID courses need to involve more of the senses, and need to separate learning (play) from evaluation (fitness) to give CBID education a distinctive, effective, and biologically inspired style.

Returning from the workshop, we created several drafts of the proposal but had trouble getting it to 'gel'. We returned to the presentation repeatedly and changed the proposal to be more consistent with our original thoughts. For example, using some of the funding to support a graduate student would only help that one individual, rather than supporting the Georgia Tech ecology. Instead, we decided that money would be better spent to bring in speakers, develop seminars, create a library and build a Biomimicry database.

The ecology model proved to be a powerful way of looking at Georgia Tech as a thriving, self-sufficient community that CBID must promise to enhance in order to be welcomed. The workshop helped us define how CBID can change and add to Georgia Tech so that Biomimicry research and education become vibrant and valued contributors. Biologizing the problem not helped deliver a short-term

breakthrough - it also provided a sustained advantage throughout the proposal process.

And the best news of all - we have received word that Georgia Tech has approved the first year of funding for CBID!

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Aikido Agriculture

Our sub-team started with the broad vision of applying Biomimicry to the design of a completely sustainable community of 5000 people located within the rainforest of Costa Rica. We further narrowed our focus to the design of an agricultural system to support this community, combining sustainable food production and distribution. We recognized that the community would not be completely self-sufficient, and would need links to other communities that provided complementary products and services due to the unique characteristics of their environment.

We faced a number of challenges in trying to biologize the problem. There are few examples of farming in nature – nutrient recycling proved to be a poor analogy. It was also important to include humans in the equation, particularly their need for social interaction. At the same time, existing human patterns of agriculture often go against nature's principles and directly harm natural systems.

We decided to study now nature creates and distributes food through 'food webs', and also apply the qualities of success inherent in the rainforest system:

- Repetition of systems
- Diversity
- Dispersion
- Co-operation
- Balance

We took each of the Biomimicry conditions that allow life to sustain itself and mapped them for our agricultural system:

Conditions	Design Components
Design from the bottom up	Rely on principles of natural succession (use pioneer species to stabilize and build soil nutrients). Allow for self-assembly through incorporation of plant and animal communities with natural affinities for one another. Incorporate rotational forestry to allow for year-rounding harvesting and multi-crop production.
Fit form to function	Take advantage of existing rainforest and its multi-canopy structure to optimize agricultural footprint. Utilize all three dimensions. Optimize land, seasonal production and nutrients.
Integrate cyclical processes	Integrate sewage and waste treatment to turn waste into food. Harvest and reuse rainfall. Integrate composting systems for human organic waste and forest litter.
Resourceful and locally attuned	Tap free energy from sun and water. Let nature decide what crops are successful. Emphasize multi-use (trees for fruits and wood, bees for pollination and honey).
Adapts and evolves	Encourage educational components both within community (defined role to track successes and failures, agricultural stewardship program), and between communities (information pollination, sharing of knowledge, products and services). Pharmacologist/shaman role to identify and utilize medicinal plants.
Creates conditions conducive to life	Avoid herbicides, pesticides and fertilizers through compatible and complementary species. Design in redundancy to handle crop failures. Use only native or adaptive species to reduce risk of disease or invasive competition.

A key goal was to design the right scale and the mix of agriculture to support the community. The design links the various systems of a domesticated forest as well as a wild forest into a cohesive agricultural web that uses all available resources and recycles all waste.

Various types of agricultural production were laid out in concentric patterns based on frequency of need and care. Day-to-day agriculture, water collection and waste recycling would be carried out close to home. Less intensive (weekly or monthly) agriculture and common areas would be further way, located in common community spaces. At the edge, the domesticated forest would transition into the wild forest.

Various analogies from nature suggested different forms that the community could take, including designs based on ferns, leaf structures or rivers and tributaries defining paths and nodes for meeting places. The preferred analogy for the community form was the leaf pattern with a central hub and 'spokes' radiating from the center. Parallel or concentric 'veins' provide redundancy and opportunities for growth through infill.

A consideration for the team was developing a model that could be applied to a variety of situations. We wanted the model to support a permanent, growing and working community, but also discussed applications for temporary communities that may need to be established for emergency relief efforts.

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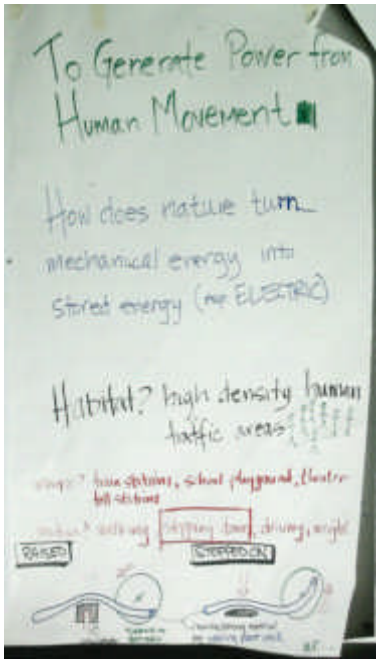
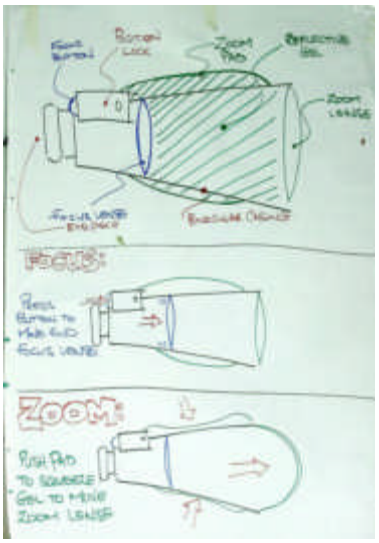
Zoom-Ocular

Coming into the course, I was interested in gaining a better understanding of how people use resources, the impact on the environment, and what I as an engineer could do to encourage sustainable solutions. One of the challenges that I often face is communicating complex engineering concepts to people from other disciplines.

Since returning from the workshop, I have found myself better able to bridge the 'discipline gap' through analogies to natural systems, helping other people to grasp and become enthusiastic about concepts and potential solutions.



During the workshop, our sub-team was challenged with a product design issue. We were captivated by a plant we observed in the jungle where hydraulic fluid flow caused its leaves to move. This led us to think about movement without motors as well as other forms of "free energy". Our design problem became defined as: "How can we use movement as an energy source in a retail product?" 'People power' has the potential for providing stable and consistent energy in many areas where people collect in high densities, such as airports, train stations and concerts. Could that energy be captured to power something directly or offset existing energy use? Such a system would have the potential for matching supply with demand without a requiring a storage system - as the volume of people drives up energy use, there are more people generating energy. The team had difficulty finding natural analogs that turned motion into electricity or light. We kept falling into the trap of copying another man-made device, material or process - this was exacerbated by a lack of biology information and resources.



On a nature walk to clear our heads, Chris spotted a bird in a tree - Michelle was unable to find the animal and focus on it with her binoculars fast enough before it flew away. We realized how difficult it is for naturalists to use binoculars, especially when trying to take notes and at the same time follow a target that either is only visible for a short time or constantly moving. What if the binoculars could zoom and focus automatically? This became our new product design problem. We wanted to use the knowledge of the biologists in our group to help us learn about sight. Jeannette and

Marc were invaluable as resources as we looked at how various creatures such as eagles and crabs see and focus. We mimicked a number of natural systems, such as the flexible lenses of eyes to provide autofocus and zooming without complex moving parts.

In retrospect, one of the hardest challenges we faced was identifying what problem we were trying to solve. Most of us were used to having a specific problem presented to us. Biomimicry challenges us to solve the 'right' problem. Janine presented a good example when she described the range of issues involved with air conditioning - are we dealing with inefficient fans and ducting, or our tendency to seal ourselves in an enclosed space? If we solve a specific problem, are we really making a difference in the larger system? Root cause analysis techniques can help to explore and verbalize a complete set of problems, but do not always lead us to an innovative restatement of the problem. Studying the range of solutions that nature uses to solve problems can extend our 'palette'.

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Organizational Dynamics

The team assembled for this problem came from diverse backgrounds: Environmental Activist; Architect and Teacher; Process Engineer and Corporate Designer. Our overall goal was an environmental future that is sustainable.

We understood early on in the project that it was essential to understand the problem clearly and simply, and to find a method by which we could biologize the question to identify clear analogies in nature. Each of us came from a place where we recognized that the structure and ingrained nature of our business or organization has both advantages and disadvantages. The challenge was creating an environment that would be able to accept the idea of sustainability in a new way - through the lens of Biomimicry. We are all driven to making the future brighter and choose to find a way within our systems to that end.

Problem Statement: "How do we develop an effective organization to promote a new idea in an established environment? How do ideas take root?"

We quickly adopted Costa Rica as a model of a mature ecosystem - within that model there are many examples that we could use to help us. We reviewed the ten commandments of mature ecosystems and constantly referred to them to illustrate and understand the challenges:

1. Use waste as a resource
2. Diversify and co-operate to fully use the habitat
3. Gather and use energy efficiently
4. Optimize rather than maximize
5. Use materials sparingly
6. Don't foul their nests
7. Don't draw down resources
8. Remain in balance with the biosphere
9. Run on information
10. Shop locally

We found many examples within the Costa Rica environment that speak to mature and supporting systems and that clearly demonstrate the "ten commandments". We chose two examples specifically to focus the discussion:

- **Pioneer species** take advantage of new openings, often pre-existing or dormant, create an environment suited for successor species
- **Ecosystem engineers** have characteristics of pioneer species but continue to enrich ecosystem and develop new physical and biological interactions over time (e.g. corals, mangrove)

We studied how materials flowed through the mangrove system and how surrounding areas benefit from the "work" the mangroves do. We could see how the mangrove maintains and sustains the environment. When we look at ourselves and our environment, we see ourselves taking first the role of the pioneer species as does the mangrove - ready for opportunity and optimal conditions, providing the catalyst for change, perhaps dormant - waiting for

Natural Analogies

Ecosystem engineers have characteristics of pioneer species but continue to enrich ecosystem and develop new physical and biological interactions over time (e.g. corals, mangrove)

opportunity. Pioneers. Over time as ideas start to take root, we need ecosystem engineers; we need to expand the usable area that allows for evolution over an extended time frame. As the mangroves hold on to the edge of the land, we hold on to the edge of ideals. We protect and anchor, gently but persistently holding steadfast.

In trying to "get ideas to take root" we must pioneer and then we must engineer for the environment to continue the path towards sustaining those ideas. The mangrove on the coast of Costa Rica is a perfect model.

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Members Corner

Martha Norbeck - The LEED (Leadership in Energy and Environmental Design) Green Building Rating System "... is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings." It is based on a points system comprising 69 questions organized in 5 categories. LEED workshops promote "...integrated, whole-building design practices". However, LEED does not provide specific guidance in how to solve specific design challenges that will result in both individually high point scores as well as an integrated solution. This challenge is for the design team to navigate.

The challenge I've undertaken is to work on integrating the methodology of Biomimicry with the LEED framework. By looking at how nature would solve the problems of architecture, I hope to develop an expanded LEED framework that will help architecture be more in tune with nature's principles. By building on the success of LEED in moving architecture towards greater sustainability, new ideas can be introduced into a receptive environment

A biomimetic approach to this challenge demands a multidisciplinary approach. I have rallied together a local group of two biologist, a mechanical engineer and three architects to ask what would nature do … to infiltrate water, to circulate air, to retain heat … and so on, using the LEED framework to guide our inquiry. We are seeking to take a take a systems view and focus on root problems. For example, rather than trying to reduce storm water runoff after the fact, a better approach

would reduce or eliminate runoff 'at the source'. Examples where this approach has already been tried include an integrated solution for reducing both runoff and the requirement for water inputs in the 44-acre South Waterfront redevelopment project in Portland, Oregon, and the "upstream" solution proposed for the Phipps Conservatory and Botanical Gardens in Pittsburgh.

Initially, I explored developing a distributed group - it quickly became clear that face-to-face meetings were essential. Awareness of body language is critical when discussing a topic in a truly multidisciplinary group, where each participant brings language and perspective differences. Being able to detect and react to any communications issues is essential for efficient problem solving. Face-to-face meetings seem to encourage greater commitment by establishing a routine. In addition, getting everyone in the same room can lead to freer interchange of ideas. Often, innovative solutions arise out of an 'off the cuff' comment.

Our goal is to prepare an initial biomimetic review of the LEED framework by this November, in time for the Green Build Conference sponsored by the US Green Building Council in Atlanta, Georgia.

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Weblog, Anyone?

Communication and collaboration are vital for Biomimicry to thrive - it thrives on multidisciplinary thinking. Unfortunately, communication is a double-edged sword - a lifeline and a fire hose. Although e-mail allows us to maintain a broad range of contacts, e-mail comes with a price. Aside from the challenge of keeping distribution lists current, the sheer volume of e-mail and the challenges of filing and retrieval can quickly become overwhelming.

Janine had pointed me to a Weblog system called TypePad which the database team had been using heavily. Weblogs are not a panacea, nor will they displace e-mail or more structured applications like the Biomimicry database. However, Weblogs can be very useful for communicating loosely structured information of interest to a group of people.

Key advantages include:

- Information is captured and stored in one place, for review at the reader's convenience (great if you are a 'newbie' and need to catch up)
- Information can be easily added and retrieved from any browser
- Information can be structured into categories by the submitter or administrator
- TypePad provides flexible controls for accessing information
- Users can create comments without needing to register on TypePad

Weblogs have some disadvantages:

- Need to be connected to the Internet to review material
- No search engine for private or semi-private Weblogs
- No 'subscribe' capability to provide notification of new material
- Authors need to register and be authorized to specific Weblogs - this allows them to create new entries (in contrast with comments to existing entries)

My plan is to create three types of Weblogs:

- Public - anyone can read and comment
- Semi-private - intended for the Biomimicry community, controlled through a common username/password
- Project - intended for a smaller group, with a unique username and password

One of the public Weblogs will be used to replace the Clippings resource currently maintained on ThinkCycle (see next article). Another public Weblog is the 'Book Club' at http://biomimicry.typepad.com/bookclub/ used for reviews of relevant books. For the moment, both Weblogs will prompt for a username and password - see the 'Clippings' article for details.

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Clippings

Clippings of general interest to the Biomimicry community are being posted at http://biomimicry.typepad.com/clippings/. This Weblog will eventually be available to the public, but for the moment, a username and password are required. When prompted, enter 'public' (without the quotes) for both.

You are welcome to comment on any entry through the **Comments** field in the entry trailer. TypePad asks for an e-mail address which will be publicly visible - I set up an e-mail account on Yahoo (Hotmail is also popular) specifically for this purpose, in case the e-mail gets SPAMed.

Resources

Recent BioInspire newsletters:

- July 2005 Newsletter: Sustainability in Design: Have we heard enough?
- April 2005 Newsletter: Art as Landscape/Landscape as Art

The Biomimicry Guild Newsletters are generally available through ThinkCycle at http://www.thinkcycle.org/tc-space/tspace?tspace_id=49344 - they will be migrated to TypePad at some point. You do not need to register with ThinkCycle to read the newsletter. A ThinkCycle Quickstart guide is available at: http://www.thinkcycle.org/tc-notes/show-note?tc_note_id=41609.

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