One Step Past Sustainable Design:
Biomimicry and Bio-Inspired Design
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Over the past decade or two, various aspects of environmental awareness have begun to play an important role in undergraduate education in areas as diverse as agriculture, engineering, sociology, and urban planning.

This is not surprising given the litany of environmental problems facing our culture:
• the growing number of toxic waste facilities
• the debilitating effects of air, water, and Earth pollution
• the fact that many landfills have reached their capacities
• the growing consumer demand, especially among the young, for responsibly produced and disposed-of products
• and with more and more products being made overseas, there is a sense that we have lost control over the human or environmental consequences of manufacturing.

One metric of this escalating concern is that even the industry behemoths are taking action. IBM, for example, now has a program that will recycle unneeded computer hardware from any manufacturer for a small fee. Nike, in turn, has its Reuse-A-Shoe program that takes discarded footwear and recycles the outsoles into a rubber that is used in manufacturing new treads. On a governmental level, the environmental crisis has reached such epic proportions in Taiwan that it has banned the distribution of plastic bags and disposable tableware in restaurants, convenience stores, and fast-food restaurants.

Concern for the environment has spilled over into design and ID programs and, quite appropriately, more and more ID educators have begun focusing on ecological issues. But more often than not, eco-minded design is treated as an adjunct subject or as a one-time course that will somehow “ecologize” the students who took it. The truth of the matter is that the practice of designing for reuse, disassembly, recycling, and remanufacturing—the cornerstone principals of sustainable design—are becoming an increasingly important factor in being an industrial designer. While all of the previous efforts at bringing a more Earth-friendly and ecologically-aware perspective to bear on industrial design have been well intentioned, it is important for ID educators to know that they can still go even further—and from our perspective, they must go further.

This conviction is based on a simple, yet powerful, realization that long before there was a specialization known as industrial design, nature was doing exactly what ID purports to do: solving complex problems via simple, iterative processes. One could look back hundreds, thousands, or even millions of years and consistently find that nature provided inspiration and models relevant to contemporary practice. In this sense, nature was, and is, our great teacher.
Although we are bound by industry as industrial designers, it is nature that provides a model for all of us to aspire to. This is probably the great paradox of our professional lives. To move forward, industrial design must look outside of industry and design, as we have known them. At the moment when it is all too apparent that our man-made powers have allowed us to transcend the natural world, it is exactly the natural world that we must return to. We must re-connect with nature, with those processes that have created the world.

By so integrally fitting form to function, nature uses only the energy it needs. Nature—through its various cycles and processes—utilizes everything and wastes nothing. Nature runs on free energy from the Sun, and does not use toxic, harmful, or nonrecyclable materials. Such retrograde materials are neither economical nor practical.

As committed educators, we need to be learning from nature and asking a series of big questions:

WHAT IF before we teach the conventions of sustainable design, design-for-disassembly, and cradle-to-cradle conceptualization, we taught our students how to look directly to nature for inspiration?

WHAT IF when you visited any upper-level ID studio—instead of seeing pin-ups of modified Hondas and Nissans straight out of the movie The Fast and the Furious or digital video game beauties, or various iconic designs from Newson, Rashid, Stark, or whomever—you saw an image of a big horn sheep hoof, a sample of a fish jaw, a collection of palm leaves, and the like?

WHAT IF—before we design anything—we asked our students to first examine nature and ask how it would solve a series of similar problems?

WHAT IF we taught a way of understanding nature that treated nature not as a resource from which materials are taken but instead as an integral model, measure, and mentor that gives us something for what we do and guides us in the process?

A final question:

WHAT IF you could make the link between biology and design in such a way that today’s students will not only understand that link but value it and want to apply it to their work?

Posing these questions also raises the question of how biology might be related to, or even integrated into, an ID curriculum. Our initial answer—and the trigger for taking this discussion to the next level and ultimately for writing this article—was the book Biomimicry by nature writer Janine Benyus. What Benyus proposes is that we designers need to learn to ask the right question—by always asking, for example, how nature would solve this particular problem?

Although other texts had covered parts of this material earlier, we found that from a design point-of-view, Biomimicry was the first book to crystallize the manner by which technology and ecology could come together in a new way. In point of fact, there had never been a biomimicry-
During the two-day workshop, students get hands-on experience studying objects from nature. It was not that easy to embrace nature, however. Perhaps it was our urban location, our adjacency to Silicon Valley, or the fact that so many top design firms were already our neighbors, but we actually came close to blowing it. From a curricular and student project perspective, we were privileging technology for the sake of technology, as it seemed to be for all intents and purposes the coin of the realm. Using nature as a role model was so simple and so overwhelmingly obvious that we almost missed it!

Because our students, like virtually all ID students, had no prior experience with college-level biology, we opted to jump-start the biomimicry class with a two-day workshop. The Biomimicry Foundation (www.biomimicry.org) started by Janine Benyus, offers workshops taught by Dr. Dayna Baumeister (an organismic, ecology, and marine biologist) that provide a brief introduction into the world of biologic sciences and short exercises into how nature and design can be integrated. Baumeister also uses her vast collection of bones, seeds, nuts, and fossils as inspiration for in-class examples expanding the students’ consciousness.

What we learned was that utilizing nature as a teaching tool is about more than just teaching nature appreciation. It is about succinctly making the connection between nature and design. It includes peeling away various assumptions, misperceptions, and mythologies concerning nature. As bizarre as it sounds, nature had to be recontextualized for the ID students so it could be better understood.

This is much more challenging than it sounds. The Italian design critic Andrea Branzi has said of our culture that “abnormality is the new normality,” and similarly, it might be said that what is man-made and artificial is seen today by many students as the natural state of things. So, very often what a student thinks of as “nature” or “natural” is the product of a large government or corporate effort, not a relatively unbothered plant, mammal, or animal.

For that reason, when we began the biomimicry class we proceeded judiciously. The first thing that we found was that students had to be given the appropriate tools if they were going to make nature-based design choices. Often, these “tools” took the form of more specific or even personal questions. How is it that nature adheres things without using toxic glues? How is it that brilliantly colored butterfly wings use no pigment? How is it that certain leaves repel water without using a hard plastic coating?
Once we got the students asking the right questions, we realized that nature offers countless such provocations. In turn, these provocations had the potential to suggest heretofore-unseen ways by which products might be conceived, developed, produced, and, ultimately, revolutionized.

Through learning to ask the right questions and doing deep research (multiple source information-gathering, internet, and trial-and-error first-hand experience), students can embody bio-inspired or “biomimetic” functions in their design practice. Students can learn what works, what is appropriate, and what lasts (and when it is appropriate to last) by using ecological standards to measure innovation. Teaching them to look to nature for inspiration will help prepare them for a lifetime of nature-based design choices.

Learning to ask the right questions, however, is only a first step in setting up an ID program that takes biology seriously enough to integrate it into its curriculum. It is such a new concept that there is no model to copy, no multimedia instruction manual or telegenic guru to call on, no magic help button to push or dedicated service organization to consult.

But there are pieces from the larger cultural landscape that are more than relevant to biomimicry and ID. We can seize on such material and make it our own. Scientists such as E. O. Wilson (writing in *Consilience*), for example, make powerful and compelling arguments for the centrality of biology in all human endeavors. Introducing such an eminent Harvard professor into the fold brings considerable credibility to our cause. Or similarly as businessman-turned-ecologist Paul Hawken references Biomimicry in his book *Natural Capitalism* and believes there is a more organic way to move manufactured products in a market economy.

More generally, some very important lessons were learned about how to implement the concept of bio-inspired design within an ID program. One of the most important lessons was to “pre-figure-out” exactly what type of information would be pertinent for ID students; there were no givens. The obvious information to share with them was anything that had a direct relationship to design, materials, and manufacturing. The less obvious—and almost more important realization—was that the list should also include information on motion, mobility, thermodynamics, “right-sizedness,” adhesion, self-healing, weight, strength, flexibility, tension, compression, “bendiness,” and genetics. Even more esoteric details such as those having to do with methods of hinging, attaching, and communicating gender and/or sexuality were also found to have great potential relevance.

Another important lesson had to do with coming to terms with the many specializations that biology offers. It quickly became clear that there were as many types of biologists as there are designers, and seldom do their knowledge and skills overlap. While we were looking for a holistic approach to biological subject matter, contemporary biologists practice their science within ever more specialized channels. A micro biologist compared to an entomologist is as different for us as an industrial designer is to a fashion designer.

Based on our experience, three general areas of biology are directly applicable to ID programs. The first is large-scale biology such as mammalogy or entomology. This area of biology is
optimal for teaching ID students lessons about adaptability and relationships to nature. Large-scale biology addresses questions such as why polar bears have hollow hair; why peacock feathers have such brilliant colors without using pigment; why geckos are able to walk up walls without using adhesives.

The second area of biology that we defined is small-scale biology, and this includes specializations such as microbiology and genetics. By studying this area, ID students can learn about processes such as osmosis, genetic selection, and energy use and consumption. Learning about small-scale biology can help ID students understand about structure, natural building blocks, and balance.

The third type of biology that we defined is ecosystems biology. Learning about large-scale ecosystems can teach ID students valuable lessons about two very important attributes: being resistant yet adaptive to change, and being independent yet interconnected to a larger system.

It is important to find the correct biologists to lecture on the three different areas to be covered. A biologist that is a part of a major Ph.D. program and has focused on their area of specialization will more likely be able to draw upon the connections needed for an ID program. Certain candidates could be weeded out immediately; molecular biology, for example, was too small-scale for our needs; first- and second-year grad students were simply not far enough along in their studies. Those that had already taught and had elementary design sensitivity were typically given extra consideration.

It should be noted that these three very different types of biology can rarely be taught by one individual. Biologists with the typical Ph.D. background required to teach a college-level biology class are generally ill equipped to teach the range of biology needed for a biomimicry class, much less be able to integrate this new concept into an ID program.

From our experience, this job of connecting the most interesting dots between biology and design falls to specifically motivated ID faculty. We found, for example, that one way to teach biomimicry was to use the ID instructor as an “idea facilitator” while simultaneously pulling in speakers to cover different areas of biology. To make this work, the instructor should not only be well versed in sustainable design practices but also have a passion for nature and the environment. As it turns out, this is a small demographic!

The other point is that prestigious awards and a brilliant design career are not the traits one needs to teach this class— a deep appreciation of nature and the ability to inspire bio-derived ideas are much more important.

It is also important to make sure that the visiting biologists understand what bio-inspired design is. Reading chapter four from Biomimicry called “How will we make things?” seemed to help get them on board philosophically. It was also important to explain (at length sometimes) what exactly industrial design is. The reason for this was simple. Spontaneously asking biologists for an explanation of what they think ID was brought up narratives of sewer systems, factories, and
In class and field research, and drawings kept in a notebook provide limitless nature-based concepts for design work. (Drawing by Adam Reineck.)

After the instructor is in place and the biologists are signed up, the class can then be separated into two sections: research and implementation. The research and biology lectures should happen at the beginning of the semester in order to give students a base from which to design. During this phase, students should keep concise records of their research via bio-information data (BID) sheets and drawings. On each BID sheet, they should record parameters such as: function, creature type, scientific name, lessons learned, applications, source, and date recorded. It is important that the information collected is shared with other members of the class in order to expand the knowledge of the entire group.

Currently there is no one “bio-function” library or Web site, so any information that is recorded should be kept in some sort of database for future use. We are looking at a Web-based home for this type of information. Students should also do sketches and drawings of items from nature that spark their interest. A connection seen on a crab claw can quickly become the hinge of a door or chassis. A feather can help a student learn about ways to connect things without using glue. The class should also experience nature first-hand. Actual observation and experience of nature is the best teacher. Wading through a marsh, going for a hike in the hills, or taking a trip to the local arboretum can provide a wealth of visual information to a student who is looking for inspiration. Drawing, writing, and collecting samples are all ways of recording and translating data for future use.

Each student who is enrolled in the class should have access to magnifying glasses for field research and an in-class microscope (40x) will help train them to

The bio-information data (BID) sheet archives data collected by students.

In-class and field research, and drawings kept in a notebook provide limitless nature-based concepts for design work. (Drawing by Adam Reineck.)
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Once all of their research is done, their data is input on their BID sheets, and their drawings are complete, it is time to assign design projects. There has always been a disconnect between the fields of biology and industrial design, although nature has been designing perfect objects for years. Through research, asking the right questions, and observation, students learn how to make the connection between biology and science in such a way that it will enable them to use the information they have collected in the future.

A few important points need to be made: first, that “biomimicry” and “bio-inspired” design is not inherently sustainable design. It can be, but using petroleum-based products to make “biomimetic” Velcro® is not exactly a sustainable product, and, second, a completely biomimetic product is almost impossible to design and even harder to produce. It is overwhelming for a student to be assigned a project that has to be entirely bio-inspired. Rather, one idea is to ask them to choose an existing product and redesign one small part of it using biology as their inspiration. Starting small can inspire big things to happen. After the skills of research are acquired, implementing the practice of including one “biomimetic” function into every project should become a standard practice for all ID students.

One of the notable problems in this first biomimicry course was that there are so few examples of successful biomimicry-derived designs that students were frustrated. This is both a problem of the student and of the teacher. One of the things that biomimicry laid bare was that many students already have stylistic or formalistic tendencies in mind when they engage with a design problem. All students were naturally (or unnaturally) falling back on traditional design styles and methods to solve problems. Some students had a problem focusing on the details of biomimetic design—often they bit off more than they could chew.
In addition to any design concepts, students were responsible for process and research book—a repository for all notes, drawings, research, and concepts collected over the course of the semester and organized in a logical and methodical manner. Included in this book was all of their work, along with any work from other students in the class. The concept of bio-inspired design is also about sharing the information learned. A process book with the research from ten students can provide ten times the amount of information needed years down the road.

In summary, teaching biosciences to designers in tandem with sustainable design is an important step for ID departments. Both biology and sustainability are equally important, but when taught together they become synergistic— their sum is greater than the effect of which each is individually capable.

ID can stick to traditional design-related subjects, and if it does, it will die the slow death of professional marginalization. Conversely, ID can position itself as more of a hub, a hub from which challenging spokes of growth radiate outward to provide new possibilities for the shaping of culture as well as business. Why overmanufacture, overcomplicate, and overdesign products when nature has the simplest solution to almost any design problem? In making the bio-approach a reality, ID students are the immediate beneficiaries, and further down the road, society will be the ultimate beneficiary.

I would like to thank Jay Baldwin for co-teaching this class, and department chair Steven Holt and associate chair Leslie Speer for having the intelligence and foresight to make this class a reality.