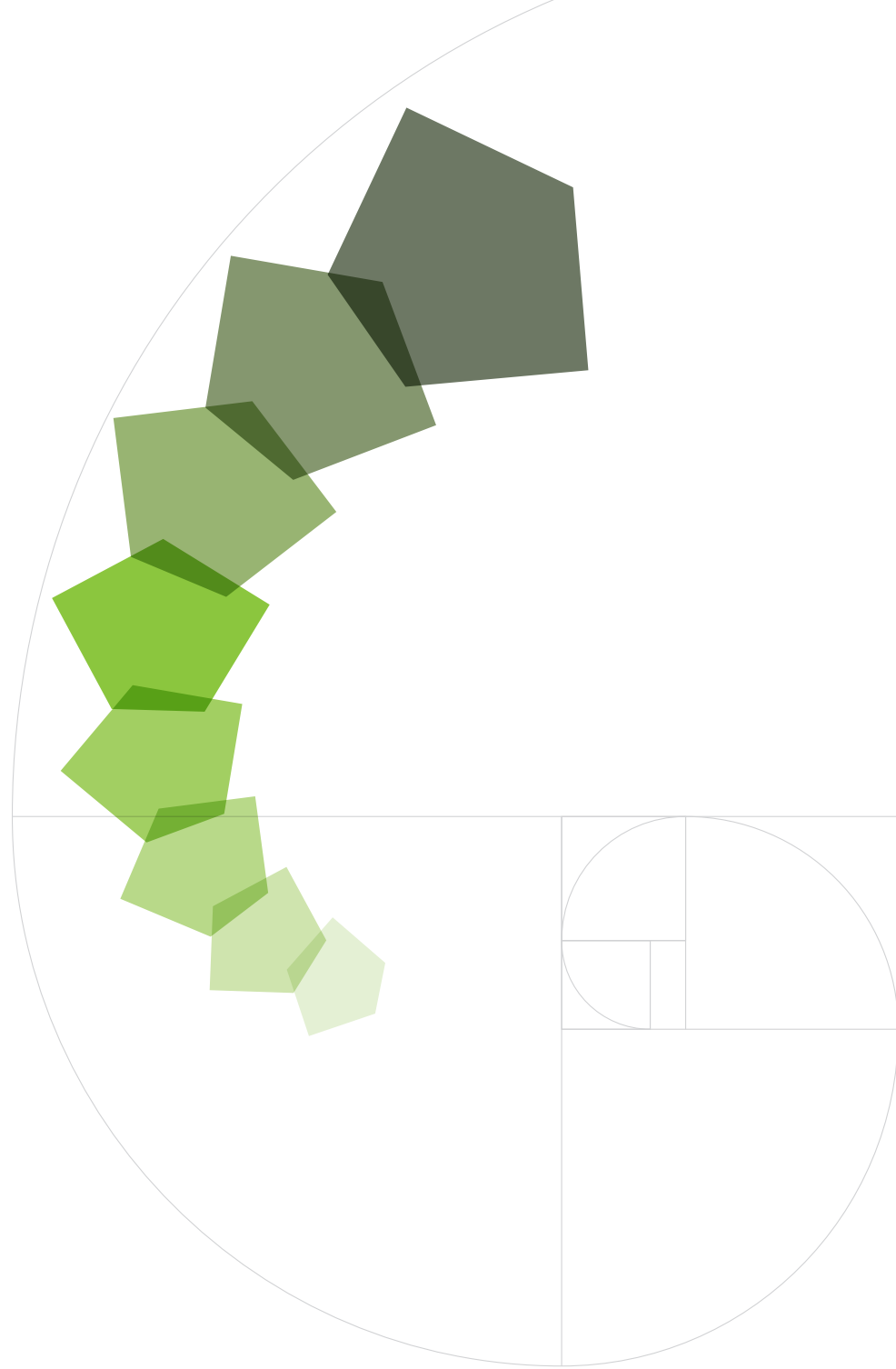


GRAPHIC DESIGN + BIOMIMICRY

Integrating Nature into Modern Design Practices

Margaret McKosky



GRAPHIC DESIGN + BIOMIMICRY

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This book is the final print application,
documenting all of the research done for this
thesis project prior to attaining a Masters of
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purposes only. Every effort has been made to
ensure that credits accurately comply with the
information supplied. I apologize for any
inaccuracies that may have occurred and will
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for encouraging me to share this project

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for supplying me with knowledge and opportunities

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whose patience, love and support sustain all efforts,
but were especially tested on this one

Bi•o•mim•ic•ry

(noun)
the design and production of materials,
structures, and systems that are modeled
after biological entities and processes ¹

¹ New Oxford American
Dictionary 3rd ed © 2010

from the Greek bios, life, mimesis, imitation



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BEGINNING

Situation Analysis

¹ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

² For a detailed discussion of Janine Benyus's thoughts on Biomimicry, visit TED Talks at www.ted.com

³ For more information on Biomimicry, visit <http://www.biomimicryinstitute.org/>

Biomimicry is a relatively new discipline that studies nature’s finest ideas and then attempts to imitate these designs and processes to solve human problems. It is simply innovation inspired by nature,¹ or as Janine Benyus, one of the leading researchers of biomimicry today, would say it is the 'conscious emulation of life’s genius on the path to a sustainable future.'² The core concept is that nature over 3.8 billion years has already used its imaginative prowess to solve many of the problems that society is currently grappling with today. Nature has found what works, what is appropriate, and most importantly, what lasts here on Earth.

That said, life found within nature is the secret to survival and the area to which we should be seeking the answers to our problems. In order to emulate nature’s genius and reflect it onto our existing world, we must view nature in an entirely different manner. As the Biomimicry Guild and Institute believes, we need to look at nature as model, measure, and mentor.³ The Guild and its collaborators have developed a specific practical design tool called the Biomimicry Design Spiral based on the Golden Ratio for using nature as model which helps to further explain this notion.

Sustainability is also an important contributing factor and recurring theme throughout the process of biomimicry. Essentially, it is the goal when using biomimicry within the realm of design to create hybrids of timeless, sustainable pieces. This is where nature as measure is introduced. In learning from the principal factors that work within nature, we can then embed them into our own sustainable design solutions.

Lastly, in viewing nature as mentor, it is a summation of how one should view nature with a modern outlook. It is vital to note that biomimicry introduces an era based not on what we can extract from nature and all that it encompasses but on what we can potentially take away and learn from nature. When the world of biomimicry and graphic design mesh, a beautiful landscape of opportunities will emerge.

The challenge at hand is to take these time-tested ideals nature has produced over the years and echo them to produce effective design solutions. By constituting nature as model, measure and as mentor, a new way of evaluating and creating effective design solutions will emerge out of the abyss of the already creative design process to an entirely new, innovative process full of potential.

Biomimicry can be used as a tool to create more sustainable design solutions because it is a design methodology itself, occurring in the ideation phase of the graphic design process rather than the execution phase. For instance, a designer would start with a human design problem, identifying the root of challenge and then review how nature would go about solving this problem. *What would nature do?* It is crucial to look at the natural form, process, and system already found within nature so one can mimic its process within the ideation stage.

There will be a cross-fertilization of ideas along the way, but in the end, the juggernaut of biomimicry will shed a new light onto the field of graphic design. Thus creating an avant-garde mode of thinking which in turn will lead to an alternate, innovative and revolutionary graphic design process.



OBJECTIVE

Scope of Project

The idea for this thesis project came to me after many scrutinizing hours of brainstorming and asking myself: What is it that I want to say after the culmination of my six years of design study and education? I knew I wanted to create something that had the ability to change designers perceptions, ultimately challenging the current paradigms. I also knew I wanted to demonstrate how design cannot only be good, but *do* good. I am always amazed and inspired by how elegantly ecosystems thrive, foster cooperative relationships, and adapt to ever changing conditions and wonder, how can graphic design find its niche within the current thriving ecosystem today? So, I chose to integrate two very distinct disciplines, graphic design and biomimicry, not only because I am passionate about both areas, but I feel that in order to design for the greater good, it is necessary to look to nature in order to do so. This is essentially what biomimicry strives to do. It looks to organisms and their natural ecosystems to draw inspiration and emulate their designs in the best way possible. Nature’s design principles have developed over 3.8 billion years and have produced the most ecological, timeless, and constructive design solutions so not only is it logical to look to nature to solve our problems, it is crucial for our survival if we wish to generate any positive changes for our future.

As with any creative process, it requires practice for it to become second nature. This new graphic design + biomimicry process I am proposing is meant to challenge the current paradigms and create the potential for change. In doing this, I am aware that not all designers will agree with this new process or the ideas presented in this book and may think that some of them are a little too metaphorical, per say.

¹ Christopher C.H. Simmons,
Just Design

Yet this is the beauty of biomimicry; it allows designers to echo actual strategies and principles found within nature, creating an entirely new design that one may never have thought of before.

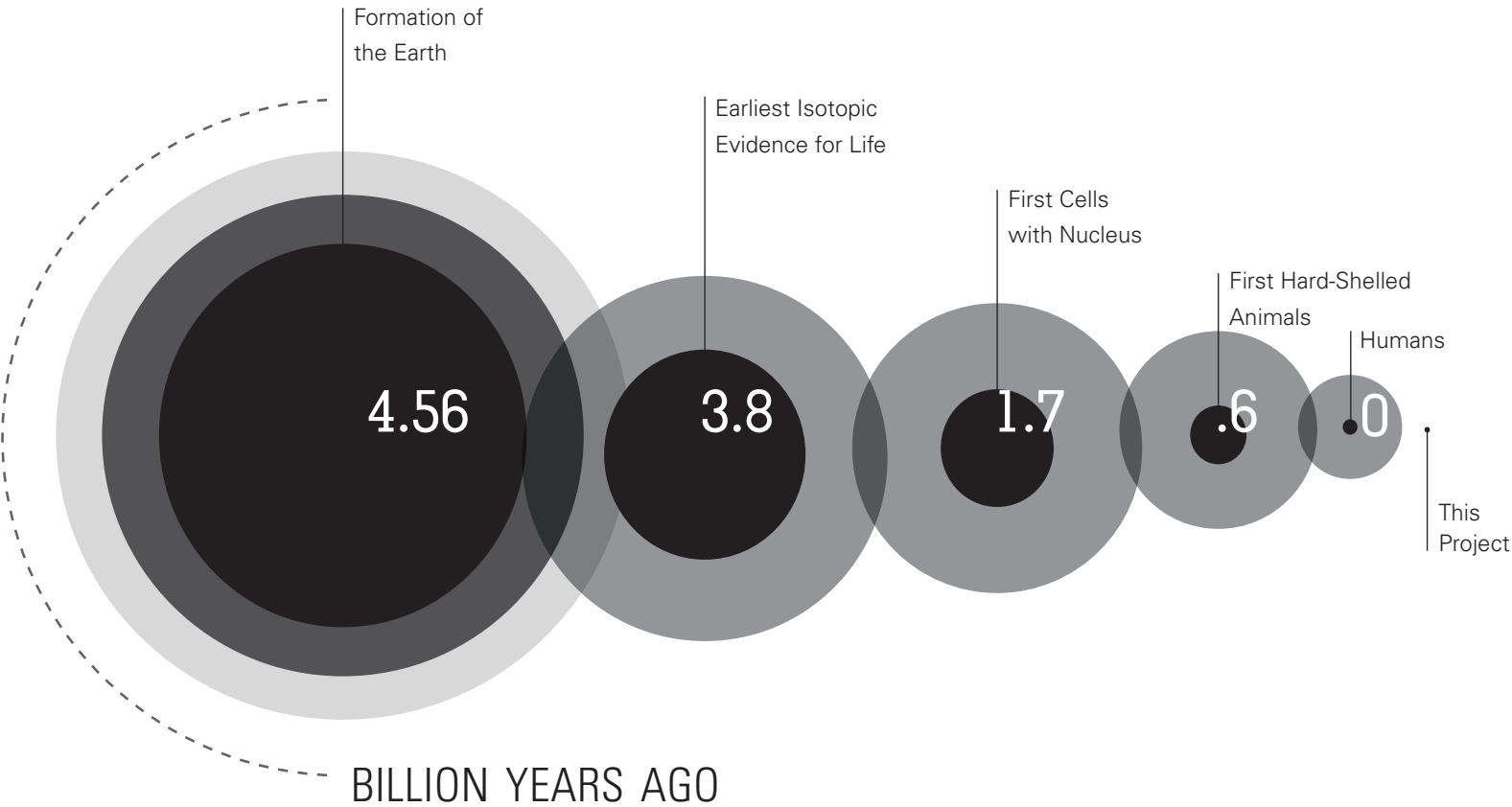
Naturally, as designers we are problem solvers. We apply our creative talents to finding new and appropriately innovative solutions to common questions. These questions may include how to best articulate a brand, how to connect with a particular audience or how to communicate across cultural boundaries.¹ Now more than ever there are bigger problems than just brands and connecting to consumers. There are fundamental needs such as equality, education, food, water, community, and sustainability. As graphic designers we should be creating work that has a purpose. There is a lot of beautiful graphic design work being done everyday, but what is it for?

This book is also about trying to find work that has meaning and that will ultimately make a positive impact. I understand there is very necessary work designers must do every day that may not have the most meaning to them or influenced by nature’s designs. I am not saying that biomimetic graphic design and *good* design should be held above that of design which seeks to do anything less than help save the world. Good design in this context is defined as being made using life’s principles, eco-friendly materials, optimizes all materials rather maximizing, involves cross-disciplinary teamwork, etc. Any inference that the work presented within this thesis and final print application or *good* graphic design work that applies life’s principles or uses eco-friendly materials is more noble or worthy is not my intention. The purpose of this thesis and this book is to raise awareness, propose a new mindset and celebrate this newfound biomimetic graphic design process. Whether for the greater good or greater profit, it is all still why we do what we do.

² Jessica Jones,
Design Momentum Blog
<http://designmomentum.wordpress.com>

That said, it is very easy for graphic designers to get caught up in only pleasing clients, focusing on articulating their message in order to communicate with their audience. Sometimes designers become too focused on one aspect and forget about how their piece will fit in with the rest of the ‘ecosystem’ and the other functions a piece should serve. Since we work in a cultural business, we have the potential to change our client’s perceptions of their consumption patterns as well as our own, helping to reduce our overall carbon footprint. This perhaps is the greatest leverage point for biomimetic-graphic design. We must learn to be a part of a multi-disciplinary brainstorming team in order to identify the best leverage points for the most change.² After engaging in this book, designers will know how to do this, using the biomimetic principles to help guide them. I am hoping designers will try to incorporate this new design process and take away a new mode of thinking; applying this process not just into their work, but into all aspects of their lives allowing them to be more creative overall.

In this book I have tried embracing what others have done before me, exhibiting what they have found and proposing my own ideas and solutions. This is the accumulation of all my research and should act as a catalog of my ideas and findings. Hopefully after looking and reading through this reference guidebook, designers will be encouraged by this different way of thinking, forcing themselves to innovate, experiment, push and adapt their designs further than ever before. The objective at hand is to create good design that also has the potential to *do* good, for the world and everything that encompasses it. We are on the cusp of great change: will designers curl up at the thought of this or embrace this new mode of thinking to help shape a positive future for design, people, and most importantly, our planet?



Life's design brief is simple.
Learn how to create and make things while
creating conditions conducive to life on earth.

JANINE BENYUS

¹ Janine Benyus,
Biomimicry in Action
July 2009 TED Talks
www.ted.com

1 **DEFINING**

ANALYZING

OBSERVING

SELECTING

IMPLEMENTING

EVALUATING

What Would Nature Do?

Nature is the ultimate designer, developing processes that over time continue to produce effective and timeless design solutions. Imagine designing Spring, or any season for that matter. How would you orchestrate it? How would you delegate? Imagine the timing, the precision, the coordination without the protocols. There is a lot of showing off, love in the air, grand openings...the organisms have all of their priorities in order.¹ Each one with its own process and system knows what to do, when to do it, and how to do it. Designing Spring? A piece of cake...for nature that is.



AWARENESS

Innovators at the Institute

One person in particular has been devoting her life and career to biomimicry, studying its methodologies and principles over a long period of time. Her name is Janine Benyus, the pioneer responsible for the breakthroughs in the field of biomimicry. Her work has been a catalyst for many innovations that emulate nature’s processes and has been used in the research, design and manufacturing of many products. She is currently the president of the Biomimicry Institute as well as a biologist at the design table, innovation consultant, and author of six books including *Biomimicry: Innovation Inspired by Nature*. Benyus began her career in 1996 co-founding the Helena, Montana based Biomimicry Guild with Dr. Dayna Baumeister. Then, in 2005 she co-founded The Biomimicry Institute with Bryony Schwan and in 2007 Chris Allen joined the team to help launch the ground-breaking database *AskNature.org*, the world's first digital library of nature's solutions containing nature’s answers to many complex design challenges.¹ Her in-house biologists at the Guild have provided consulting services in design, manufacturing and management to hundreds of corporations, universities, architectural firms and NPO’s, including GE, HOK, Boeing, Herman Miller, Interface, Kohler, Kraft, Nike, IDEO and Procter & Gamble. She has also helped to introduce tens of thousands of people to the exciting field of biomimicry through international presentations such as TED talks and GreenBuild. In 2008, Benyus received "Time Magazine’s" Heroes of the Environment award and in 2011, she was a recipient of a prestigious Heinz award in the sum of \$100,000. Teresa Heinz, chairman of the Heinz Family Foundation, described her as “showing us that the solutions to many of our biggest challenges are right there in front of us in nature’s vast reservoir of ideas.”² While biomimicry has existed as a tool in fields such as chemistry for years, as a methodology it had not crossed over into other disciplines until Benyus took the first stride in doing so.

¹ Biomimicry 3.8
<http://biomimicry.net/>

² The 17th Heinz Awards
<http://www.heinzawards.net>

³ The Biomimicry Institute
<http://www.biomimicryinstitute.org/>

⁴ Alissa Walker,
What Would you Ask Nature?
<http://www.fastcompany.com/>

Janine Benyus is also the visionary co-founder of Biomimicry 3.8, formed by integrating The Biomimicry Institute and The Biomimicry Guild in 2010. Biomimicry 3.8 brings together scientists, engineers, architects, designers and other innovators to create sustainable technologies and business practices. The organization achieves this through a global network of experts providing education, professional training, research, analysis and consultation to individuals, institutions and corporations. It is vital to note that the Institute is a not-for-profit organization that promotes the study and imitation of nature’s remarkably efficient designs to use those models to create sustainable technologies.³ Today, Biomimicry 3.8 also offers short-term workshops and two-year certificate program in biomimicry for professionals.

Biomimicry 3.8 focuses on three areas:

- 1 Developing educational programs for students, professionals and the general public
- 2 Working to create public policies that use biomimicry as a solution to sustainability challenges
- 3 Encouraging companies that are profiting from biomimicry to provide financial support for biodiversity

Thanks to the efforts and work of the biologists, designers and innovators at Biomimicry 3.8, more and more designers are realizing a simple truth when trying to find responsible, ecological solutions: If we’re trying to do it, chances are, nature already did it better.⁴



INDUSTRY STANDARDS

Modern Design Practices

Biomimicry is quickly becoming a cornerstone for sustainable design practices and the Institute and Guild have worked with companies to help them achieve ground-breaking designs, products, and materials all inspired by nature. Designers from all over the globe, designing everything from toothbrushes to trains and airplanes, are working to integrate the principles of biomimicry and sustainability into all aspects of design. This includes education, to practice and production, and ultimately consumption. What is happening here within the creative industry is that new standards are being set, ultimately challenging the current paradigms that exist in modern design. Designers are starting to catalyze this new system and way of thinking by collectively building their intelligence around important issues such as climate change and social justice, and tackling those issues and challenges with optimism and creativity. This is the satisfaction a designer is able to attain when modeling his/her work using the biomimetic + graphic design principles. They come up with ideas that they may have never thought of before that nature brilliantly thought of and designed millions of years ago. These ideas can suddenly turn into the most remarkable, yet simplest ideas. In taking these older ideals devised by nature and applying them within a new process, creates designs that are timeless, innovative, and revolutionary.

However, it is not as simple as it may seem at first. Many designers who want to incorporate biomimicry into their work and design process may not know where to start. Some famous biomimetic solutions have gotten passed around the mainstream press— including examples like self-cleaning surfaces modeled on lotus flowers, or the sticky repositionable tape inspired by gecko feet or wind turbines inspired by whale fins— but biomimicry is not as easy as using nature as a crib sheet.

¹ Alissa Walker,
What Would you Ask Nature?
<http://www.fastcompany.com>

² Alissa Walker,
What Would you Ask Nature?

³ The Biomimicry Guild
http://www.biomimicryguild.com/guild_badt.html

⁴ Alissa Walker,
What Would you Ask Nature?

“One of the big realizations that designers have when they play with biomimicry is that it’s not a tool, it’s a mindset shift,” says Dayna Baumeister, who co-founded the Biomimicry Guild with Benyus in 1996. “Because of that— because of the fundamentally different way of thinking— it’s hard.” ¹ "Even for biologists, it requires a shift in thinking," says Baumeister, "from learning about nature to learning from nature, including how each of those processes fit within a larger ecosystem." "In a way, it’s examining nature’s solutions for survival, but through a design lens," says Chris Allen, project manager for *AskNature.org*. “You can look at brilliant engineering and strategies living for over thousands of years.”²

Because biomimicry experts believe that designers play an integral role in making sustainable, nature-inspired decisions in a project, they believe that is where their influence is best appropriated. A biologist working in biomimetic design is known as a Biologist at the Design Table, or, in a biomimetic-appropriate acronym: a BaDT.³ BaDTs create a bridge to biological understanding. Biomimetic work is deeply rooted in solid science, but it is a BaDT’s job to translate that science so designers can immediately make the link to the design challenge. This way biologists are able to be part of the design team from brainstorm to prototype, continually adding biological insight to the process. There are currently very few BaDT’s— only about 75 worldwide— since they have to undergo extensive training.⁴ But eventually, the goal is to have a BaDT in every design firm who can help guide the designers towards smarter, more nature-influenced solutions.

It is crucial that designers embrace this new set of biomimetic standards and understand that the cross-disciplinary dialogue is a vital and necessary component within the design process in order to emulate designs found within nature. Designers need to continue to collaborate with other professionals. Not strictly biologists, however, but also scientists, engineers, architects...The more areas of expertise in the room, the greater the range of possibilities in coming up with timeless, sustainable design solutions. This new process also gives designers and professionals the competitive edge within the industry. People are extremely invested and interested in the field of biomimicry because it has produced some of the most successful and innovative designs seen today. When products are designed with the biomimetic industry standards, not only are they aesthetically pleasing, they are also modern, functional, sustainable, cost-effective and life-friendly designs.

As previously mentioned, the Guild has worked with world-class companies to help them achieve this shift in thinking, from a long-standing relationship with the flooring and finishes company Interface, to a team currently on-site at an architectural project in India. In India, they are creating buildings that not only are made from natural materials, they actually behave like natural organisms.⁵ Using biomimetic principles, we have also been able to learn more about our own species. The Guild is starting conversations with global companies that manufacture goods such as cosmetics— in which case their own in-house scientists have been studying hair and skin for decades. Currently there is a great deal of excitement bridging algorithms found in nature and information technology or ‘generative design,’ where we are able to extrapolate data from the way that nature goes through its iterative design process in evolution.

⁵ Alissa Walker, What Would you Ask Nature?

⁶ Wendy Jedlicka, Sustainable Graphic Design

It is important to note that to adopt this biomimetic mindset shift, one is also agreeing to adopt responsible design practices. Practicing responsible design is more than just using life-friendly materials and sustainable technologies. It is about raising awareness, getting involved and staying active. It is crucial to let others know about the exciting field of biomimicry and the current biomimetic standards. The easiest way to do this is to adopt these new standards within one’s own process and to one’s designs. It is also about being active within one’s local community and getting involved with any programs or organizations that are striving to create a positive environmental impact. This is the only way to challenge the current paradigms and spread the word about biomimetic design.

Another way one can practice responsible design is to always be conscious of one’s surroundings within one’s local community and the larger ecosystem we reside in. Use materials that are found locally rather than ‘outsourcing’ to the internet. Always ask: *What Would Nature Do?* How would nature solve this design problem? If one looks hard enough, what will be found is that nature is where all of the answers to our design problems lie. Good, responsible design practice involves multiple viewpoints and is adaptive to new information.⁶

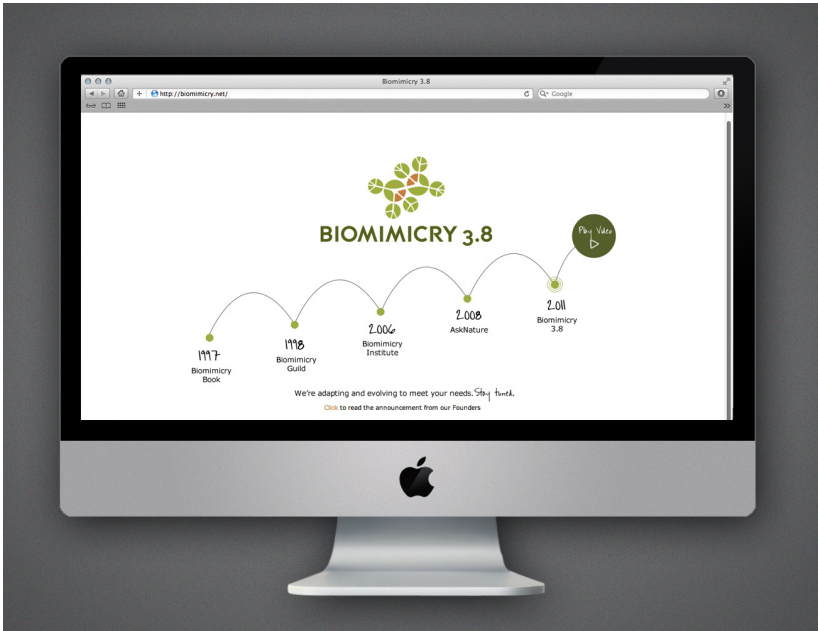
RESOURCES

You have read, defined and now know the basis of what it means to integrate biomimicry + design, and hopefully you are inspired and want to learn more! The following resources will provide a good starting point.

BIOMIMICRY 3.8

The Biomimicry 3.8 website provides the basics about biomimicry + design and gives you information on various learning opportunities and workshops, as well as biomimicry-related activities going on at academic institutions around the world. Exploring the Case Studies will give you a feel for how biomimicry plays out by emulating nature's forms, processes, and systems. Make sure you sign up for the Biomimicry Newsletter so you can stay up-to-date with all of the exciting biomimicry inspired designs happening today!

<http://biomimicry.net/>



TED

TED is a nonprofit organization devoted to Ideas Worth Spreading. It began in 1984, starting out as a conference bringing together people from three worlds: Design, Entertainment, and Technology. Since then its scope has become ever broader.

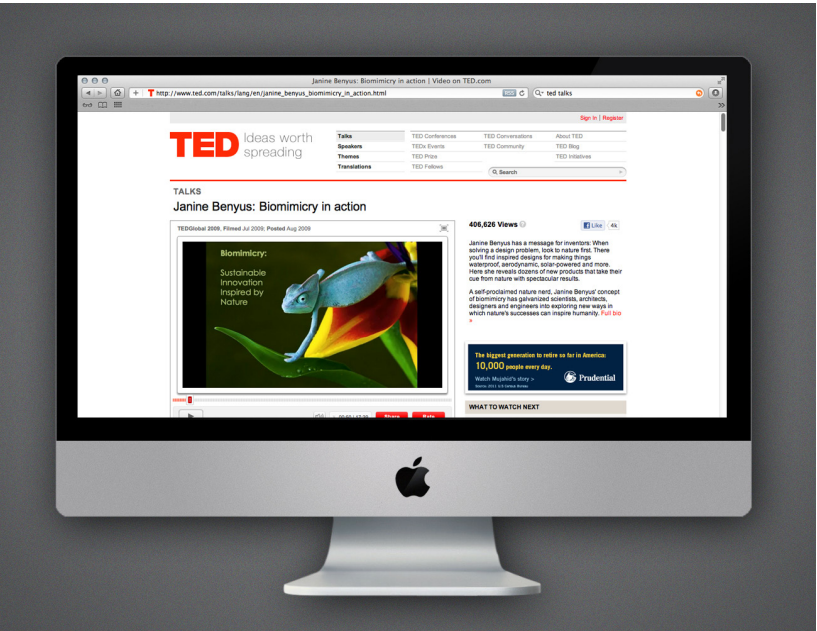
Janine Benyus has been appearing on TED since 2005 as a speaker in their TED Talks. She shares her brilliant insight and developments on biomimicry, providing heartening examples of ways in which nature can influencing our current designs and technologies.

<http://www.ted.com/>

There are other inspirational videos to see as well on various biomimicry topics and design.

CHECK OUT

Benyus: Biomimicry in Action
Benyus Shares Nature's Designs



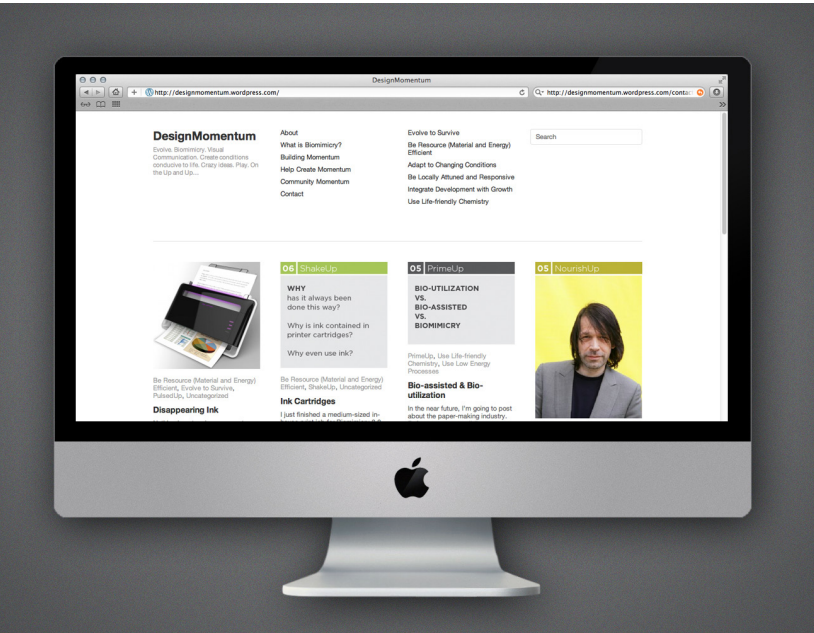
DESIGNMOMENTUM

http://designmomentum.wordpress.com/

This blog was created by one of the designers and visual communicators at Biomimicry 3.8, Jessica Jones. Its purpose is to promote the biomimetic way of thinking. She has carefully organized her thoughts and research over the years into several sections revolving around the word 'momentum.'

DesignMomentum is meant to help build and create momentum within the small niche of graphic design and biomimicry. This is all in hopes of raising awareness of life's principles and to foster and bring forth a new, alternative design process, promoting positive change within the design community.

It provides excellent case studies to best illustrate her points, helping others to understand how designing from nature and using life's principles can create some of the best design solutions.



BOOK LIST

What you should read next...

Biomimicry: Innovation Inspired by Nature

Janine Benyus

Biologic: Designing with Nature to Protect the Environment

David Wann

Cats’ Paws and Catapults: Mechanical World of Nature and People

Steven Vogel

Cradle to Cradle: Remaking the Way We Make Things

William McDonough & Michael Braungart

Deep Design: Pathways to a Livable Future

David Wann

Design Lessons from Nature

Benjamin De Brie Taylor

Nature’s Operating Instructions: The True Biotechnologies

Kenny Ausubel

On Growth and Form

D’Arcy Wentworth Thompson

Sustainable Graphic Design

Wendy Jedlicka

Structural Biomaterials

Julian Vincent

The Way Nature Works

Robin Rees



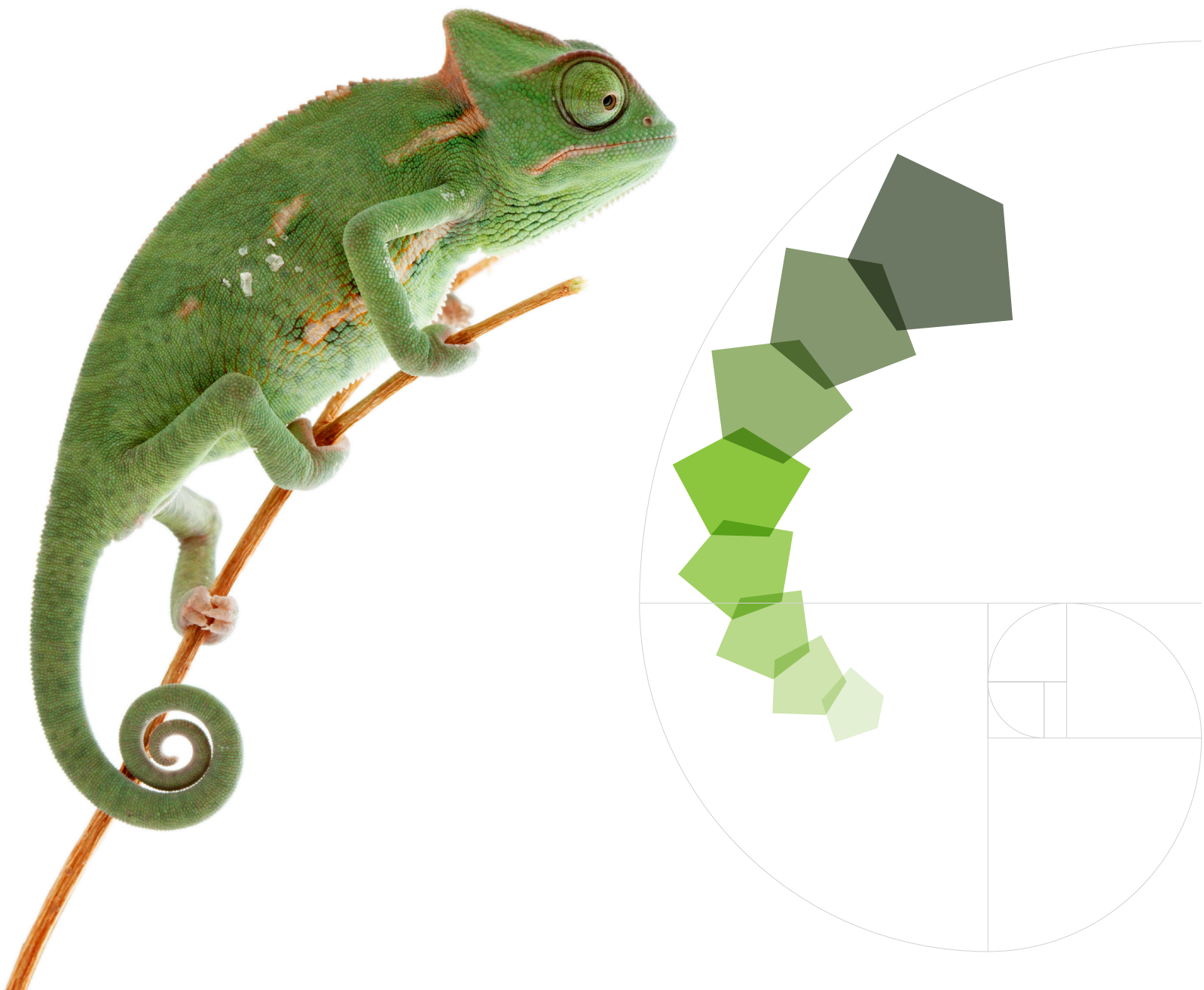
Biomimicry focuses on finding structures, processes, strategies and mechanisms that nature has been using for a billion years, that we can emulate and use in modern design.

TERRY TEMPEST WILLIAMS

- 2
- DEFINING
- ANALYZING**
- OBSERVING
- SELECTING
- IMPLEMENTING
- EVALUATING

How Would Nature Begin?

In asking this question, it is integral to first consider how nature communicates. How would nature begin its design process, delegating specific tasks to each organism to confirm the design gets completed? Not just completed, but completed in the *right* way and in the most *sustainable way* conducive to life. These are fairly simple questions with many elegant insights and all the answers lie within nature and the organisms that keep our ecosystem revolving. This second step in the process after defining the problem or issue is *analyzing*. Nature has been innovating for 3.8 billions years and has already solved many of the design challenges we are having today. So in order to understand nature's process, we must perform a comprehensive analysis.



METHODOLOGY

Biomimicry + Graphic Design

To better fit in with the rest of nature, humans (graphic designers) can more correctly identify the problem, filter through nature’s solutions, think in a systematic perspective, and design for human user experience.¹ Exploring how to integrate biomimicry + graphic design is one of the many avenues to a more sustainable world and is arguably one of the most powerful leverage points to creating conditions conducive to life. Before exploring how biomimicry can help graphic designers create more sustainable solutions, it is essential to revisit the methodology of each discipline so one can understand how both can work together.

METHODOLOGY OF BIOMIMICRY

Biomimicry is the conscious emulation of nature’s genius— innovation inspired by nature.² In a society accustomed to dominating or 'improving' nature, this respectful imitation is a radically new approach; a revolution really. Unlike the Industrial Revolution, the Biomimicry Revolution introduces an era based not on what we can extract from nature, but on what we can learn from her.³ Biomimicry's methodology is analyzing nature and mimicking it's functions and deep patterns to create life-friendly solutions. It is not the aesthetic mimicry of something without function, a point especially important for aspiring biomimetic graphic designers.⁴ For example, biomimicry is not converting your canvas size to be the same proportion as the golden ratio because this ratio in nature serves as a streamlining function for growth and water flow. Biomimicry is not die-cutting your piece into the shape of a nautilus shell or simply using color palettes found in nature. This is a common misconception among designers who are just learning and being introduced to biomimetic graphic design.

¹ Jessica Jones, DesignMomentum Blog <http://designmomentum.wordpress.com/>

² Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

³ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

⁴ Jessica Jones, DesignMomentum Blog

⁵ Kenny Ausubel, *Nature's Operating Instructions*

The golden ratio or color palettes found within in nature are a good place to start and use for inspiration, but then one must take these and adapt them in a way that nature would within its ecosystem, providing not only form but function as well. This is where the methodologies of graphic design and biomimicry intertwine, using some of the basic elements and principles found within design and nature.

Mimicking form, function or shape is just the first step of becoming better adapted. Learning from nature really means remembering nature’s processes and ecosystem strategies, that everything is created and done in context for a particular reason in conditions that are conducive to life.⁵ Until we understand this and create designs and products that mimic living systems and processes rather than a machine, we have not reached the full potential of biomimicry.

Since biomimicry has emerged as an ever-evolving discipline, it has proven that life and nature has a lot to teach within the realm of technology and design. The methodology and biomimetic approach is taking the design principles and genius of the natural world and looking at their solutions in order to solve current design challenges. It is simply going out into nature to see her solution to the problem. When it comes to people’s understanding of biomimicry, there is not a lack of information, but a lack of integration. What is necessary today in order for designers to create and practice with greater holistic awareness and sustainability is an integration and meshing of both methodologies. Nature has had over 3.8 billion years to research and develop well-adapted solutions including 10 – 30 million different species. Organisms have already solved the problems that designers, engineers, and architects have spent years working on. The answers are everywhere and in order for designers, engineers and architects to see these answers, what is needed is a change in the lens with which they are seeing and observing.

The significant aspect to note is that these solutions are solved in context; that context is the earth...the same context with which we are trying to solve design problems. The question designers should ask themselves is how does life make things without using harsh chemicals and manufacturing products via factory lines? How does life make ‘things’ disappear into systems? The answer is simple. Life creates conditions conducive to life. It builds soil, it cleans air and water, mixes the cocktail of gases that every organism needs to live all while doing it in the middle of great foreplay, and meeting every species’ needs. Organisms have figured out a way to do the amazing things they do while taking care of the place that is going to take care of their offspring.

A prime example of an organism that has been doing this is the hummingbird, an organism about the size of a human thumb. It flies up to 35 miles an hour (faster than people can get around most cities in a cab) and migrates about 2,000 miles a year. Those journeying down the eastern flyway reach the tip of the Gulf of Mexico and then pause for a period of time, fueling up on 1,000 blossoms a day. Finally, they burst across 600 miles of open water without stopping, on a whopping 2.1 grams of fuel. And that is not jet fuel: it is nectar. But here is what is amazing. In the process of fueling up, the hummingbird manages to pollinate its energy source, ensuring that there will be nectar next year— for itself, for its offspring, or for completely unrelated species of nectar feeders. Imagine doing that at a gas station. And of course, when it dies, its body decays and nurtures the roots not only of flowers, but of mushrooms, grasses, trees, and shrubs. There is nothing special about it; no government regulations are behind it. It is simply part of the system that keeps us alive.

⁶ Kenny Ausubel,
*Nature's Operating
Instructions*

Much of the research in biomimicry is years and years from fruition, yet it is a path; an approach. It requires designers to visit the outdoors and keep asking: How does nature teach? How does nature learn? How does nature heal? How does nature communicate? As humans, we may learn faster but nature has been at it longer. So quieting human cleverness and getting over this fact is the first step in biomimicry. Next, comes listening, then trying to echo what we hear. This emulating is hard and humbling work. When what we learn improves how we live, we grow grateful and that leads to the last step in the path: stewardship and care-taking, a practical thanksgiving for what we have learned.⁶

METHODOLOGY OF GRAPHIC DESIGN

Designers are visual communicators. In order to create, we have to go through a process. It requires being innovative, meticulous and resourceful, taking each project from initial concepts to a final design solution. In the simplest of terms, we take a design problem, generate ideas through sketching and brainstorming and implement the best idea to produce a successful design solution.

However, design is not entirely about juxtaposing images and text to produce content in relation to the context of the problem. It has the power to do more. There is a common misconception among the general public (non-designers) who may not be aware of the methodology of graphic design or what graphic designers do. Some may think that all graphic designers do is make and print *stuff* that will only end up in landfills as waste. This is such a negative outlook to have because then every designer would ask themselves, “Why am I designing this if it is just going to end up in the trash?”

Today we have the power to change that negative outlook and turn it into something positive. Take that piece of ‘trash’ and see how it can better fit within the larger ecosystem, creating conditions conducive to life and benefiting society rather than hindering it from reducing our carbon footprint. In order to explore graphic design as a strategic process to assist societal problems, one needs to think very differently in terms of multidisciplinary design teams and working directly within his/her local communities and cultural organizations. While this new process affects the graphic design methodology by instituting the use of natural processes, principles and influences to promote change within critical social issues; the role of good communication design is just as relevant. Herein lies an incredible opportunity for graphic designers to illustrate his/her social relevance, influence, and creativity by using biomimicry within one’s process.

After assessing both methodologies, it is critical we look at both side-by-side to see the commonalities, as well as the drastic differences. There are really two schools of design and thought to analyze and evaluate; the graphic design (technologic, human) side versus the biomimicry (biologic, nature) side. Looking at both natural and human technologies forces us to think about each in novel ways. For the graphic designer, a perceptive look at nature’s technology can do just that: It can provide the wide-angle view that reveals possibilities that would otherwise escape consideration. Also, this view of nature as technology has provided an unusual perspective on the natural world around us.⁷ Recognizing that nature deals with the same variables as do human designers leads us to comparing both products and processes. The two sides and their technologies share the same planet, they experience the same pressures, temperatures, gravitational accelerations, winds, and water currents so why not examine them in this manner. It comes down to...what can we learn in doing this?

⁷ Steven Vogel, *Cats’ Paws and Catapults: Mechanical World of Nature and People*

Inspired by—
thoughts of Steven Vogel, *Cats’ Paws and Catapults* & David Wann, *Biologic*.

GRAPHIC DESIGN

(Technologic, Humans)

Designers create something that does not exist

Human technology springs from what is variously called invention, discovery, development or planning

Graphic Designers can borrow devices from other designers and history

Humans have a great affinity for flatness

Designers love the mechanical and geometrical shapes, using right corners in abundance

Designers, and people, like to create by taking something and manipulating it into something else, taking away and adding, then disposing what was not used

Overly productive, using brute force resulting in excess, waste and pollution

What can our technologies provide?

VS

BIOMIMICRY

(Biologic, Nature)

Biologists study something that exists: nature, in all its splendor

Nature's process is that mechanism Darwin uncovered, evolution by natural selection

Nature must follow an inherited plan set by genetic code and evolution

Nature makes very few flat surfaces

Nature, on the other hand, uses very few right angles, if any, using curves and gradual gradients

Nature, however, would cut something into pieces and reassemble them from the ground up, building by lacing them together; optimizing the material with little to no waste to dispose of

Highly protective, using finesse resulting in conserving and nurturing

What do we *need*? How can nature provide?



MEME

Nature's Design Principles,
Indirect Method

¹ New Oxford American Dictionary 3rd ed © 2010

Meme, by definition, means an element of a culture or system of behavior that may be considered to be passed from one individual to another by non-genetic means, esp. imitation.¹ Biomimetic graphic design in itself is somewhat of a 'meme.' It is a design process and style that has been spread and passed along throughout today's culture and society via various channels and networks of communication. To be active within this biomimetic graphic design unit, designers must transmit their ideas through the form of cultural analogues that can respond and adapt to the ever-changing times and conditions. To better understand this, it is critical that designers learn, memorize and apply the following design lessons and life principles nature has so graciously given us.

This is the indirect method of beginning to apply the two methodologies; biomimicry + graphic design, by using abstracted principles of how nature designs. These principles of nature are present in all organisms at multiple scales and levels that fuel and inspire deep sustainability. They are the criteria for thriving and surviving on earth, while creating conditions conducive to life and can be applied to all stages of the graphic design or visual communication process. Each principle challenges humans to think systemically within a broader context than just thinking of a single organism. The following principles are a distilled combination of those life's principles enumerated by the Biomimicry Institute and Janine Benyus, Michael Braungart and William McDonough (*Cradle to Cradle*), Steven Vogel (*Cats' Paws and Catapults*), D'Arcy Thompson (*On Growth and Form*), Julian Vincent (*Structural Biomaterials*), Jeremy Faludi (sustainable design strategist and researcher, articles for *Worldchanging.com*) and my own limited experience of knowledge and research on the subject of biomimetic design.

14 Design Principles of Nature

- 1 Self-Assembly from the Ground Up
- 2 Waste = Food
- 3 Evolve Solutions, Don't Plan Them
- 4 Adapt to Changing Conditions, Adjust to the Here & Now
- 5 Respect Diversity, Diversify to Fill Every Niche
- 6 Self Appropriate Technologies
- 7 Be Resourceful
- 8 Optimize Rather than Maximize
- 9 Use Life-Friendly Chemistry
- 10 Organize Fractally
- 11 The Entire System is Greater than the Sum of Its Parts
- 12 Leveraging Interdependence, Feedback Loops
- 13 Foster Cooperative Relationships
- 14 Don't Foul your Nest

1 Self-Assembly from the Ground Up

The most important things happen at the smallest scales. For instance, on the material level, instead of taking a block of something that you cut away, take small parts that combine to form the whole. This reduces waste and increases design flexibility.



Jessica Jones, the graphic designer and visual communicator at the Institute put it very eloquently when I spoke with her via phone conference...

If you gave nature a piece of construction paper and asked it to make a leaf, it would cut it into pieces and then reassemble the pieces from the bottom up...but humans would take it, take scissors and cut the shape out of it.
(story original told by Janine Benyus)

On the system level, design networks, not pyramids. The nodes should create the overall structure by their interrelations, because this method is more robust, scalable, and flexible than a system with an over-arching plan that must have certain nodes in certain places.¹

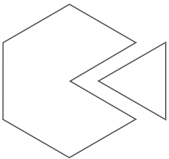
The second aspect of this, 'the most important things happen at the smallest scales,' refers to the fact that the most complex, detail-filled aspects of biological designs are done at the smallest scales: at first, a bone looks like a stick; look closer, and you see its porous structure; look closer, and you see the material is a composite; look closer, and you find that composite has three or four deeper levels of substructure; look closely enough and you get to the DNA, which is complex enough to contain the blueprints for the whole bone and the rest of the animal.² Sometimes designing for the most minute detail can cause the whole over-arching design to be determined.

¹ Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

² Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

2 Waste = Food

This perhaps is one of the most important principles, using waste as a resource rather than disposing of it off in a landfill. Michael Braungart and William McDonough, authors of *Cradle to Cradle: Remaking the Way We Make Things*, have the best developed model for this, with their concept of biological nutrients and technical nutrients. Strictly speaking, as Janine Benyus points out, modern industry does act like ecosystems in nature— a ‘type 1’ system, the weeds that colonize an area after a disturbance. However, type 1 ecosystems are not sustainable, they eventually give way to type 2 and type 3 ecosystems, which have increasingly greater interdependencies, with increasingly closed-loop resource flows, such as rainforests.³ Creating type 3 industrial ecosystems has historically been tricky to implement because the pace at which products change, and markets change, are often rapid— industry has so far always been in a ‘disturbed’ state as new technologies change the rules of the game; natural ecosystems, by contrast, transform from type 1 to type 3 over thousands of generations of the species involved.⁴ How can we help push industry forward? The adoption of open standards can help here, so that components are more interchangeable between products and industries— this helps manufacturing systems develop long-term stability standards needed for building webs of interdependencies. Likewise less dependence on new cutting-edge technologies makes it easier to fit into existing webs. An important corollary of ‘Waste = Food’ that Janine Benyus makes is “don’t draw down resources, live off the interest.”⁵ It is a financial analogy, describing how mature (type 3) ecosystems do not need new income since they are living off of the interest from the great biological wealth they have acquired over time. Mining or harvesting too much of the world’s existing natural resources is like spending the capital you are trying to live off the interest of, and it will catch up to you.



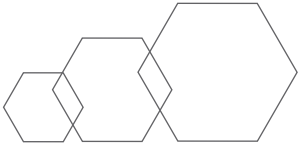
³ Janine Benyus, Biomimicry: Innovation Inspired by Nature

⁴ Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

⁵ Janine Benyus, Biomimicry: Innovation Inspired by Nature

3 Evolve Solutions, Don't Plan Them

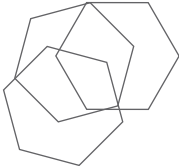
This means to design without authorship and to let go with dignity. Many designers may not be fond of this third principle because it strives away from the traditional process of artists and *their* work. It is now about creating the right context for possibilities to emerge. As Jeremy Fauldi explains, the most direct example is genetic algorithms. Their huge success has proven the usefulness of this technique and principle. This in turn falls back onto the idea of design being iterative and continuous. That is making multiple prototypes, user-testing them to find the favorites and most successful, then mixing and matching elements from each to create another generation of prototypes which are in turn user-tested, ad infinitum.⁶ Incidentally, this is the method advocated by IDEO, one of the most successful design firms in the world.



⁶ Jeremy Faludi, *Biomimicry for Green Design Worldchanging: Change Your Thinking*

4 Adapt to Changing Conditions, Adjust to the Here & Now

This fourth principle directly applies to Darwinian evolution; true evolution in the sense that a design is never done, it is only a means of adaptation. As Janine Benyus says, effective adaptation requires organisms to be information-driven, with local expertise.⁷ It also requires timely expertise. Species that range across dramatically different habitats must adjust themselves to the new locales, and those that stay in the same place but whose habitat changes (say, from summer to winter) adjust as well; i.e. hibernation. In the product world this means customizing for different users and different circumstances, to extend the product life-cycle. In more advanced implementations, it means the products adjust themselves without need for user intervention.



⁷ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

⁸ David Wann, *Deep Design: Pathways to a Liveable Future*

⁹ Jeremy Faludi, *Biomimicry for Green Design Worldchanging: Change Your Thinking*

5 Respect Diversity, Diversify to Fill Every Niche

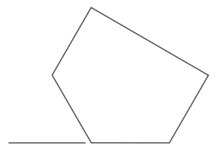
Respect diversity as a tenet can be very broad, covering a global level but it can also be scaled down to be compared to the industry, market and product level. In regard to the global level, it is showing a wide scope of respect and honor to all cultural, ethnic, racial, sexual, religious and spiritual diversity of beings within the context of individual responsibility.⁸ To respect and maintain biodiversity or a diversity of living species for a chance to change and evolve through natural selection is key.



On the market level, traditional industry already adapts to this. However, on the product level, mass-customization does a similar thing. The biomimetic-design lesson here ties in with the second principle, 'Waste = Food.' It is to find untapped niches where waste is being created, where it could instead be used as a resource. Smart manufacturers close their own resource loops; smart entrepreneurs close other peoples' loops.⁹ Solving a problem using a single solution, with no diversity, may make it vulnerable to outside influences.

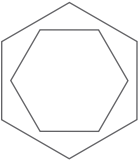
6 Self Appropriate Technologies

This sixth principle is fairly simple: use the right tools for the right job. This ensures time and cost efficiency and it also prevents the act of re-design. This also ties in with the first and second principles, 'Self-Assembly from the Ground Up' and 'Waste = Food.' In self appropriating technologies, it confirms less waste which means less cleanup; less conflict; fewer costs.



7 Be Resourceful

Being resourceful may seem like another fairly broad principle to apply, but generally speaking it encompasses gathering and minimizing efficient energy and materials needed to produce a successful design solution. In regard to *gathering* efficient energy and materials, you do not necessarily need to study nature to get the importance of this, but it has a cornucopia of strategies you may have never tried. For example, ants have been studied to improve shipping schedule algorithms, plant leaves have been studied for solar energy absorption, mollusks have been studied for building shells out of seawater without even moving.¹⁰ The list goes on....



As for *minimizing* energy and materials to be resourceful, nature has an abundance of great examples. Plants and animals always try to use material and energy efficiently, because for them energy and material costs are the only costs. Successfully minimizing mass and energy use requires thorough optimization to the problem at hand, so organism structures are highly information-driven. On the other hand, industry's costs are primarily financial, so it usually finds it easier to simply use more material or energy than spend the extra time researching how to use it well. Yet, minimalist designs can be the most successful and cost-effective in the industry.¹¹

¹⁰ Jeremy Faludi, *Biomimicry for Green Design* Worldchanging: Change Your Thinking

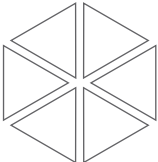
¹¹ Jeremy Faludi, *Biomimicry for Green Design* Worldchanging: Change Your Thinking

¹² Jessica Jones, *Biomimicry: Sustainable Graphic Design* by Wendy Jedlicka

¹³ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

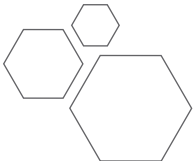
8 Optimize Rather than Maximize

Optimize rather than maximize as a concept of creating designs that are multifunctional, always fitting form to function. This is general systems-thinking advice, but Benyus points out its ubiquitousness in biology. Creatures always have to balance multiple cost/benefit dimensions, there are no single-minded goals like being bigger or faster. A quick rule of thumb here is perform as many functions with as few components as possible, tying in the seventh principle of 'Be Resourceful' when it comes to selecting and gathering your materials. It is a good exercise to explicitly lay out all the factors you are trying to balance and organize. For instance, graphic designers can maximize the number of pages in a piece or the size of the paper which will probably allow for a more easily achieved eye-catching composition and attract more viewers; yet the functional design of the piece may be compromised if it is now too large for users.¹² Always remember to optimize all variables.



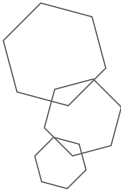
9 Use Life-Friendly Chemistry

This principle, from both Benyus and Vogel, is fairly self-explanatory. Benyus describes the way we manufacture products is by 'heat, beat, treat.' She claims it has become the de-facto slogan of our industrial age; it is the way we synthesize just about everything. Nature, on the other hand, cannot afford to follow this strategy. Life cannot put its factory on the edge of town; it has to live where it works. As a result, nature's first trick of the trade is that nature manufactures its materials under life-friendly conditions— in water, at room temperature, without harsh chemicals or high pressures.¹³



10 Organize Fractally

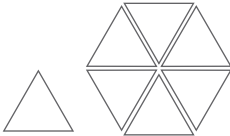
This tenth principle, organize fractally, looks at self-similarity in the way of planning for several different scales at once. Fibonacci spirals do not occur all over the place in nature because they are pretty, they occur all over because they are an algorithm that allows perpetual growth to any size without having to readjust or plan ahead. Fractal structures do not have to be as 'smart' as other structures which require different planning for different scales. This ties in with design having form and multi-functionality.



11 The Entire System is Greater than the Sum of Its Parts

People tend to design one function at a time, creating separate elements for each task and then creating the product by assembling all the pieces. There are many advantages to this, but in these products the whole will only be the sum of its parts. One of the hallmarks of complex systems is 'emergent phenomena,' the fact that the whole is greater than the sum of its parts.¹⁴

An example of 'emergent phenomena' is looking at how an individual bee has a small brain and simple behavior, but a swarm of bees is a sophisticated organism all its own. Emergent phenomena are hard, if not impossible to predict, and in the built world mostly happen by accident. However, designing with it in mind can not only help avoid unintended consequences, but can open new opportunities—the democratizing force of the internet being a prime example.¹⁵ The key to this principle is designing lots of little, simple things that together can do sophisticated things; this can be a biomimetic design tool because it lets you build robust systems without infrastructure, build smaller and smarter stuff without super-high technology.



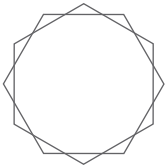
¹⁴ Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

¹⁵ Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

¹⁶ David Wann, Deep Design: Pathways to a Liveable Future

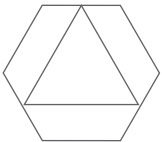
12 Leveraging Interdependence, Feedback Loops

Inter-relatedness and leveraging interdependence systems relies on learning the lessons from the ecosystems that we are a part of. This principle basically outlines what the biomimetic + graphic design process tries to do. We need to learn how to work with the cycles of the sun, water, wind, and geothermal energy rather than depleting finite resources that can be more effectively used elsewhere.¹⁶ In doing this, we can help to create a continuous locally attuned feedback loop that allows for the renewing of resources, recycling of all materials, and self-organizing of systems; all of which allows the fostering of cooperative relationships—the thirteenth design principle of nature. Natural ecosystems are able to sense boundaries and changing conditions, whereas humans are not so well adapted in doing. It is crucial that we look to these systems and feedback loops in order to solve our design problems in the most economical fashion.



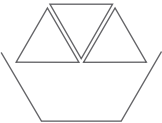
13 Foster Cooperative Relationships

Just as in a natural ecosystem where one organism lives off another, providing the nourishment it needs to survive; graphic designers use print manufacturers to ensure their jobs and designs survive. It is using the same cycle of give and you shall receive. Both need each other in order to survive within the creative design industry. So, fostering cooperative relationships means we need to encourage creative thinking and cultivate relationships with other designers and manufacturers in the industry in order to keep this continuous cycle going. For instance, a stock photography company allows a printing shop to give its clients (graphic designers) access to its database account. A client can use any photograph as long as it uses the printing shop for printing. In turn, the stock photography company receives more revenue/exposure, the printer receives more services, and the client receives complementary or reduced-cost photos.¹⁷ It is actively seeking out a relationship to ensure positive business practices to get things done, benefiting all in the process.



14 Don't Foul your Nest

This last principle is another genius idea of Benyus. 'Don't foul your nest' is saying that in the grand scheme of things, do not use or design with harmful materials or effluents. Do you really want to live in a home that gives off harmful gases such as formaldehyde or dioxins? This sounds simple and obvious, but if engineers, architects, and other builders actually started following this principle alone, it would cause a revolution.¹⁸ This also refers to design in the sense that you should not 'foul your design' with any unnecessary components.



¹⁷ Jessica Jones, Biomimicry, *Sustainable Graphic Design* by Wendy Jedlicka

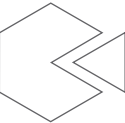
¹⁸ Jeremy Faludi, Biomimicry for Green Design *Worldchanging: Change Your Thinking*

14 Design Principles of Nature

1 Self-Assembly from the Ground Up



2 Waste = Food



3 Evolve Solutions, Don't Plan Them



4 Adapt to Changing Conditions



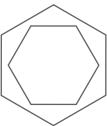
5 Respect Diversity



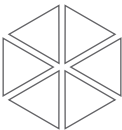
6 Self-Appropriate Technologies



7 Be Resourceful



8 Optimize Rather than Maximize



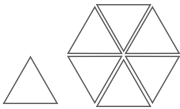
9 Use Life-Friendly Chemistry



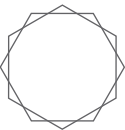
10 Organize Fractally



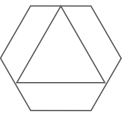
11 The System > the Sum of Its Parts



12 Leveraging Interdependence



13 Foster Cooperative Relationships



14 Don't Foul your Nest





GRAPHIC DESIGN

Universal Principles & Elements

When looking at graphic design and contemporary trends, it is apparent complexity is increasing because of the expansion of new technologies. With technological and societal advances, emphasis is now placed on new applications including tablets, mobile devices, e-books, etc. The major focus is no longer on pure form generation which has been the case in the past, but instead, is placed on other elements such as device, user needs and involvement, affordability, resources, and environmental concerns. Although, this is not to say that form generation is not an important aspect to the field anymore because it is still one of the most important facet of graphic design; there are just other elements that designers today need to be aware of that designers in the past did not. For instance, web designers now need to be aware of responsive design, ensuring that their design not only looks good on a desktop, but on smaller scales such as tablets and smartphones.

Although these digital technologies afford greater freedom and flexibility, they can often cut short the creative window for concept development and creative thinking. People, places, thoughts and things become familiar through repeated exposure.¹ There is much temptation to turn directly to the computer and type in a Google search. This often results in images or ideas that are tired and trite. It is important that designers do not get trapped in the technological pitfall of leaving little to no imagination or bypassing the creative brainstorming processes of sketching and ideation.

Although every designer has his/her own creative process, all are based on the foundation of knowing the basic elements and principles of design including balance, rhythm, proportion, dominance, unity, form, shape...However, there are other principles that designers should remind themselves of such as

¹ Ellen Lupton & Jennifer Cole Phillips, *Graphic Design The New Basics*

Hick’s Law, Ockham’s Razor, etc. Graphic design is a discipline directed toward the development and distribution of information in a visually creative way. Instead of the all of the focus being directed towards distributing the information in the best manner to please clients; the larger focus should now be how can one experiment with this visual language, while integrating nature in a way that still conveys a message. This is in hopes of ultimately producing a form of universal design. Good design has often been labeled as being based on a type of logic, grid system and structure with a resolved plan. For instance, a well designed logo is usually a progression of ideas and forms, sketching and re-sketching until the final design is achieved. What needs to be stressed is that there is a level of importance in sketching and process that unfortunately in modern design practices with the acceleration of technology, is getting lost due to immediate satisfaction with internet access. It is important to reassess and look back to the basic principles found within nature in order to move forward. In doing this, it will ensure that the work designers produce in the future will continue to be successful, timeless, and sustainable.

14 Universal Design Principles & Elements

The following 14 Universal Design Principles and Elements are an extension of Nature's 14 Design Principles to show how both relate and correspond to each other within the biomimetic design process.¹

Each design principle falls into 1 of the 3 categories:

Form

Systems

Thinking

Category

Form

- 1 Form Follows Function
- 2 Mimicry
- 3 Self-Similarity
- 4 Symmetry
- 5 Uniform Connectedness

Systems

- 6 Convergence
- 7 Feedback Loop
- 8 Hick's Law
- 9 Hierarchy of Needs
- 10 Life Cycle

Thinking

- 11 Depth of Processing
- 12 Five Hat Racks
- 13 Mental Model
- 14 Ockham's Razor

¹ For more detailed synopsis of the principles, reference *Universal Principles of Design* by William Lidwell, Kritina Holden and Jill Butler (descriptions seen here are excerpts from this book)

Form The following design principles pertain to the form and physical shape of a(n) object(s)

1 Form Follows Function

Beauty in design results from purity of function. The form follows function axiom is interpreted in one of two ways— as a description of beauty or a prescription for beauty. The descriptive interpretation is that beauty results from purity of function and the absence of ornamentation. The prescriptive interpretation is that aesthetic considerations in design should be secondary to functional considerations. When making design decisions, focus on the relative importance of all aspects of the design— form and function— in light of the success criteria.

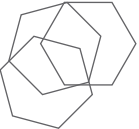
7
Be Resourceful



2 Mimicry

The act of copying properties of familiar objects, organisms, or environments in order to realize specific benefits afforded by those properties. In nature, mimicry refers to the copying of certain properties to hide from or deter other organisms. For instance, the viceroy butterfly mimics the less tasty monarch butterfly to detect predators. In design, mimicry refers to copying properties of familiar objects, organisms or environments in order to improve the usability, likability, or functionality of an object. There are three basic kinds of mimicry in design: surface, behavioral, and functional. Mimicry is perhaps the oldest and most efficient method for achieving major advances in design. Consider surface mimicry to improve usability, ensuring that the perception of the design corresponds to how it functions or is to be used.

4
Adapt to Changing Conditions



3 Self-Similarity

A property in which a form is made up of parts similar to the whole or to one another. Many forms in nature exhibit self-similarity and as a result it is commonly held to be an intrinsically aesthetic property. Natural forms tend to exhibit this at many different levels of scale, whereas human-created forms generally do not. This naturally occurring self-similarity is usually the result of a basic algorithm process called *recursion*. Recursion occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input. The ubiquity of self-similarity in nature hints at an underlying order and algorithm, and suggests ways to enhance the aesthetic composition of human-created forms and perhaps their structural composition as well. Consider self-similarity in all aspects of design: story boarding, visual displays and structural compositions. The reuse of a single, basic form to create many levels of metaforms mimics nature's tendency towards parsimony and redundancy and can create interesting organizations at multiple levels of scale.

10
Organize Fractally



4 Symmetry

A property of visual equivalence among elements in a form. Symmetry has long been associated with beauty, and is a property found in virtually all forms in nature. It can be seen in the human body as well as plants and animals. Symmetry in natural forms is largely a function of the influence of gravity and the kind of averaging of form that occurs from merging genetic information in reproduction. There are three basic aspects of symmetry: reflection, rotation, and translation. Use symmetry in design to convey balance, harmony, and stability.

9
Use Life-Friendly Chemistry



5 Uniform Connectedness

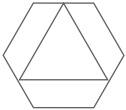
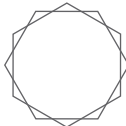
Elements that are connected by uniform visual properties, such as color, are perceived to be more related than elements that are not connected. This is one of the *Gestalt principles of perception*, asserting that elements connected to one another by uniform visual properties are perceived as a single group or chunk and are interpreted as being more related than elements that are not connected. There are two basic strategies for applying uniform connectedness in design: common regions and connecting lines. Common regions are formed when edges come together and bound a visual area, grouping the elements within the region. Connecting lines are formed when an explicit line joins elements, grouping the connected elements. Use uniform connectedness to visually connect or group elements in a design. Employ common regions to group text elements and clusters of control elements, and connecting lines to group individual elements and imply sequence.

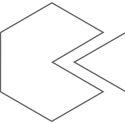

11
The System > the Sum of Its Parts




Systems

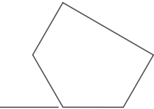
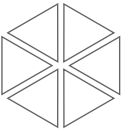
The following design principles pertain to entire systems of design and how they function over time

PRINCIPLE	DESCRIPTION	RELATION
6 Convergence	<p>A process in which similar characteristics evolve independently in multiple systems. Natural or human-made systems that best approximate optimal strategies afforded by the environment tend to be successful, while systems exhibiting lesser approximations tend to become extinct. This process results in the convergence of form and function over time. The degree of convergence in an environment indicates its stability and receptivity to different kinds of innovation. Consider the level of stability and convergence in an environment prior to design. Stable environments with convergent system designs are receptive to minor innovations and refinements but resist radical departures from established designs. Unstable environments with no convergent system designs are receptive to major innovations and experimentation, but offer little guidance as to which designs may or may not be successful.</p>	<div>13</div> <div>Foster Cooperative Relationships</div> 
7 Feedback Loop	<p>A relationship between variables in a system where the consequences of an event feed back into the system as input, modifying the event in the future. Every action creates an equal and opposite reaction. When reactions loop back to affect themselves, a feedback loop is created. All real-world systems are composed of many such interacting feedback loops— animals, machines, businesses, and ecosystems. There are two types of feedback loops: positive and negative. Positive feedback amplifies system output, resulting in growth or decline. Negative feed-back dampens output, stabilizing the system around an equilibrium point.</p>	<div>12</div> <div>Leveraging Interdependence</div> 

PRINCIPLE	DESCRIPTION	RELATION
8 Hick's Law	<p>The time it takes to make a decision increases as the number of alternatives increase. Hick's Law states that the time required to make a decision is a function of the number of available options. It can be used to estimate how long it will take for people to make a decision when presented with multiple choices and has implications for the design of any system or process. Keep Hick's Law in mind when designing systems that involve decisions based on a set of options to increase efficiency, resulting in less waste.</p>	<div>2</div> <div>Waste = Food</div> 
9 Hierarchy of Needs	<p>In order for a design to be successful, it must meet people's basic needs before it can attempt to satisfy higher-level needs. This principle specifies that a design must serve the low-level needs (it must function) before the higher-level needs (creativity) can be addressed. Good design follows the hierarchy of needs principle, whereas poor designs may attempt to meet needs from the various levels without building on the lower level of hierarchy first which results in a waste of resources. There are five key levels of needs: functionality, reliability, usability, proficiency, and creativity. Functionality needs have to do with meeting the most basic design requirements. Reliability needs have to do with establishing stable and consistent performance. Usability needs have to do with how easy and forgiving a design is to use. Proficiency needs have to do with empowering people to do better things than they could previously. Creativity is the level in the hierarchy where all needs have been satisfied and people begin interacting with the design in innovative ways.</p>	<div>1</div> <div>Self-Assembly from the Ground Up</div> 

PRINCIPLE	DESCRIPTION	RELATION
10 Life Cycle	All products progress sequentially through four stages of existence: introduction, growth, maturity and decline. This roughly corresponds with the natural life cycle of birth, adolescence, adulthood and death. For example, a new tablet is envisioned and developed; its popularity grows; after a while its sales plateau; and then finally, the sales decline. Understanding the implications of each of these stages allows designers to prepare for the unique and evolving requirements of a product over its lifetime. The introduction stage is the official birth of the product. The growth stage is the most challenging stage where most products fail. The maturity stage is the peak of the product life cycle. Finally, the decline stage is the end of the life cycle. Always consider the life cycle of a product when planning and preparing for the future. Always work closely with early adopters to refine and tune products in the introduction phase. During the growth phase, focus on scaling product supply and performance. Also focus on customer satisfaction through performance enhancements and improved support during the maturity phase. Then, once you hit the decline phase, focus on facilitating the transition to next generation products.	<div>3</div> <div></div> <div>Evolve Solutions, Don't Plan Them</div>

Thinking The following design principles pertain to how we process information when visually communicating a message

PRINCIPLE	DESCRIPTION	RELATION
11 Depth of Processing	A phenomenon of memory in which information that is analyzed deeply is better recalled than information that is analyzed superficially. Thinking hard about information improves the likelihood that the information will be recalled at a later time. This phenomenon of memory results from the two ways in which information is processed known as maintenance rehearsal and elaborative rehearsal. Maintenance rehearsal simply repeats the same kind of analysis that has already been carried out. For instance, someone repeats a phone number aloud back to the themselves to help them remember; no additional analysis is performed on the phone number. Elaborative rehearsal involved a deeper, more meaningful analysis of the information. For instance, when someone reads a passage from a book aloud and then has to answer questions about the meaning of it; additional analysis as to word and sentence meaning require additional thought. Consider depth of processing in design contexts where recall and retention of information is important. Use unique presentation and appropriate tools to engage people to deeply process the information relevant to an audience.	<div>6</div> <div></div> <div>Self-Appropriate Technologies</div>
12 Five Hat Racks	There are five ways to organize information: category, time, location, alphabet, and continuum. The organization of information is one of the most powerful factors influencing the way people think about and interact with a design. The five hat racks principle asserts that there are a limited number of organizational strategies, regardless of the specific application, so optimization of each category in the simplest manner is key in users understanding and processing information.	<div>8</div> <div></div> <div>Optimize Rather than Maximize</div>

13 Mental Model

People understand and interact with systems and environments based on mental representations developed from experience. They do this by comparing the outcomes of their mental models with real-world systems and natural environments. With regards to design, there are two basic types of mental models: mental models of how systems work (system models) and mental models of how people interact with systems (interaction models). Design with people's differing interaction models in mind. If there is a standard mental model for how something works, try to design leveraging that model.

5

Respect Diversity

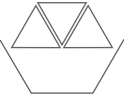


14 Ockham's Razor

Given a choice between functionally equivalent designs, the simplest design should be selected. Ockham's razor asserts that simplicity is preferred to complexity in design. Many variations of the principle exist, Aristotle explaining it as "Nature operates in the shortest way possible." Implicit is the idea that unnecessary elements decrease a design's efficiency and increase the probability of unanticipated consequences. Use Ockham's razor to evaluate and select among multiple, functionally equivalent designs.

14

Don't Foul your Nest



Synthesis

Below is an informational chart to help demonstrate the combination of the 14 Universal Design Principles & Elements + 14 Design Principles of Nature, which help to form the Indirect Method of the biomimetic design process, theory and system.

	Universal Design Principles	Design Principles of Nature
	Form Follows Function	Be Resourceful
	Mimicry	Adapt to Changing Conditions
	Self-Similarity	Organize Fractally
	Symmetry	Use Life-Friendly Chemistry
	Uniform Connectedness	The System > the Sum of its Parts
	Convergence	Foster Cooperative Relationships
	Feedback Loop	Leveraging Interdependence
	Hick's Law	Waste = Food
	Hierarchy of Needs	Self-Assembly from the Ground Up
	Life Cycle	Evolve Solutions, Don't Plan Them
	Depth of Processing	Self-Appropriate Technologies
	Five Hat Racks	Optimize Rather than Maximize
	Mental Model	Respect Diversity
	Ockham's Razor	Don't Foul your Nest



PROCESS

Integrating the Disciplines,
Direct Method

Process, by definition, is a series of actions or steps taken in order to achieve a particular end; a natural or involuntary series of changes; or a systematic series of mechanized or chemical operations that are performed in order to produce or manufacture something.¹ To bring biomimicry into graphic design, it is necessary to go through a series of stages within the process to assist as a planning and organizational tool. Designers need to understand that the process is not simply looking at an organism and mimicking its shape, patterns or color palette. One has to look at the entire system in which the organism lives, the function of the organism, as well as the form and parts of the organism that allows it to survive. It is a process where a designer defines a challenge functionally, seeks out an organism or ecosystem that is the master of that function, and then begins a conversation about how the design might emulate that function or concept,² allowing for many different solutions. If designers wish to adopt the biomimetic + graphic design process, then they must also see their profession as an integrated process and a problem-solving discipline. Successful graphic designers correctly define the context of their design, users and constraints. It is cross-disciplinary, allowing architects to learn from animal architecture, and graphic designers to learn from animal communication, biologists and life’s principles.³ The process of collecting several organism examples helps to analyze the principles involved— if many different organisms use variations of a common strategy, then you know your approach is pretty promising. The entire process is a mix of intuitive and deliberate actions, resulting in brainstorming without censorship to create the final solution.

¹ New Oxford American Dictionary 3rd ed © 2010

² Jessica Jones, excerpt in *Sustainable Graphic Design*, Wendy Jedlicka

³ Jessica Jones, excerpt in *Sustainable Graphic Design*, Wendy Jedlicka

This graphic design + biomimetic process is born from new ideas, conceived from old ideals. It is taking nature’s time-tested ideals over a period of approximately 3.8 billion years and introducing and integrating them with modern design practices. It is a synthesis of graphic design + biomimicry. The direct method, unlike that of the indirect method using abstracted principles of how nature designs, is exactly what it states: directly going out into the environment and seeking a natural system and organism; finding an example and defining the problem in its context, then finding the organisms with a similar problem and context to see what they do. The goal is to find many divergent organisms to see which has the best and most relevant strategy.⁴ Within this process, it is vital designers take into account their time and resource constraints, in order to optimize rather than maximize materials, so they can then appropriately assemble and implement the materials efficiently within their design solutions. This is the core of the biomimetic discipline.

The direct method is what you usually hear about— where the designer or engineer can point to an organism and say 'it's like that.' The value of this method is that even the most creative people still get stuck thinking along certain lines. In fact, a method called TRIZ⁵, which has been developed to catalog and analyze problem-solving techniques, claims there are just 40 methods that people have ever used to think up new inventions. Since evolution works differently from our brains, nature has used many more. Julian Vincent, author of *Structural Biomaterials*, at University of Bath has been working on extending TRIZ to biology, cataloging and analyzing the ways other organisms have ‘invented’ new solutions to problems. But so far the best way to find ideas in nature is to go look for yourself; arguably it always will be.

⁴ Jeremy Faludi, *Biomimicry for Green Design* Worldchanging: Change Your Thinking

⁵ TRIZ is the (Russian) acronym for the "Theory of Inventive Problem Solving." G.S. Altshuller and his colleagues in the former USSR developed the method between 1946 and 1985. TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups.

Defining the problem well is always a challenge in design, but then finding organisms that have relevant strategies is a trick in and of itself. Some examples are easy to find just by going for a walk and paying attention; other examples are more obscure, and require research— online, in books and academic journals, or even by hiring a biologist to consult (a BaDT). It is especially useful to find many examples from wildly divergent sources. For instance, when looking for structures, do not just look at animal bones, but also insect exoskeletons, the branches of trees, or the stems of grasses so that you have design alternatives. Just because a certain strategy evolved in one place does not mean it is the best solution; the power of biomimicry is that one can find many different solutions that he/she may never thought of. It is always a good thing to remember that good biomimetic design is inspiration from nature, not a slavish imitation of it.

As Michael Pawlyn, architect and advocate of biomimicry, states "If you look beyond the nice shapes in nature and understand the principles behind them, you can find some adaptations that can lead to new innovative solutions that are radically more resource efficient. It is the direction we need to take in the coming decades."⁶ In essence, within the graphic design + biomimicry process, what is trying to be stressed is that the natural world is a cauldron of research and development, trial and error, where technologies that fail are called fossils and technologies that succeed survive to fight another day. Why reinvent the wheel, when nature has figured out how to slither, walk, hover and fly in so many different ways? Who can deny that nature got here first?

⁶ For more information on Michael Pawlyn, see his book, Biomimicry in Architecture. You can also visit TED, www.ted.com, to see him give various TED talks on Biomimicry and its virtues.

⁷ Note, within each of these stages, there are small sub-stages like research, ideation and usability testing that also occur.

When looking at the visual process of biomimetic design, it can be shown in three different models: linear, circular, and branching. It is necessary to show the process in different forms to stress that it overlaps other frameworks and disciplines. The process of integrating the two differing methodologies is bringing nature's wisdom not just to the physical design, but also to the manufacturing process, the packaging, the shipping, distribution, and take-back decisions. We use the three different models to emphasize the reiterative nature of the process to make clear that it evolves in more pattern than one— after solving one challenge, then evaluating how well it meets life's principles, another challenge often arises, and the design process begins anew.

There are **6 Stages** within this new process:⁷

- 1 Define
- 2 Analyze
- 3 Observe
- 4 Select
- 5 Implement
- 6 Evaluate

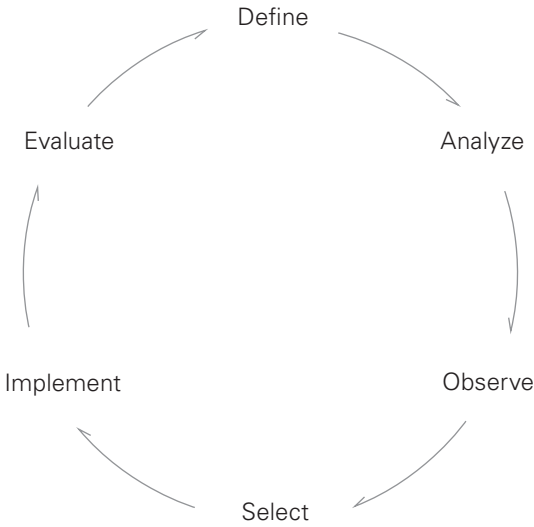
Linear Model

showing the linear and evolutionary process of nature and design



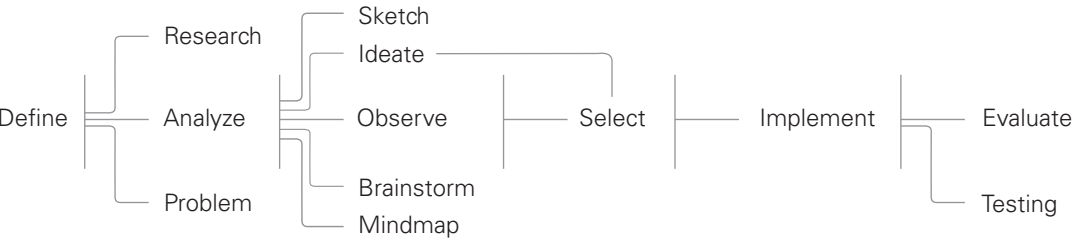
Circular Model

showing the reiterative nature of the process and continuation of the system within the feedback loop



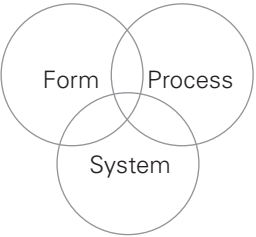
Branching Model

showing the branching nature of the process, visually connecting the smaller sub-areas with the six stages of the process



3 Lenses

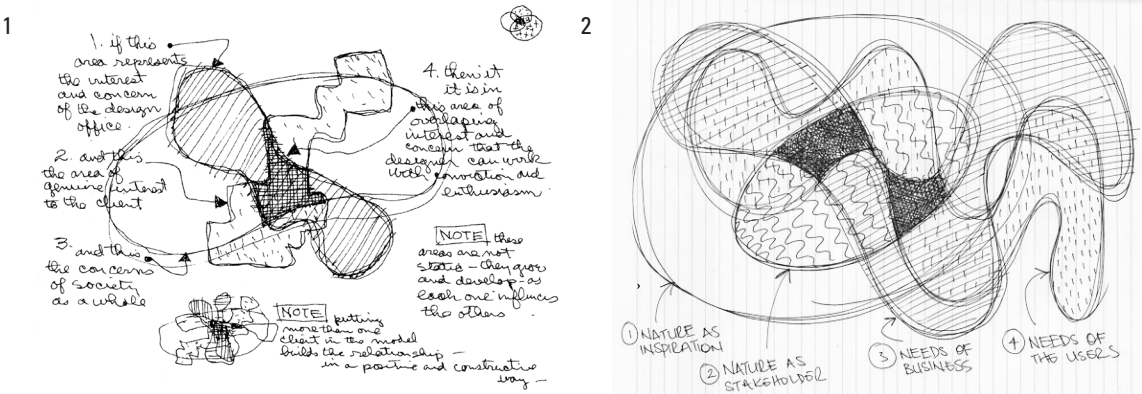
There are also three different lenses through which you can evaluate and explore this biomimetic design process through: form, process and system. Carl Hastrich, a professor at OCAD University in Toronto and toy designer, describes looking at biomimicry as placing a heavy emphasis on the system as context, and broader inspiration into why an adaptation from an organism occurs. "Ecosystems are an emergent property of biological organisms and the environment, and in order to really understand it we need to look at the full context. The weakness of some investigations at a systems level occur when there is no deeper understanding of the biological mechanisms that occur for systemic relationships to form. Therefore it is inherently complex to research and a difficult story to tell."⁸



Below are other organic interpretation models showing design's role and value within society, as well as the reverse, exploring society's value to design. Carl Hastrich took Charles Eames 1968 diagram, explaining the design process as achieving a point where the needs and interests of the client, the designer, and society as a whole overlap, and re-designed it to fit his own mode of thinking regarding biomimicry and design.

¹ Charles Eames, 1969, for the exhibition "What is Design" at the Musée des Arts décoratifs, Paris, France

² Humble Evolution of Charles Eames definition of Design; Carl Hatrich's attempt to define "Biomimicry Design" <http://bouncingideas.wordpress.com/>





SYSTEM SOLUTION

Ethos, Reconnect

To fully understand this graphic design + biomimicry process, it is important to show an example of the process and a final design system solution. The example shown here falls in the Graphic Design category of branding and identity.

1 Define

To create **an identity mark that clearly represents the biomimetic design process**. It must incorporate both natural and organic forms, as well as geometric and mathematical undertones. There must also be a functional quality present within the identity and implied in some fashion.

2 Analyze

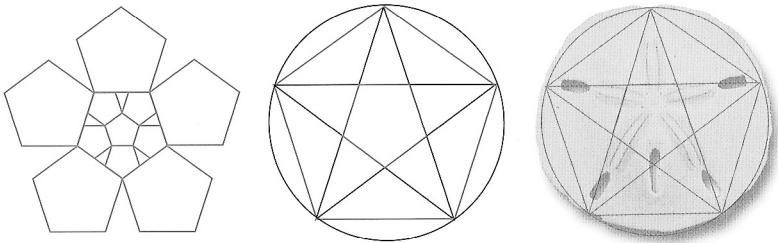
What would nature **do**? How would nature **begin**? How would nature **solve this particular problem** and in what **context**? What **tools** would nature use? How would nature **delegate**? How would nature **assess**?

Answers:
Nature would strive to find one form at increasingly smaller scales, optimizing the amount of resources and materials. It would begin with looking at nature's 14 design principles and seek out an organism or system that best describes this problem in order to emulate it. After finding this organism, it would look for materials and tools that were found locally within the system. It would then assess it's design by looking at how it fits in with the rest of the ecosystem.

3 Observe

Go out into the environment and **look at natural systems and organisms**. Which ones best fit within the context of this problem, can be implemented in the simplest way, and can be found locally?

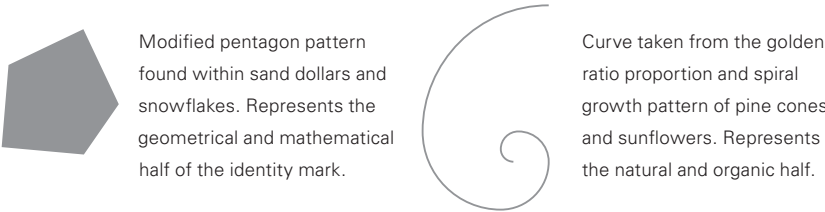
Inspiration
Sand Dollar & Snowflakes



4 Select

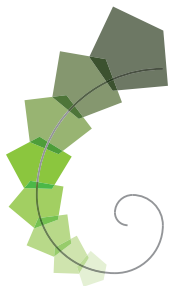
Choose the **best form within the organism or system to emulate**. It also needs to imply the overall function of the system and meaning behind the mark.

Inspiration
Golden Ratio & Spiral Growth Patterns of Pine cones and Sunflowers



5 Implement

Use the **same** pentagon **form throughout**, multiply it at different scales to **preserve resources, time and materials**. Apply it to the natural grid pattern, ensuring both the geometrical/mathematical and organic/natural sides are met.

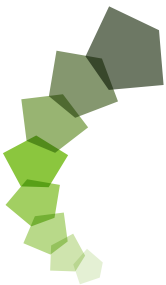


6 Evaluate

How would **nature assess this design**? Does it use **Nature's 14 design principles**?

Answers:
It shows the methodologies of both graphic design (geometric/mathematical) and biomimicry (natural/organic), represented through continuation of the pentagon form along the golden ratio, curved grid pattern. It optimizes the amount of resources and materials by using the same pentagonal shape throughout at differing scales and using only 1 color at differing hues and tones. It also represents and shows the function of the biomimetic process in representing the evolving stages of the biomimetic process, as well as the continuous pattern of the life cycle of design found within nature.

Final Design System Solution



¹These stumbling blocks are based off the work of Steven Vogel, *Cats' Paws and Catapults* and Jeremy Faludi, *World Changing: Change Your Thinking*.

3 CAVEATS | Where Nature's Principles Will *Not* Help

Although this entire reference guidebook's premise relies on the biomimetic design process and design principles of nature, it is important to be realistic about where these life principles and strategies *will* and *won't* help you. This is not to completely destroy the defense of this thesis or the principles just mentioned, but there are definitely some drawbacks to the way life designs, which you probably do not wish to emulate. However, these drawbacks are necessary in order for there to be progress within the evolutionary process.¹

- 1 Evolution can only find local optima, not global optima. Put in another way, evolution requires every generation to have an immediate advantage— when transitioning from one strategy or principle to another, you cannot get worse for a few generations, knowing that in the end you will get better than you could have with the original strategy. Thus nature shuts out many design possibilities that we humans can find.
- 2 Second, natural products need continual maintenance and/or rebuilding. This can easily be turned into an advantage for products meant to biodegrade or planned to obsolesce. Most often it is simply a reminder to not imitate *too* slavishly.
- 3 Finally, organisms cannot borrow designs from others, they have to evolve from what they have now. Human designers, however, can mix and match freely from different products in whole other genres. There is nothing wrong with making a building whose walls insulate like penguin feathers but are structured like a crab shell. Some companies are doing things like this in biology with genetic engineering, but the law of unintended consequences has frequently shown it to be a bad idea.

CASE STUDIES

You have analyzed the methodologies of both biomimicry + graphic design, and now know the stages of the biomimetic design process. The following case studies demonstrate how the process was applied to actual design scenarios.

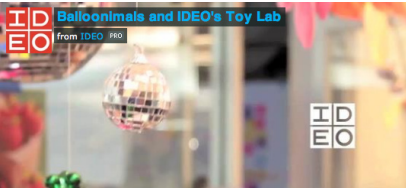
LOGO CONCEPTS: IDEO

<http://designmomentum.wordpress.com/>

IDEO has a very novel and intriguing logo.¹ It is simple and that makes it easy for them to reshuffle information within the design and yet still retain the function of the logo— to recognize and associate with the brand. They are able to evolve to survive and adapt to changing conditions by integrating the unexpected and replicating strategies that work. For example, when colors become dated their designers can easily change the color because the distinct shapes will still provide the functional need. The logo can also easily adapt to fit the piece’s shape (square, zig zag, or elongated).

Nature's Principles of organizing fractally and optimizing rather than maximizing has the highest potential to create more sustainable designs.

I'm not sure if the IDEO logo design is inherently life-friendly but I’m sure this concept could be applied elsewhere. If IDEO were striving to help their clients create more life-friendly products, then the logo indirectly would help give IDEO an advantage over the competition who may not be striving to incorporate sustainability into their policies. Graphic designers can choose which companies to create a positive image for.



QR CODES

<http://designmomentum.wordpress.com/>

Nature uses many senses to communicate. It uses chemistry, and more specifically scent, as one avenue for sending signals to receiving antennae. Each chemical is a certain shape and when received, fits together just perfectly with the receiver’s chemical shape. However, humans of course have come to depend mostly on our eyes as our main sense. So it’s only natural that the coding system we develop is a visual one. It is interesting though that this code does not talk to our visual antennae directly but rather indirectly through our smart phones.

If nature needed to send a signal made up of simple, common, building blocks and by using low energy processes and reshuffling information, would it create this QR code to use as a signaling device? I think it’s on the right track. But I think the QR code definitely has a lot of room to evolve and adapt as well.

Can the coding incorporate other Life’s Principles somehow? Can it be more visually appealing, use less space, and contain more information? Should we even be focused on developing a visual code? Or will our smart phones be able to someday pick up senses that we cannot? How can we stop viewing it as just another means of advertising and use it more functionally and efficiently? How could these codes help us be more sustainable in graphic design?



¹ For more on IDEO, visit <http://www.ideo.com/>

ECO PRINTERS

<http://designmomentum.wordpress.com/>

Nothing in nature is permanent—everything is in a state of dynamic non-equilibrium. Nature adapts constantly to fit its context for use or it faces extinction. It seems that humans are not as in touch with earth’s operating conditions anymore. We create things only how we ‘perceive’ they should be created and not based on pressing needs or contexts. We are not forced to find other more context specific ways of creating because we already have a plethora of inventions that could work and we have access to inexpensive energy.

Papermaking fibers can typically be recycled only five-to-seven times before they become too short to be recycled again. The *Eco Printer*, designed by Sharsha Lee for Liteon Technology Corp, is a new mutated breed of printer well-adapted to a certain context and was designed to extend the life of paper.

It can remove ink in order to reprint on the same sheet many times over. Increasing the lifespan of paper is the main aim of the Eco Printer. This device uses special ink composed of photographic materials that can

be made to disappear after UV irradiation. It contains a UV irradiation device in the paper input tray. Printed paper is irradiated with UV light before it is re-printed. This process takes the ink out of the paper, making it clean and ready to be printed on again. The Eco Printer can be used to print temporary documents and significantly reduce paper wastage.¹



The Pencil Printer, designed by Hoyoung Lee, uses Eco Printer concepts and actually prints as well as erases. It feeds on scrap pencil and eraser pieces. It extracts the ‘ink’ from the pencil graphite and erasing material from the rubber in the eraser pieces. This radical new printer not only prints through one of its ends but has a special exit for erasing the same printed paper too. Environmental conservation at its best!²



¹ For more information on the Eco Printer, visit red dot at <http://www.red-dot.sg/>

² Find other innovative printer ideas here: <http://www.ecofriend.com/>

ECOFONT

<http://designmomentum.wordpress.com/>

If nature was in the business of designing typefaces, it would probably look similar to this EcoFont.¹ Except that nature might reverse how it built its letters with ink. Instead of cutting out dots from the line it might create the line with dots. This refers back to the 1st Design Principle of Nature, ‘Self-Assembly from the Ground Up,’ and the leaf cut out of paper analogy told by Jessica Jones (Benyus).

Test results for Ecofont Arial 12pts show ink and toner savings of 28%. In using this as opposed to traditional typefaces, you are being resourceful and material and energy efficient.

WE FOUND THIS
ECO FONT
USES 20% LESS INK
ITS FREE TO DOWNLOAD

Arial



Ecofont Arial



RIT TAGA 2011

<http://taga.rit.edu/2011/>

The RIT Taga 2011 researched and investigated the effects that font choice, typographic design, and page layout have on the conservation of ink and paper.¹ This is one part of a broader concern with the environmental sustainability of digital printing. Measurement of ink and paper consumed in the printing of documents must take into account not only choices of fonts but also their spacing and arrangement within the defined parameters and pragmatic goals of specified documents. The typefaces and layouts common in academic printing were not designed with.

The goal of reducing ink and paper consumption, but moderate changes in typographic format and can result in substantial savings in ink and paper. It was concluded that compared to thesis composition in Arial, the use of Times New Roman or a modified Déjà vu Sans font can result in savings of ink from 19-25%. Compared to typical RIT thesis guidelines, thesis formats designed for economy can result in paper savings of 27-48%. When dealing with students whose average page consumption numbers in the thousands, such as the graduate students at RIT, a reduction of even 27% (around 270 pages out of 1000) can be a huge savings.

Table 5. Ink saved compared to Arial		
Typeface	Pixels	Ink Savings
Arial Regular	1,071,130	-
Déjà vu Sans Book	1,164,699	-
Déjà vu Sans Light	894,124	16.53%
Déjà vu Light Thesis	863,994	19.34%

¹To download a .pdf the full abstract and thesis report on RIT Taga 2011, go to <http://taga.rit.edu/2011/>

INTERFACEFLOR CARPET

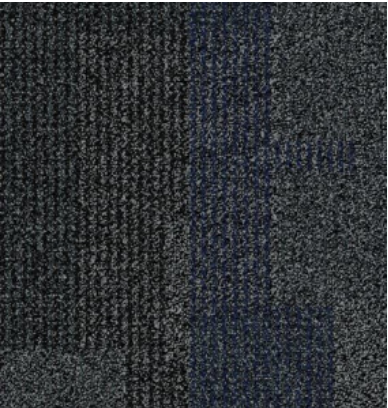
<http://designmomentum.wordpress.com/>

Interface is the world's largest designer and maker of carpet tile. Their slogan and mantra being 'By definition, we are the world's largest designer and maker of carpet tile. For us, Design is a mindset and Sustainability is the journey of a lifetime. We are Design with Purpose.' Their environmental goal is to go for zero; that is zero emissions, zero waste, and zero oil.¹ It is a tough challenge since carpet is made from oil but by using less energy and material, making products that last and recycling old carpet into new, they already have most off oil carpet.

The Interface mission and goal for their future carpet design directly correlates with three out of the 14 Design Principles of Nature:

- 7 Be Resourceful
- 8 Optimize Rather than Maximize
- 9 Use Life-Friendly Chemistry

In this specific case study, InterfaceFLOR looked to the forest floor for inspiration. After walking through the forest during a design charette, their designers had an epiphany— they noticed that the artifacts on the forest floor made a very random pattern yet was still nice on the eye. They mimicked the non-homogeneous, yet cohesive pattern in carpet tiles so that off-spec batches could still be used. Or, if a stain appears on one tile, it can be replaced from a tile from a different die lot yet still look pleasing amongst the other sun faded and slightly different colored tiles. Customers had 70% less installation waste and didn't have to back-stock identical replacement tiles (which most ends up unused). By 2009, the company's accumulated avoided costs from its waste elimination activities equaled \$433 million.



¹ For more on Interface Carpet visit <http://www.interfaceflor.com/>

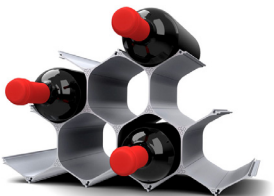
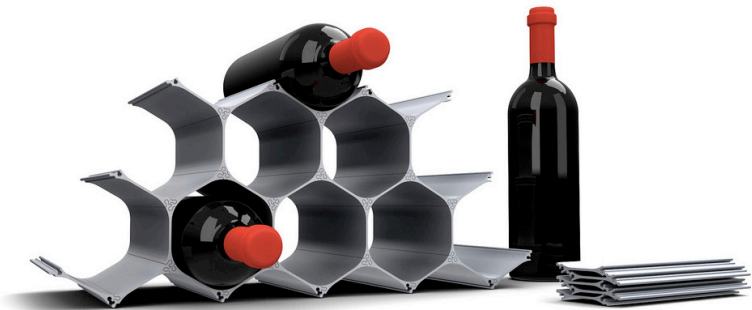
WINEHIVE

Made in America from recycled aluminum, the WineHive is an eco-friendly honeycomb wine rack, with infinite add-on capability. It was designed by John Paulick in Philadelphia, PA.¹ The WineHive is made with just a single part, that repeats itself to form an infinite array of honeycomb structures. It can be customized to fit anyone's growing wine bottle collection. The WineHive pack consists of 12 parts. It can form a 5 bottle wine rack or combine with other packs to form larger configurations. The more packs you have, the more configurations you can make.

Paulick recently graduated from Biomimicry 3.8's Biomimicry Specialist Certification Program said that he was inspired by fractal honeycomb patterns found in nature.

¹ John Paulick started a Kickstarter campaign with the goal of raising \$15,000 in 30 days to finance the initial production and packaging of his bio-inspired honeycomb wine rack. The elegantly designed and aptly named WineHive attracted attention from 681 backers who provided over \$65,000 in funding, more than 400% of his goal.

<http://www.kickstarter.com/projects/>



¹ Designed by Fernd van Engelen at Artefact in Seattle, WA. To support the project and the increased use of feedback loops, you can buy the water bottle here: <http://www.artefactgroup.com/#/content/support-999bottles-on-kickstarter>

² <http://www.kickstarter.com/projects/999bottles/999bottles>

999 BOTTLES

<http://www.artefactgroup.com/>

The 999 Bottle is not just another water bottle.¹ It is a beautifully designed system that helps you track and visualize the positive impact you can have on the environment by drinking from re-usable bottles instead of disposable ones. The stainless steel bottle features a clever three numbered dial along its length to help you track of how many times you re-use it. Each time you refill, simply advance the dial one notch. The numbers steadily add up!

An accompanying iPhone app tells you what the numbers mean, giving context to your conservation through insightful visuals that graphically depict and share the impact of your efforts. The app also allows you to join forces with your friends and track your combined impact. Most people understand and agree that disposable water bottles are expensive, a very inefficient use

of resources and harmful to the environment. But that understanding does not necessarily translate into action. According to CNBC, Americans buy 51 billion bottles of water a year, and recycle less than one quarter of them. The remaining bottles end up in a landfill or as litter jeopardizing wild life and creating unforeseen consequences to human health and the environment.²

The 999 bottle is a great example of Nature's Principle of using feedback loops. Nature constantly receives direct environmental feedback and changes its behaviors and reactions accordingly. For humans, it is hard to see that we are fouling our own nests because it is out of sight and out of mind. But with this newly designed water bottle, our waste it is no longer out of mind. Graphic designers, and designers alike, have the opportunity to give humans the visual cues they need to act differently.



Mimicry is perhaps the oldest and most efficient method for achieving major advances in design.

WILLIAM LIDWELL

¹ Jessica Jones, excerpt in
Sustainable Graphic Design,
Wendy Jedlicka

- DEFINING
- ANALYZING
- 3 **OBSERVING**
- SELECTING
- IMPLEMENTING
- EVALUATING

How Would Nature Solve the Problem?

The third stage in the biomimetic design process after analyzing the problem is *observing*. During this stage, designers will discover the natural models and systems that exist within nature. In order to emulate the system or organism that best fits their design problem, it is crucial designers abstract the strategies and functions looking to life as a model for inspiration. In asking how nature would solve this design problem, designers must look to the environment where visual communication predominates to discover biological strategies that can translate into innovative ideas.¹ Through this observing stage, designers will find novel ideas that have been refined over millions of years.



PATTERNS & SURFACE MIMICRY

Animal Camouflage

Natural patterns are fundamental to us getting along in the world. By appreciating natural patterns, we better understand the basic patterns we intuitively recognize, thus we better know how to communicate.¹ Both graphic design and nature rely on these intuitive pattern systems to transfer visual messages and stimuli, knowing the end user will perceive what these specific patterns signify, thus communicating the message successfully. Design, in the broadest sense, is the ability to communicate through an intuitive sense of pattern. It is the difference between lucid communication and meaningless noise.² It is the basics of conscious awareness of patterns that brings cohesion to a sometimes chaotic landscape by allowing us to see contrast as well as similarity. It is fundamental that designers recognize these patterns during the observation stage of the biomimetic design process in order to better adapt with nature, since it is not just people that have these instinctive and intuitive pattern recognition sensibilities. It is necessary to take a closer look at how organisms live, function and communicate. In doing this, designers will come to realize that creatures have the same intuitive intelligence as humans do that allows them to recognize certain symbols. For instance, bees find honey down a diverging maze by navigating colonized directional patterns after a few attempts. Chimpanzees use symbols not only to identify objects but also to describe conceptual impressions of the world around them. In studying chimpanzees, it was noticed that they even use rudimentary language to communicate and say 'yes' and 'no' in response to someone talking to them over the phone.³

Pattern awareness cues designers to make and select the most appropriate relationships that specifically describe a client's unique attributes, while embedding universal design concepts and principles. Thus resulting in elegant, clear, recognizable design understood by all cultures.

¹ Maggie McNab,
Decoding Design

² Maggie McNab,
Decoding Design

³ Maggie McNab,
Decoding Design

⁴ William Lidwell, Kritina
Holden and Jill Butler,
Universal Principles of Design

In talking about basic communication patterns and techniques, nature uses mimicry as its form and technique when it comes to particular pattern making and design. Mimicry is the act of copying properties of familiar objects, organisms, or environments in order to realize specific benefits afforded by those properties. In nature, mimicry refers to the copying of certain properties to hide from or deter other organisms.⁴ This is where animal camouflage, or surface mimicry, plays a significant role in evolution and survival of the fittest.

However, camouflage is not strictly about chameleons changing the color of their skin in an instant; it is also about polar bears being white and not brown like grizzlies. In order to understand animals with this ability of mastering the art of deception, it is important to know why animals have this cunning ability. A major concern of animals is to protect themselves from predators in order to survive, reproduce and pass off their genes to a future generation. Many animals have evolved adaptations known as ‘anti-predator devices’ and use camouflage to blend in with their natural environments and patterns in an attempt to be unrecognizable by predators. However, there are exceptions: animals which are dangerous to eat (i.e. wasps) advertise with warning coloration.

Animal camouflage can relate to design in the sense that mimicry refers to copying properties of familiar objects, organisms or environments in order to improve the usability, likability, or functionality of an object. Design and nature create with three forms of mimicry in mind: surface, behavioral, and functional. Surface mimicry (camouflage) is making a design *look* like something else; Behavioral mimicry is defined as making a design *act* like something else; Functional mimicry is defined as making a design *work* like something else.



FRACTALS & THE SIERPINSKI TRIANGLE

Natural Algorithms

Fractal, by definition, means a curve or geometric figure, each part of which has the same statistical character as the whole. Fractals are useful in modeling structures (such as eroded coastlines or snowflakes) in which similar patterns recur at progressively smaller scales, and in describing partly random or chaotic phenomena such as crystal growth, fluid turbulence, and galaxy formation.¹ Fractals have a number of characteristic properties, and some of the best known examples of fractals possess the intriguing feature of self-similarity which is usually the result of a basic, natural algorithm process called *recursion*. Recursion occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input. Fractals exhibiting self-similarity and recursion show the same structure on all scales.² The term 'fractal' was first used by mathematician Benoît Mandelbrot in 1975. Mandelbrot based it on the Latin frāctus meaning 'broken' or 'fractured,' and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature.³

However, before Mandelbrot coined the term 'fractal,' there was an earlier Polish mathematician by the name of Waclaw Sierpinski who was studying fractal patterns, just in a different manner and by a different name. In 1915, Sierpinski published the first set of pictures of what is now known as the Sierpinski triangle.⁴The Sierpinski triangle is composed of three smaller triangles, each of which is just a copy of the original Sierpinski triangle.



⁵ Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

⁶ By definition, a process or set of rules to be followed in calculations or other problem-solving operations, New Oxford American Dictionary 3rd ed © 2010

⁷ For more detailed instructions, see Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

What Sierpinski was trying to illustrate was that this process may be repeated *ad infinitu*: each of the smaller triangles consists of three scaled down copies of itself. If you look closely, you will see that any one of the smaller triangles in the Sierpinski triangle is the original triangle.⁵ One of the remarkable features of fractals, like the Sierpinski triangle, is that they can often be produced using very simple instructions or algorithms.⁶The novelty of these instructions is that they are based on choosing a sequence of random numbers.

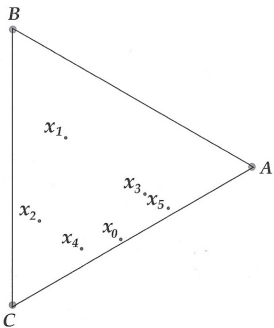
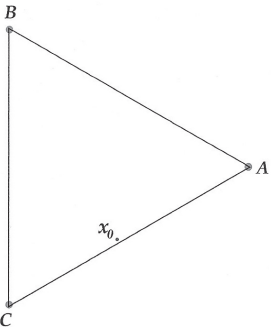
A random iteration algorithm for obtaining arbitrarily close approximations to the Sierpinski triangle is as follows:⁷

- 1 Begin by choosing an equilateral triangle in a plane
- 2 Label the vertices A, B, C and pick a point inside the triangle (outside will work as well– the end result is just the same)
- 3 Now randomly choose one of A, B, or C. If say B is chosen, move the point halfway to vertex B and mark the point. Similarly, if A is chosen, move the point halfway to A, and the same for C.
- 4 Now, repeat the process to obtain a sequence of points that can be plotted

Put simply:

- 1 Begin by choosing an equilateral triangle in a plane
- 2 Shrink the triangle to ½ height and ½ width, make three copies, and position the three shrunkn triangles so that each triangle touches the two other triangles at a corner
- 3 Repeat step 2 with each of the smaller triangles

The actual fractal is what would be obtained after an infinite number of iterations.



¹ New Oxford American Dictionary 3rd ed © 2010

²William Lidwell, Kritina Holden and Jill Butler, *Universal Principles of Design*

³ Benoît Mandelbrot, *The Fractal Geometry of Nature*

⁴ Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

⁸Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

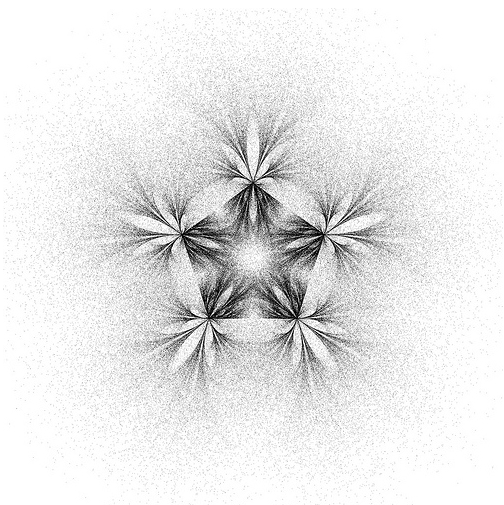
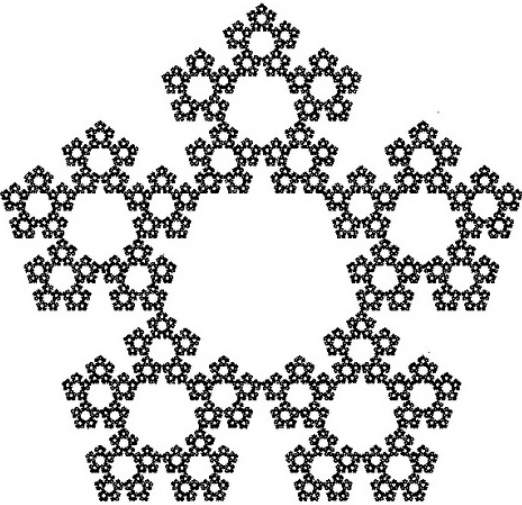
The algorithm for constructing the Sierpinski triangle was based on fixing an equilateral triangle or, more precisely, fixing the vertices of that triangle. It is natural to modify the algorithm a little by replacing the triangle with a square or indeed by any one of the regular polygons.⁸ For instance, suppose we had initially chosen a regular pentagon in the plane. After choosing an initial point inside of it, you could have defined the algorithm by making random choices of vertices and at each stage of the iteration, move halfway towards the vertex. Thus creating the algorithm and fractal pattern, which are both found naturally recurring throughout nature.

The purpose of showing fractal patterning and the Sierpinski triangle is to demonstrate that patterns and design systems within nature do not occur unmethodically over time, but due to the naturally occurring algorithms. The ubiquity of self-similarity in nature hints at this underlying order and algorithm, and suggests ways to enhance the aesthetic composition of human-created forms and perhaps their structural composition as well.

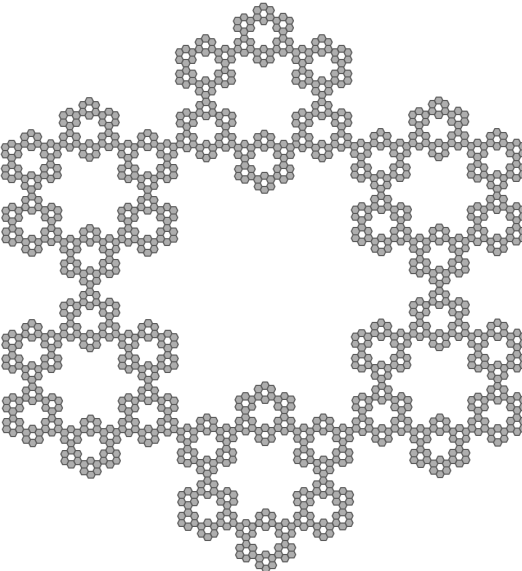
Relating this back to the earlier discussion of the surface mimicry of animals, if one was to take a close look at the hide, skin, or texturing patterns of animals, one would find that it is a structured, well thought-out pattern based upon a logical grid system and fractally organized algorithms. One of the best known and most beautiful system of patterning seen in nature is the hexagonal conformations most notoriously connected with the honey bee's cell. The hexagonal symmetry in plants and animals "doth neatly declare how nature Geometrizeeth and observeth order in all things."⁹

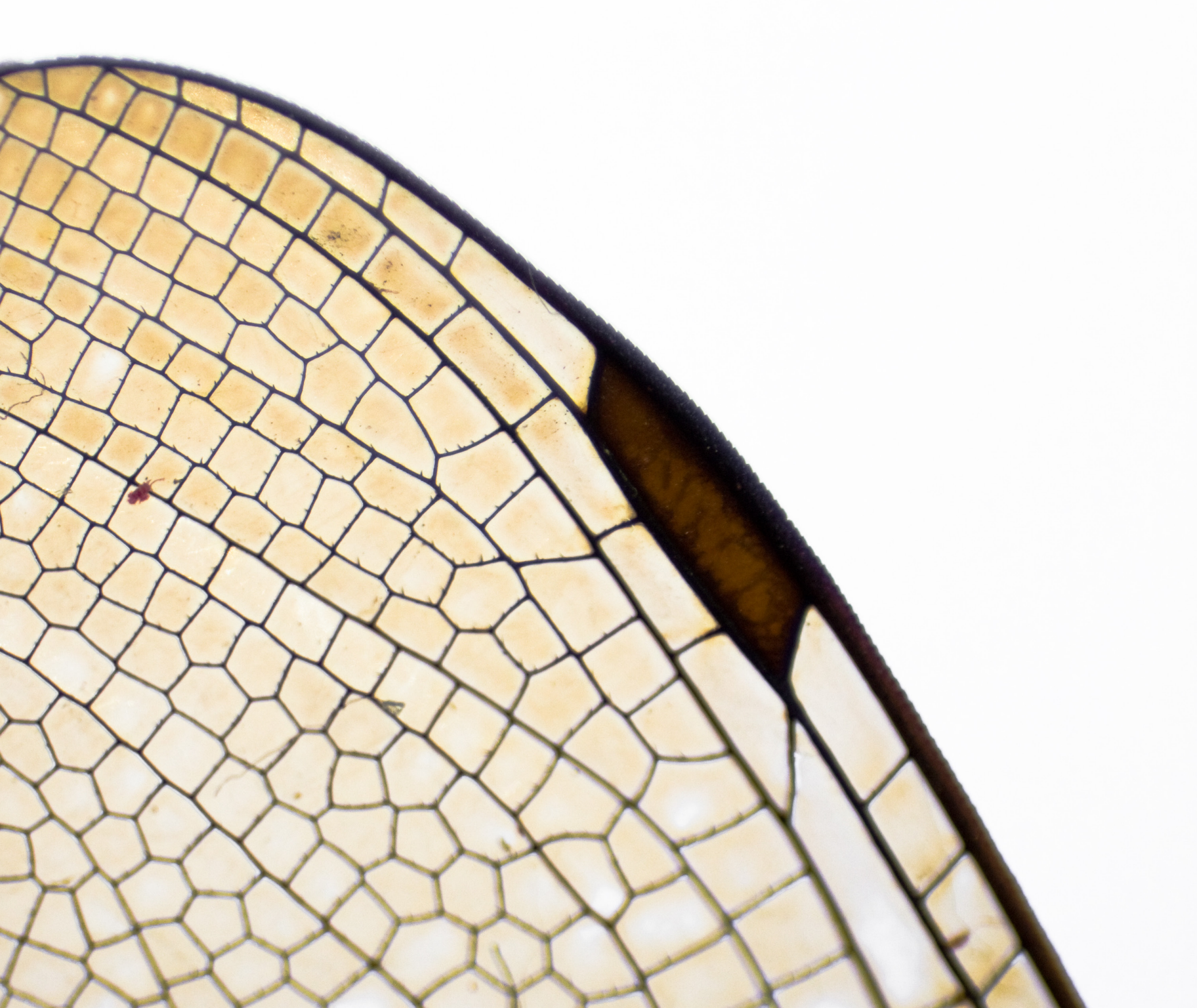
⁹D' Arcy Wentworth Thompson, *On Growth and Form*

Sierpinski Pentagon



Sierpinski Hexagon





GRAPHICAL SOLUTIONS

Tessellation Patterns

The word tessellation means to fit or join polygons into flat, continuous patterns. A tessellation pattern is created by joining three or more sides of a set of polygons. The point where the sides meet is called a vertex; the sum of the angles around a vertex equal 360°.¹ Regular tessellations are created by combining regular, congruent polygons in a uniform manner. The only three regular, congruent polygons that can possibly be used in regular tessellations are the triangle, the square and the hexagon, sometimes pentagon because only they have interior angles that divide evenly into 360°.² A semi-regular tessellation is uniform and consists of more than one type of regular polygon. There are uniform/nonuniform and periodic/non-periodic tessellations. In a uniform tessellation all vertices are congruent and the organization of polygons around each vertex is the same. In a periodic tessellation a group of regular polygons can be moved to a new position within the tessellation, where it will fit together exactly with a similar group of regular polygons.³ The hexagonal honey bee cell is one of the best known tessellation patterns and the interest here is looking into how using these joined or fit polygons can create a continuous, unique pattern design, similar to mosaic tiling, and how they can relate to the surface mimicry of animals and fractals. All share similar methodologies and principles: the use of symmetry, the Sierpinski triangle, and the concept of implementing natural algorithms and self-similarity that occur within nature. It is organizing fractally, while also optimizing the amount of materials needed to create these patterns.

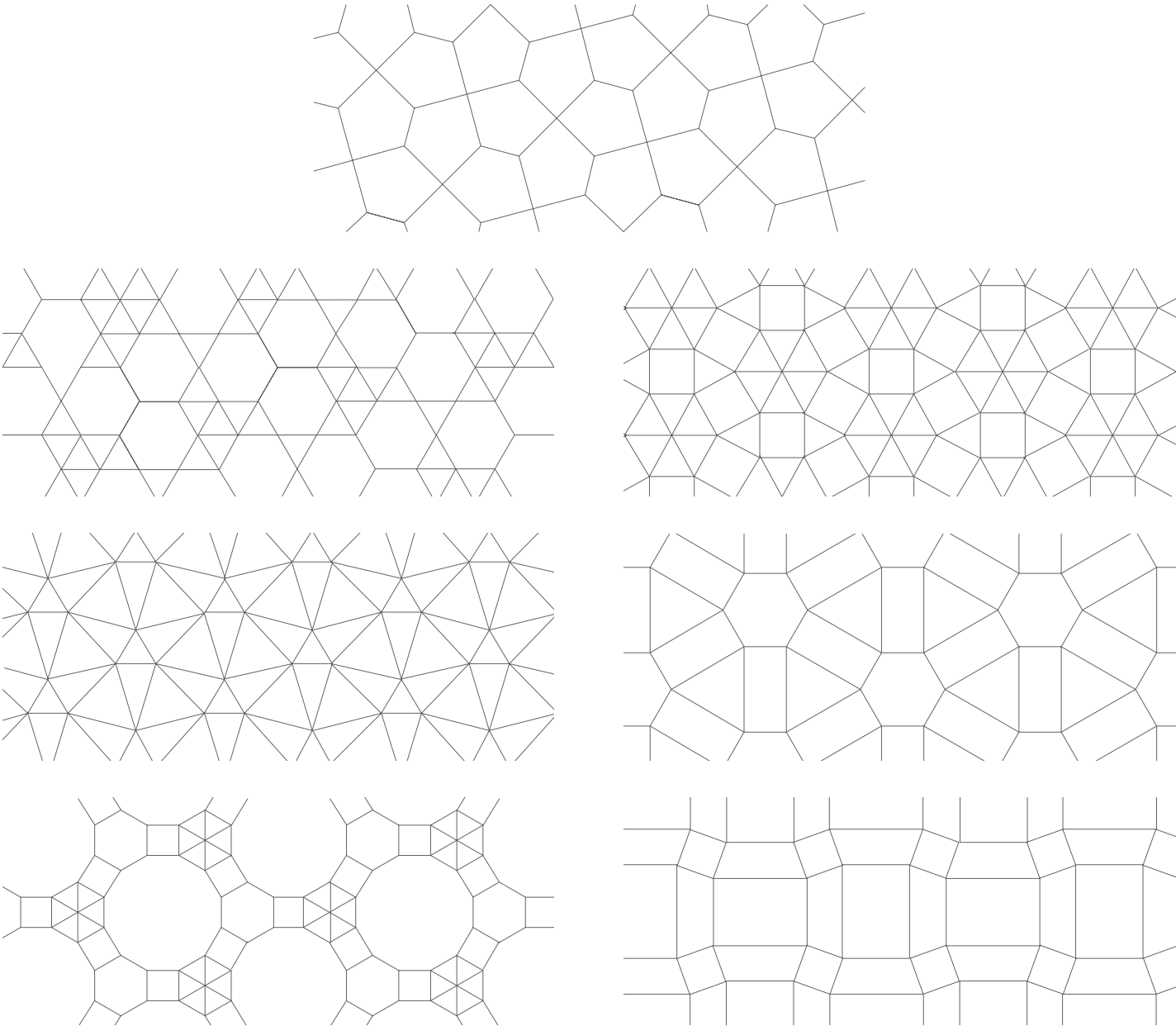
Tessellation Grid Patterns

To the right are 7 tessellation patterns designed and inspired by surface mimicry, animal camouflage, fractal patterning, the Sierpinski triangle and natural algorithms.

¹ Charles Wallschlaeger & Cynthia Busic-Snyder, *Basic Visual Concepts and Principles for Artists, Architects and Designers*

² Charles Wallschlaeger & Cynthia Busic-Snyder, *Basic Visual Concepts and Principles for Artists, Architects and Designers*

³ Charles Wallschlaeger & Cynthia Busic-Snyder, *Basic Visual Concepts and Principles for Artists, Architects and Designers*

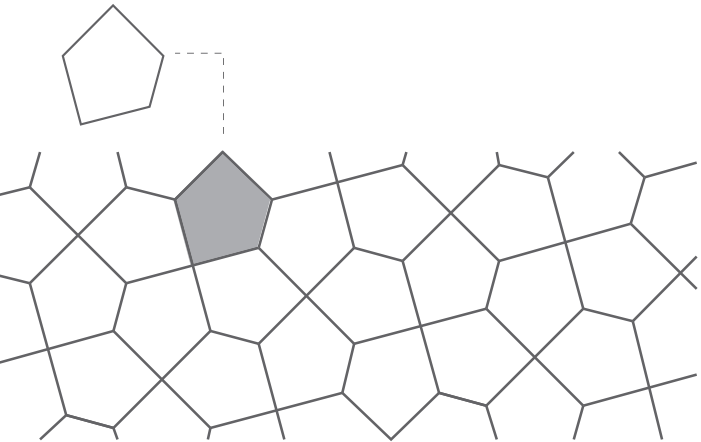


Graphical Solutions, Pattern Design

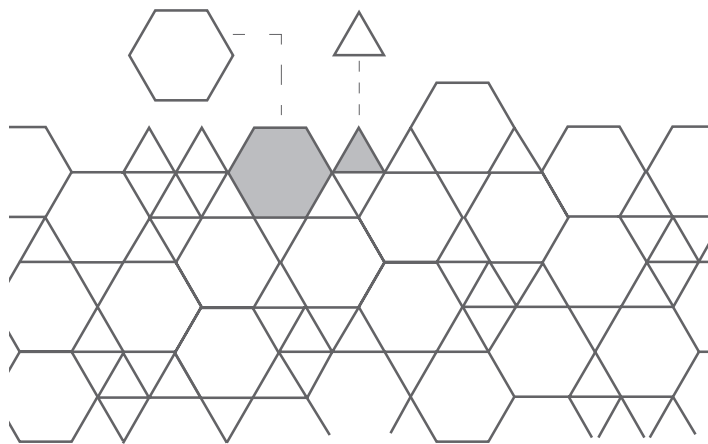
To make these pattern designs, the biomimetic design process was used. The first stage began with defining the problem: What would Nature do? How would nature create these specific patterns and in what context?¹ How would it utilize form within function? After asking these questions and going through the appropriate stages of defining, analyzing, and observing, the selection of which animals to emulate was the next step. The animal skins and camouflaging/surface mimicry techniques that were chosen were the *giraffe*, *leopard*, *chameleon*, *iguana*, *tortoise*, *monarch butterfly*, and *cephalopod (Blue-ringed Octopus)*. After the animals were chosen, the implementation stage of the process could now begin, which is where images of the same hue and mimicry patterns were chosen to be repeatedly placed beneath each polygon. The images seen looking through each polygon act as a window, showing various color hues, changes and patterns similar to those seen on the animal's transformed-camouflaged skin. In evaluating the designs, it is apparent that by using the tessellation and fractal techniques, taking either a singular polygon or multiple, different polygons and repeating them throughout at differing scales, was successful in creating individual grid-like patterns. The functioning aspect is in the form of deception to emulate the animal and disguise the form by creating shapes for specific pattern purposes. By incorporating the biomimetic + graphic design process, it is evident that these patterns are derived from nature through the use of polygon forms and images of nature, while also showing subtle hints of the geometric and mathematical side of design in creating grid systems. What is shown for each graphical solution is the final pattern design, the underlying mathematical and geometric grid system, as well as the natural inspiration and surface mimicry of the specific animal.

¹ A good example of how nature would go about doing this is seen in the hexagonal honey bee cell.

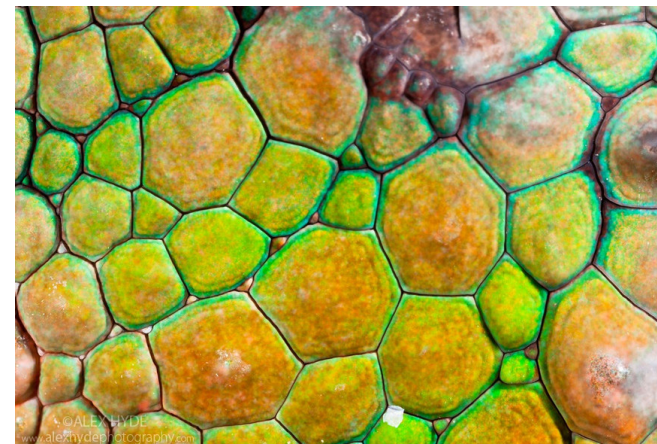
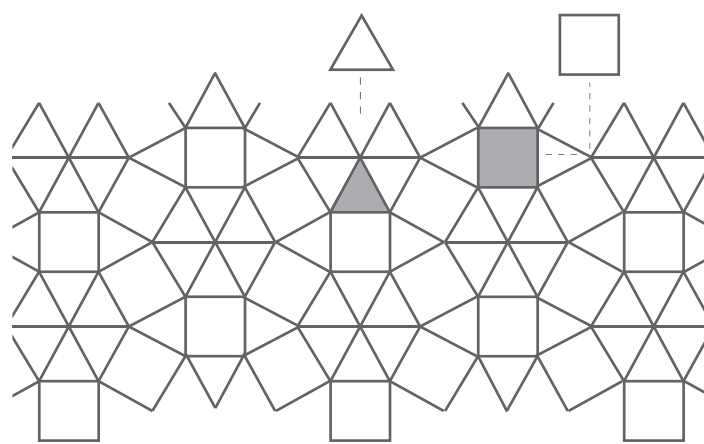
Regular Tessellation Pattern using the same pentagonal shape throughout | Giraffe



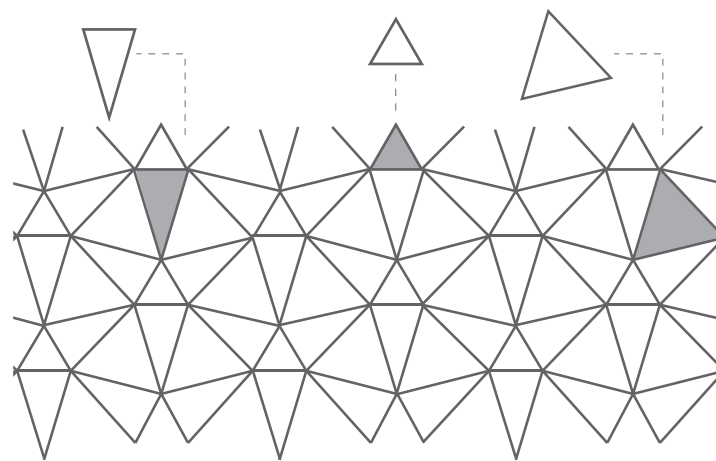
Semi-Regular Non-Uniform Periodic Pattern using 2 polygonal shapes: hexagon and triangle | Leopard



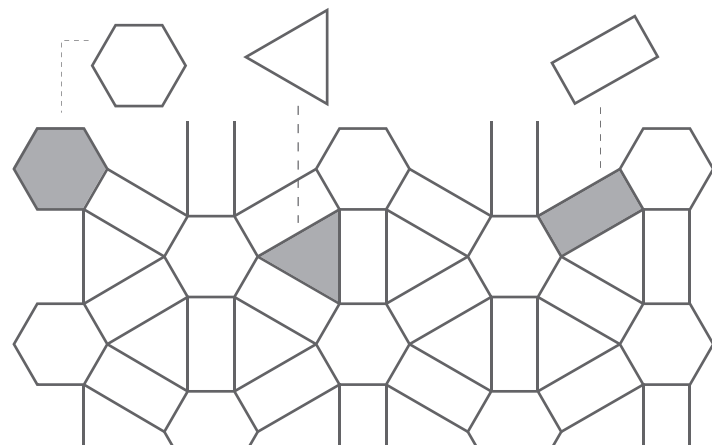
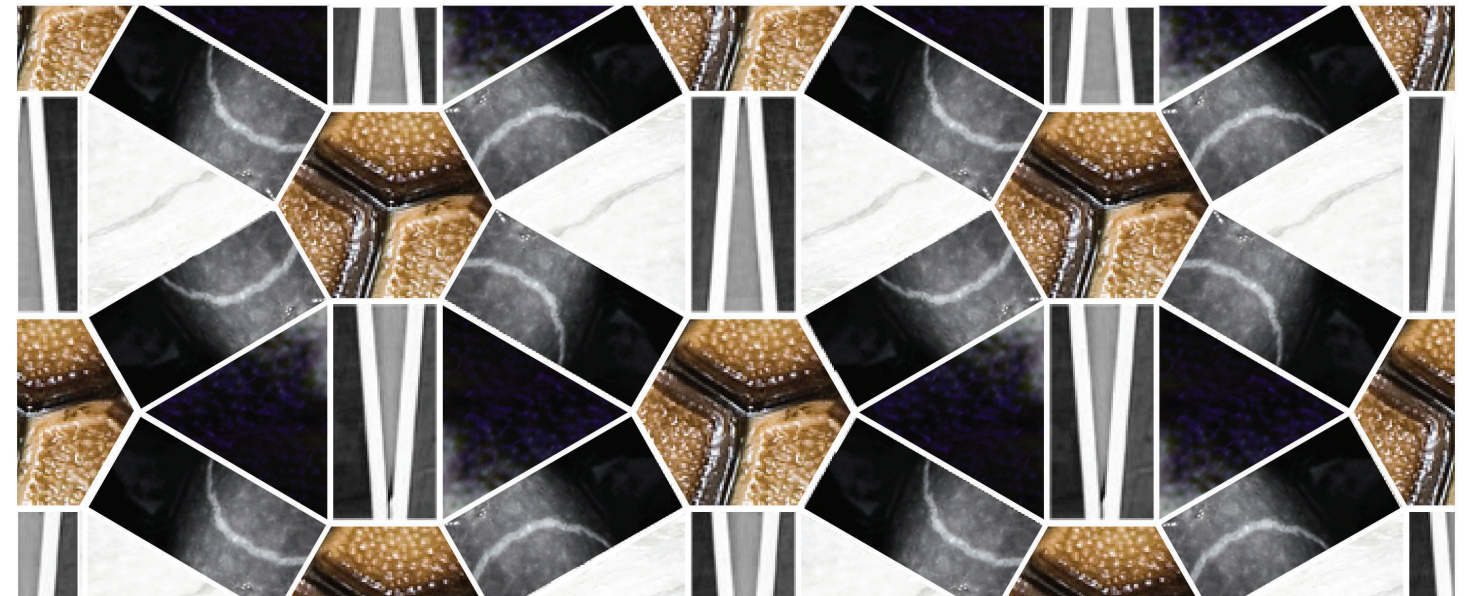
Semi-Regular Non-Uniform Non-Periodic Pattern using 2 polygonal shapes: triangle and square | Chameleon



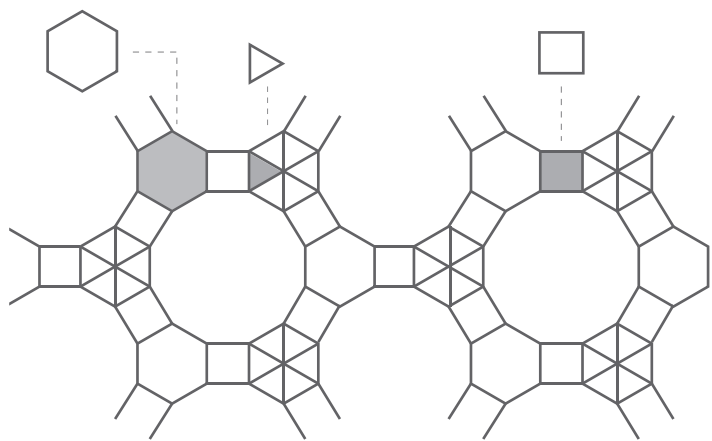
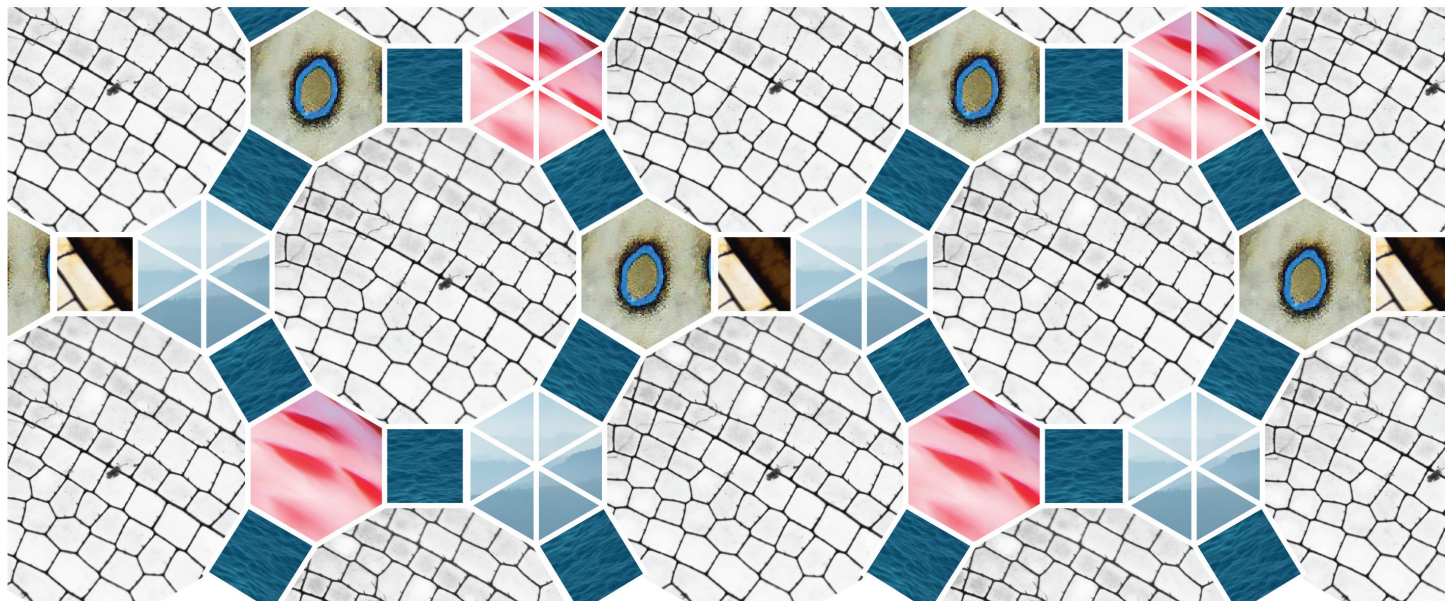
Regular Uniform Non-Periodic Pattern using the same triangular shape throughout at differing sizes | Iguana



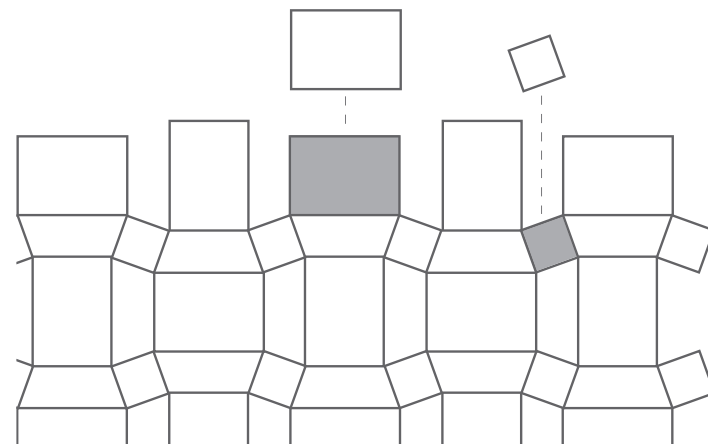
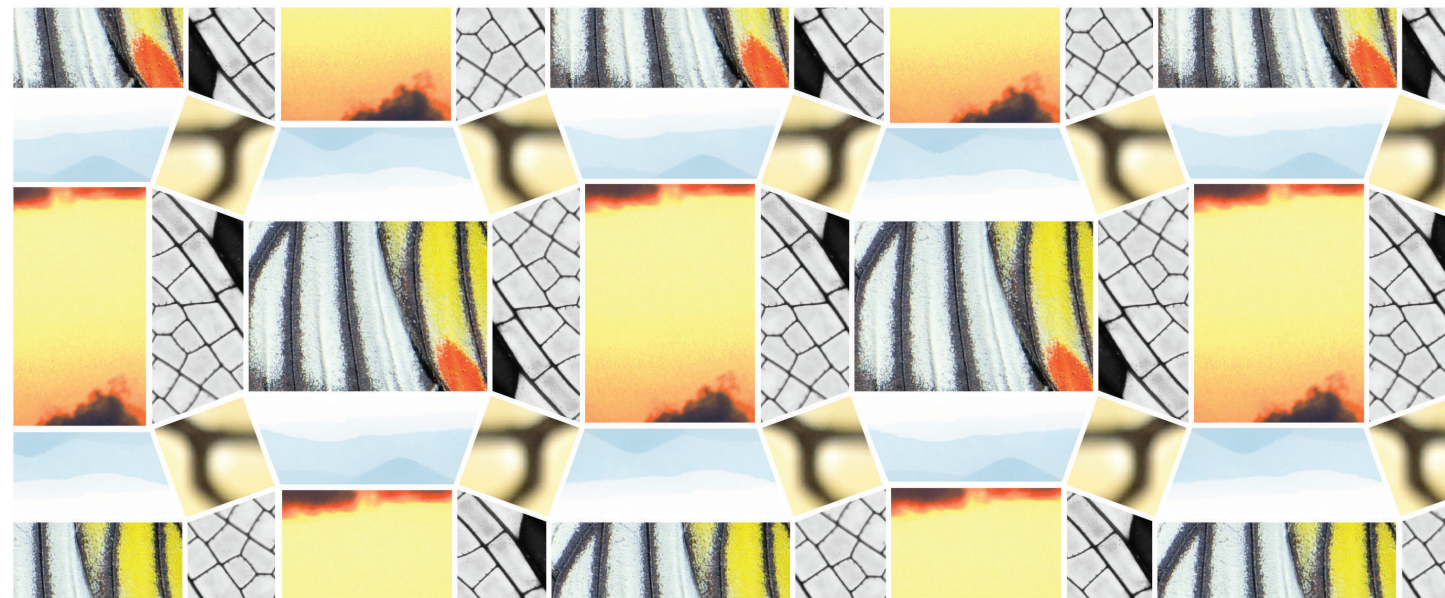
Semi-Regular Non-Uniform Non-Periodic Pattern using 3 polygonal shapes: hexagon, triangle and rectangle | Tortoise



Semi-Regular Non-Uniform Periodic Pattern using 3 polygonal shapes: hexagon, triangle and square | Cephalopod



Regular Uniform Non-Periodic Pattern using the same rectangular/square shape throughout | Monarch Butterfly



CASE STUDIES

After learning the principles and techniques of surface mimicry, fractals and tessellation patterns, it is easier to understand when applied to an actual design scenario. The following packaging design case study clearly demonstrates the third stage of the biomimetic design process, *observing*.

VISUAL MIMICRY

<http://designmomentum.wordpress.com/>

Just as some flies mimic wasps to better ward off predators, off-brands can mimic well-known brands to appeal to a pre-targeted market.¹

Many of these generic store brands have become pretty successful at mimicking the appearance and packaging of the dominant, flourishing, and popular name brand. The designers of the store brand use the time saved coming up with and testing the initial brand strategy for researching other biomimetic strategies.² While designers still have to spend some time learning and imitating, they can stay current on trends when conditions change

and can imitate the best designs, altering them ever so slightly.

To learn from past designs, designers can look through design magazines, blogs, and other materials that relate to their specialty. Just as organisms adapt to what works to keep them alive through the process of evolution, graphic designers, through trial and error, learn significantly from past mistakes and successes. Keep abreast of current design context shows how others are responding, or not responding, to these changes.

Another scenario is in looking at 'fake' spots on wildlife and the camouflaging tactics many use. Just as these attributes can misdirect or even attract prey by startling them into believing they are something resembling their predator, graphic design pieces can alert users to view specific elements of a design target first.³ Many direct mailers do this using bold typography or images clearly visible yet putting fine print at the bottom telling the whole truth. Users will easily learn the trick and a new design must be attempted. If the goal is sustained communication, endeavor to form designs that help foster cooperative relationships, not ones that fool the user.

Generic Store Brand



Name Brand



This case study perfectly exemplifies some of Nature's Design principles:

- 3 Evolve Solutions, Don't Plan Them
- 4 Adapt to Changing Conditions
- 13 Foster Cooperative Relationships

This means foregoing authorship and accommodating to the times by creating design solutions that will be sustainable and better the end user and target audience.

¹ Jessica Jones, DesignMomentum Blog

² Jessica Jones, Sustainable Graphic Design, Wendy Jedlicka

³ Jessica Jones, Sustainable Graphic Design, Wendy Jedlicka

Creativity can solve almost any problem.
The creative act, the defeat of habit by
originality, overcomes everything.

GEORGE LOIS

¹ Dave Tilford, *Sustainable
Consumption: Why
Consumption Matters*

4

DEFINING

ANALYZING

OBSERVING

SELECTING

IMPLEMENTING

EVALUATING

What Tools Would Nature Use?

The fourth stage in the biomimetic design process after observing is *selecting*. In context, this is all about the selection of tools and materials necessary to produce the final design solution. It is asking the questions, what tools would nature use? How would nature start the selection process? It is first necessary to look back at why our current consumption cycles began and how we can prevent the drought of the finite resources available. Since the Industrial Revolution began in the 1800s, the world has been on an unprecedented consumption binge. Since 1950 alone, the world's people have consumed more goods and services than the combined total of all humans who ever walked the planet.¹ Nature would never let this happen and cannot afford to.



LIFE-FRIENDLY MATERIALS

Reducing our Carbon Footprint

Modern design emerged in response to the Industrial Revolution, when reform-minded artists and artisans tried to impart a critical sensibility to the making of objects and media. Design took shape as a critique of industry, yet it gained its mature and legitimate status by becoming an agent of machine production and mass consumption.¹ In the 1940s and 1950s, organic forms and materials provided designers with a humanist vocabulary that affirmed society's place within the natural world. By the end of the century, a new 'organicism' had emerged, as nature itself was transformed by a host of technologies.² Although the Industrial Revolution gave rise to modern capitalism today and it greatly expanded the possibilities for the material development of humankind, it does so at a severe price. The electronic offshoots of the Machine Age threaten to dissolve some of nature's most valuable assets. Since the mid-eighteenth century, more of nature has been destroyed than in all prior history. While industrial systems have reached pinnacles of success, able to muster and accumulate human-made capital on vast levels, natural capital, on which civilization depends to create economic prosperity, is rapidly declining, and the rate of loss is increasing proportionate to gains in material well being.³

Every consumer product comes from the Earth and returns to it in one form or another. We have increased our supply of material goods and services at the direct expense of natural services.⁴ As Janine Benyus says, 'heat, beat, treat' has become the de-facto slogan of our industrial age; it is the way we synthesize just about everything.⁵ Nature, on the other hand, cannot afford to follow this strategy. As previously mentioned of Benyus in the second chapter, *Analyzing*, under the ninth design principle of nature, 'Use Life-friendly Chemistry,' life cannot put its factory on the edge of town; it has to live where it works.

¹ Ellen Lupton and J. Abbott Miller, *Design Writing Research: Writing on Graphic Design*

² Ellen Lupton, *Skin*.

³ Paul Hawken, Amory & Hunter Lovins, *Natural Capitalism*

⁴ Dave Tilford, *Sustainable Consumption: Why Consumption Matters*

⁵ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

⁶ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

⁷ Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

⁸ Wendy Jedlicka, *Sustainable Graphic Design*

⁹ Wendy Jedlicka, *Sustainable Graphic Design*

As a result, nature's first trick of the trade is that nature manufactures its materials under life-friendly conditions—in water, at room temperature, without harsh chemicals or high pressures.⁶ Despite what we would call 'limits,' nature manages to craft materials of a complexity and a functionality that humans can only envy. Nature has the innate capability to customize materials through the use of templates. In contrast, humans muddle by in using industrial chemistry with final products that are a mishmash of polymer-chain sizes, with most too long or too short to be of ideal use. Nature makes only what she wants where she wants and when she wants.⁷ There is no waste on the cutting-room floor. As designers, we are one step ahead in the right direction, using templates and grid systems in our designs to effectively and efficiently use the resources available to us. However, society as a whole tends to maximize when it perceives there is an inexpensive abundance of materials readily available to it. Yet the Earth has limits and boundaries, and there is a finite amount of resources at our disposal. It is important to see the entire system and become aware of costs to others when designing or choosing supplies.⁸ In terms of choosing supplies, in theory it has been known that picking an eco-material is a better move than picking an un-eco one. However, if a designer does not know why a material is eco, how to implement it correctly, or even if it actually is 'eco,' taking a typically shallow replacement approach can end up with impacts far worse than the things being replaced.⁹ This is where possessing the knowledge and skills of how to effectively select the right tools and materials is crucial. Relying on the sixth design principle of nature, 'Self-Appropriate Technologies,' will help to do so. As graphic designers, even though we cannot directly change how paper is manufactured, we can voice our concerns, suggest alternatives, and hope that people upstream and downstream catch hold of and implement our ideas. Today, we assume that the way we are doing it is the best way, but it might not be.

¹⁰ David Wann, *Biologic: Designing with Nature to Protect the Environment*

The fatal flaw of technologic and human thinking, especially in the years since the Industrial Revolution and WWII is that modern technology is like a two-legged stool: "Our science was well founded in physics and chemistry, but flawed by a missing third leg— the biology of the environment."¹⁰ It is crucial that society and modern industries today recognize and understand our routine of over consumption and how it is detrimental for future generations. David Tilford in his article, "Sustainable Consumption: Why Consumption Matters" explains in the simplest way how we are over-consuming goods and services and negatively impacting natural ecosystems:

Our cars, houses, hamburgers, televisions, sneakers, newspapers and thousands upon thousands of other consumer items come to us via chains of production that stretch around the globe. Along the length of this chain we pull raw materials from the Earth in numbers that are too big to even conceptualize. Tremendous volumes of natural resources are displaced and ecosystems disrupted in the uncounted extraction processes that fuel modern human existence. Constructing highways or buildings, mining for gold, drilling for oil, harvesting crops and forest products all involve reshaping natural landscapes. Some of our activities involve minor changes to the landscape. Sometimes entire mountains are moved.¹¹

¹¹ Dave Tilford, *Sustainable Consumption: Why Consumption Matters*

Recognizing that we need to reduce our ecological and carbon footprint is the initial step towards a more sustainable future. An ecological or carbon footprint is defined as the amount of productive land area required to sustain one human being.¹² As most of our planet's surface is either under water, there are only 1.9 hectares (about four football fields) of productive area to support each person today (grow food, supply materials, clean our waste). That might sound like a lot but our collective ecological footprint is already 2.3 hectares. This means that, given the needs of today's human population,

¹² Wendy Jedlicka, *Sustainable Graphic Design*

¹³ Wendy Jedlicka, *Sustainable Graphic Design*

¹⁴ Statistical data from www.footprintnetwork.org

¹⁵ Wendy Jedlicka, *Sustainable Graphic Design*

¹⁶ Annie Leonard, The Story of Stuff, Free Range Studios video at www.storyofstuff.com

¹⁷ William McDonough & Michael Braungart, *Cradle to Cradle*

Get certified!
www.c2ccertified.com
Cradle to Cradle certification provides companies with the means to tangibly and credibly measure achievement in environmentally-intelligent design and design for material reutilization such as recycling

we already need 1.5 Earths to live sustainably. But this assumes all resources are divided equally. Those with the largest carbon footprint— the biggest consumers of global resources— are US citizens, who require 9.57 hectares *each* to meet their demands.¹³ If everyone in the world consumed at that rate, *5 Earths* would be needed to sustain the population. People in Bangladesh, in contrast, need just 0.5 hectares; for people in China today, the footprint is 1.36 hectares.¹⁴ Part of why the US carbon footprint is so large has to do with trade access to more than the country's balance of natural capital. Much of this natural capital comes from countries that have some resources but not much else from which to earn cash.¹⁵ Due to corruption, or desperation, many of those countries are selling off their resources quickly, regardless of the long-term consequences. After six months, 99% of the resources to make things we use is converted to waste— disposed of as finished goods, but mostly as processed waste.¹⁶

The main point to understand about the selection of tools and materials within the biomimetic design process is that whatever is naturally here is all we have. Whatever humans make does not go 'away.' We need to eliminate the concept of waste which means to design things— products, packaging and systems— from the very beginning on the understanding that waste does not exist.¹⁷ Nature has relied on this mindset and because of that, has flourished on this planet for billions of years. Yet, this may not be the case in the near future if we continue our bad habits. Ways to shift these bad habits towards good ones would be to constantly ask yourself these fundamental questions: Does it make us or the planet sick? (Don't do it!) Are you picking your material because it is the best one for your application or the same as it is always done before/your competitor is using it? Can we be happy without having more and more stuff?

CASE STUDIES

The following biomimetic design case studies clearly demonstrate how in self-appropriating technologies and selecting efficient materials and resources, one can still achieve quality designs that are sustainable, as well as conducive to life.

CELERY DIVIDER TABS

<http://designmomentum.wordpress.com/>

Celery Design Collaborative seeks out beautiful and innovative ways to make things. The more interesting the challenge for them is to use design as a means of effecting change.¹ So, they took on the design challenge to try and come up with a simple solution to eliminate the waste created when a divider tab is cut out of a larger sheet of paper. And they did it. In the end, Celery designed a simple die-cut pattern where the tab can be folded out of the middle of the paper and placed through a slot to hold the tab in place.²

This consequently influences where a graphic designer places their designs and what message it communicates. This is a very good example of how nature would design using the principles of graphic design. These divider tabs also illustrate how graphic designers can have impact on an entire system. First, the designers had to recognize a status quo— they do not have to work with pre-made divider tabs that create waste when manufactured. And then they need to take that thought and design challenge to come up with a successful solution.



¹ Celery Design Collaborative, www.celerydesign.com

² Jessica Jones, DesignMomentum blog

CERTIFICATE CASING

<http://designmomentum.wordpress.com/>

Instead of buying a plastic diploma or certificate case off of the internet, Biomimicry 3.8 designed their own. This is the first prototype with even more potential to make it more life-friendly in the next iteration. As all designers know, there are time and resource constraints in which a project must be completed, so most projects will not be completely life-friendly the first go around. Biomimicry is inevitably iterative just as nature is constantly adapting and evolving.

- This adopts the following design principles of nature:
- 6 Self Appropriate Technologies
 - 7 Be Resourceful
 - 8 Optimize Rather than Maximize
 - 13 Foster Cooperative Relationships

The case doubles as a clip board and a mat for framing, and of course a protective casing for getting it back home.

Biomimicry 3.8 did not want the end users to just stick it in their bookshelf (where most plastic diploma cases end up) but instead showcased on a wall. The graduates are part of a larger network and meme and by providing a pre-made mat this encourages them to frame it and remember this bigger idea. The clipboard also suggests continued learning and collaboration toward a greater goal.

The laser cuts were also made on a personal laser cutting machine. Local connections are a leverage point for designers in cultivating cooperative relationships.



Perhaps in the end, it will not be a change in technology that will bring us to the biomimetic future, but a change of heart, a humbling that allows us to be attentive to nature's lessons.

JANINE BENYUS

- DEFINING
- ANALYZING
- OBSERVING
- SELECTING
- 5 **IMPLEMENTING**
- EVALUATING

How Would Nature Delegate?

The fifth stage in the biomimetic design process after selecting the appropriate tools and materials is *implementing*. It is here where the collaboration at the design table begins. BaDT's, architects, designers, business men, CEO's all come together. Using the language of change, businesses are now asking what natural capital is and how it is spent. What economic lessons can be drawn from nature? How do market forces shape the way we live, work, and play? How can we nurture the corporate green thumb? Today's leaders understand the interplay between governments and people, stockholders and stakeholders, humans and the environment and how all things interconnect and direct how and what we need to create.¹

¹ Wendy Jedlicka,
Sustainable Graphic Design



BIOMIMICRY + CORPORATIONS

Network & Facilitate

Bringing biomimicry into every corporation around the world is a dream for biomimetic designers. In doing that, it would enable for more interdisciplinary team work where biologists would work with architects, designers, and CEO's, ultimately cultivating and fostering cooperative relationships around the globe. Today, business attitudes are already acting on this and implementing the biomimetic design process within their corporations. The reason biomimicry is so important to integrate into businesses and corporations and why this topic is stressed is because of the power and ability these corporations have and hold in changing the perception of their consumers; which in turn has the power to generate change and the perception of society in general. In an interview with Janine Benyus, she explains why biomimicry now is so vital and why it is the key to bettering our future:

We humans are at a turning point in our evolution. Though we began as a small population in a very large world, we have expanded in number and territory until we are now bursting at the seams. There are too many of us, and our habits are unsustainable. Having reached the limits of nature’s tolerance, we are finally shopping for answers to the question: “How can we live on this home planet without destroying it?” Just as we are beginning to recognize all there is to learn from the natural world, our models are starting to blink out— not just a few scattered organisms, but entire ecosystems. A new survey by the National Biological Service found that one-half of all native ecosystems in the United States are degraded to the point of endangerment. That makes biomimicry more than just a new way of viewing and valuing nature. It’s also a race to the rescue.¹

So, in order to act on this biomimetic design process in hopes for betting the future, what is need is a shift in perception, including a shift in the way we live and work within businesses. Many innovators are starting to grasp this concept.

¹ For the full interview with Janine Benyus, go to <http://www.biomimicryguild.com/janineinterview.html>

² For more information about Michael Pawlyn and his work with *Exploration*, go to <http://www.exploration-architecture.com>

³ Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age, 2/22/12 <http://www.wired.co.uk/>

⁴ Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age

⁵ Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age

One of them is, Michael Pawlyn, a world renowned architect, established the architecture firm *Exploration* in 2007 to focus on environmentally sustainable projects that take their inspiration from nature and biomimicry.² He recently published a book, *Biomimicry in Architecture*, that not only gives examples of where biomimicry has been used in corporations, but also answers some of the issues that naysayers raise.³ Pawlyn argues that a lot of the technology needed to make this integration of biomimicry within corporations happen is already available. In the book, he points to George Chan's sorghum brewery in Tsumeb, Namibia, which was built to deliver 'good beer, no pollution, more sales and more jobs.' It produced 12 products instead of simply just beer and these included the nutrient-rich alga spirulina, mushrooms grown in the spent grains and gas from an anaerobic digester which was used instead of burning wood.⁴ Pawlyn enthuses:

For me, biomimicry is just one of the best sources of innovation to get to a world of zero waste because those are the rules under which biological life has had to exist. And it hasn't just existed in a really miserable, self-denying way, but in a celebrated, abundant and regenerative way. I think we need to move to a far more positive way of talking about the future. A lot of sustainable design has got very stuck in very familiar solutions and even familiar materials and forms, and so there's so much more to it. If you look beyond the nice shapes in nature and understand the principles behind them, you can find some adaptations that can lead to new innovative solutions that are radically more resource efficient. It's the direction we need to take in the coming decades.⁵



CREATIVE SESSIONS

Cross-Disciplinary Design Tables

One of the largest, contributing factors when integrating biomimicry into corporations is the use of cross-disciplinary design tables during creative brainstorming sessions. This is where innovators and professionals from all fields come together and sit down to discuss the potential biomimicry has in helping their businesses and corporations thrive in the marketplace and co-exist with the surrounding ecosystems. Two major design companies, IDEO and Smart Design, put biomimicry and BaDT's (Biologists at the Design Table) to the test, tackling design problems for real-world clients alongside biologists from the Biomimicry Institute.¹ The magazine, *Fast Company*, posted the following case studies and wanted to do a follow up/check in with both IDEO and Smart Design to see if they thought biomimicry as a new tool could help advance their businesses. Below is a section of the article from fastcompany.com, shown to best illustrate what the companies thought of the entire process:

Richard Graves, vice president of the community for the U.S. Green Building Council, said he was skeptical at first having IDEO take a biomimetic approach to redesign their organizational structure and if it would prove useful beyond just theory. "To be honest, I was not sure how much we would get that would be usable, but I see many ideas that can be explored and developed," he says. "I was surprised at how many of the ideas seem very practical and implementable." One particular solution that stood out to him was an idea to signal the health of USGBC chapters that was inspired by a pink flamingo: The "health" of the flamingo—or how much shrimp it eats—is outwardly reflected in the shade of pink of its feathers. "Having a simple, clear characteristic that reflects the health of an organization would be very useful in the chaotic world we live in," he says. "How to achieve this?"

Ultimately, Graves was impressed with the way biomimicry reframed their internal issues. "Biomimicry is a great tool to integrate into the design process of an innovative company or organization," he says. "We saw it as a way to have a different lens on challenges we have been working on for some time."

The second challenge focused on Smart Design's ideas for cities to conserve water as part of IBM's SmarterCity initiative. "IBM itself is no stranger to a biomimetic approach," says Ian Abbott-Donnelly of IBM Big Green Innovations, pointing to a recent computer-chip using the same self-assembling nanotechnology that builds snowflakes and seashells. But the fact that Smart Design was able to examine biomimicry at city-scale, using larger principles based on an ecosystem's feedback loops, proved that biomimicry can work for their initiative working at the civic level. "This work gives some well thought-out stories of how to apply biomimicry to cities which can easily be discussed with teams operating in cities," he says. "I am hoping that this new thinking will enable cities to explore and implement solutions which have the right insight to be effective." ²

The Biomimicry Guild is currently working on a concept called the Biomimicry Innovation Process, which can help take the process from this charrette point into conception and marketplace in the most sustainable way. Bringing business and biomimicry closer together will be due to the variety of participants in the Biomimicry Professional Certification program, an intensive biomimicry training program.³ The latest round of graduates in the two-year program included biologists, engineers, designers and even four people with business backgrounds and it is that kind of diversity and cross-disciplinary approach that will ensure that biomimicry can be embraced by various walks of life.

¹ See the Case Studies section at the end of this chapter for further information on these companies and their biomimetic process and approach towards design problems

² For the full article, go to <http://www.fastcodesign.com/1661865/could-biomimicry-build-a-better-company-than-your-boss>

³ For more information about applying for the Biomimicry Professional Certification Program, go to http://www.biomimicry.net/ProfessionalPathways/upcoming_courses/bspecialty.html

CASE STUDIES

Below are the two case studies with IDEO & the USGBC, as well as Smart Design's IBM SmarterCity Initiative, that were previously mentioned. Both show how by incorporating the biomimetic design process within your own corporation's creative sessions can lead to new, innovative ideas and design solutions.

IDEO & THE USGBC

<http://www.fastcompany.com/>

The United States Green Building Council (USGBC), most notably founded the LEED certification system that rates structures by sustainability.¹ With 80 local chapters nationwide, they struggle with challenges like making group decisions and the ability to keep members motivated and involved. The USGBC wanted to investigate redesigning their organization in a way that was more closely aligned with their mission to protect and celebrate nature. In their words, they wanted to be more 'resilient and organic' in how their organization communicates with stakeholders.

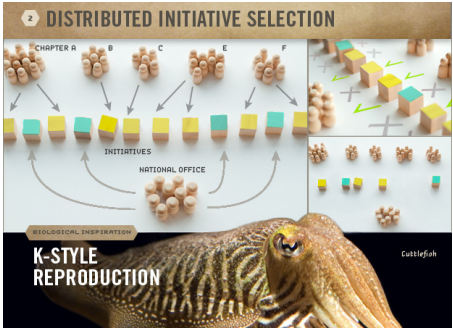
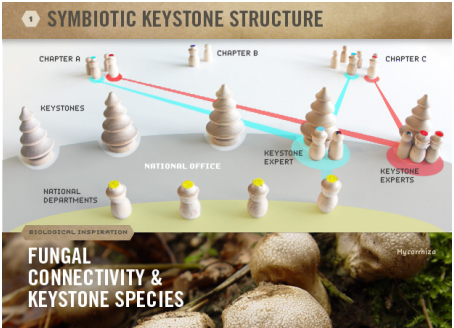
IDEO's Boston office took on this hefty problem from the USGBC, which would essentially require a system-wide redesign for the way that their members communicate. Yet after interviewing USGBC stakeholders, IDEO's team reframed the statement to broaden the focus to the organization's structure itself and how different parties would connect within it, including the tools that would help make these connections. The reframed challenge became to 'design an organization strategy to improve the effectiveness of a locally distributed effort, while staying aligned to the national

USGBC mission.' A biomimetic approach was particularly intriguing to the IDEO team because the firm is so well known for their human-centered design process. But instead of dismissing their own approach for a strict biomimicry approach, the IDEO team and their assigned biologist at the design table (BaDT) Tim McGee had a better idea. Working with IDEO's project lead, designer Eleanor Morgan, McGee weaved biomimicry into IDEO's human-centered approach, resulting in a 'mash-up' that incorporated biomimicry thinking into IDEO's existing design pathways.

¹ Seen here is just a portion of the article on fastcompany.com. To see the full article, go to <http://www.fastcompany.com/1643489/biomimicry-challenge-ideo-uses-nature-to-reorganize-the-usgbc>

The result was almost paradoxical, says creative director Jane Fulton Suri. "We were really happy just to go along with their process and throw ours out the window," she says. "But in talking with Tim it was clear we'd all benefit from learning about how these two processes could effectively meld together."

McGee thinks the hybrid approach revealed some insight into the Biomimicry Guild's process. "I think IDEO's outstanding insights into 'human centered' design can actually help define and drive what it means to do biomimicry," he says, "because at the center of our relationship with nature is ourselves." For IDEO, the challenge gave the team a new set of tools they hope to apply to future projects. "It really does feel like an amazing untapped resource," agreed Fulton Suri. They also realized how biomimicry in general could be a part of their own mission to create positive impact, says Morgan. "If we could distribute these BaDTs around the world we could be in a better place."



SMART DESIGN & IBM'S SMARTERCITY INITIATIVE

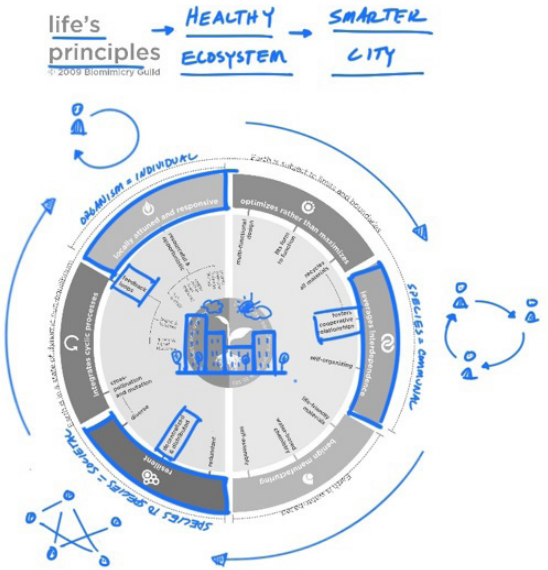
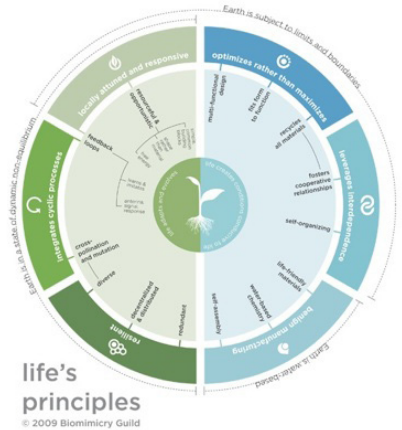
IBM's SmarterCity initiative is a program that uses the company's information technology to help municipal governments create healthier, more intelligent urban environments for their residents.¹ Using their ability to collect and analyze data, IBM is able to provide information about elements of daily city life ranging from weather and traffic to water usage and air quality. But what they have done with that data has largely been used to make policy and economic decisions. IBM asked how they could use nature to understand how these overlays of information could help guide residents toward making better personal decisions for the good of the city. A New York-based team at Smart Design accepted their challenge.

After having a discussion with IBM, and walking through some day-in-the-life exercises that explored issues facing urban dwellers, Smart Design chose to focus on water conservation. Because of the complexity surrounding its systems, water is often misunderstood, says Tucker Fort, Smart's director of industrial design. "But unlike something like energy, it's a finite resource." Water was also something that residents interacted with everyday, and since IBM's goal was to make cities more responsive and resilient, using a biomimetic approach for encouraging more responsible water usage could have a real impact when implemented across an entire municipal area. Smart zeroed in on urban water consumption to explore how nature could inspire relevant, everyday solutions for city inhabitants to conserve water.

To immerse themselves in a biomimetic mindset, Fort, along with director of interaction design Ted Booth, and their team were introduced to the emerging discipline of biomimicry by their BaDT (biologist at the design table) Mark Dorfman. After a biomimicry primer, the team engaged in a blind-folded exercise where they were encouraged to smell, taste, touch, and listen to nature— anything that would break them of their reliance on vision. This is something Dorfman calls "quieting our cleverness." "If I were to show you a pine cone, you would see it and immediately know what it is, and that might be the end of your curiosity and exploration," says Dorfman. "But if you're blind-folded and handed a pine cone, you'll have to explore its shape, texture, smell, before figuring out what it is."

<http://www.fastcompany.com/>

The hope is that this process will open the designer's mind to viewing living things through a functional lens— a way that is particularly relevant to solving design challenges. Examining this representation of nature's complex systems, the designers realized that their solution would not come directly from an organism, but from this entire system as a whole: These core principles for life could work as a metaphor for a city, inspiring and informing solutions to make a healthier and smarter environment. For this solution, it also helped them to realize a simple truth: That some of the world's largest challenges will be overcome by changing the behavior of each individual within a larger system. "The modern city is just like an ecosystem," says Fort. "It seems so obvious, but if you just go right below the surface, there are all these inspirations and connections that are so meaningful."



¹ Seen here is just a portion of the article on fastcompany.com. To see the full article, go to <http://www.fastcompany.com/1648801/biomimicry-challenge-smart-design-ecosystem-approach-to-water-conservation-for-ibm>

We must be the change we wish to see in the world.

MAHATMA GANDHI

DEFINING

ANALYZING

OBSERVING

SELECTING

IMPLEMENTING

6 **EVALUATING**

How Would Nature Assess?

The last stage in the biomimetic design process after implementing the solution is *evaluating*. This is the point where a designer should step back and really assess the final design solution, asking incremental questions such as: Are the 14 design principles of nature evident and appropriately used? Did I understand and implement the solution to its fullest potential? In asking these questions, it is therefore, very important that designers understand and realize how we, humans, process information visually. There is a psychology and depth of processing involved within the change of the biomimetic mindset; changes in which we evaluate nature, how we design and ultimately, how we live our day-to-day.



THE BIOMIMETIC MINDSET

Psychology of Processing

It is crucial designers know how individuals process information. In order for an individual to understand a design solution resulting from the biomimetic design process, he/she needs to know the 'biomimetic' thinking behind the designer. Otherwise, one may think that any biomimetic design is 'just a form mimicking a natural form;' which is superficial thinking. There needs to be an evaluation of the final design solution, as well as an evaluation of how humans consume, teach, live, spend, work, play, and design. Are people doing all of these things in the manner that is the most conducive to life here on this planet? How would nature assess society's daily habits? In applying the biomimetic mindset, it opens up the possibility to make the necessary changes to live more sustainably.

In order to change one's mindset, perception, and/or outlook, one needs to expand the possibilities and one's creativity. This is the beauty of integrating biomimicry and nature's design principles within graphic design; coming up with ideas or solutions that one may have never stumbled upon otherwise. In order to expand one's creativity, he/she needs to affirm one's own individual creativity. Although many facets of human creativity are similar, they are never identical. All pine trees are very much alike, yet none is exactly the same as the other.¹ This is the benefit of having BaDT, combining creative minds of all types and backgrounds to create a unique design solution.

Along with expanding possibilities and creativity, focus is also key. All too often we are bombarded with information; an information tidal wave of sorts. With minds processing techniques and abilities, we do not make the fullest use of our ability to see.

¹ Michael Michalko, *Thinkertoys*

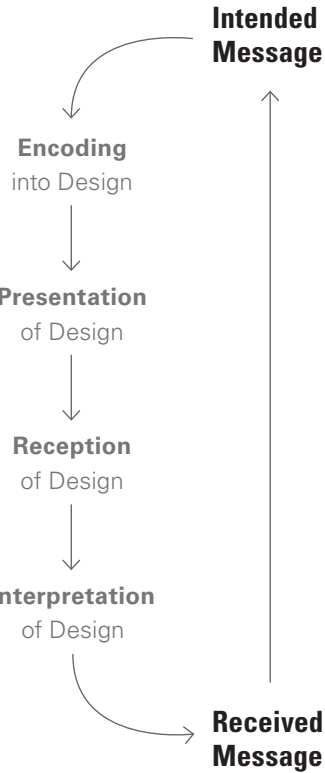
² Michael Michalko, *Thinkertoys*

³ Done in the defining stage of the Biomimicry + Graphic Design process

⁴ Michael Michalko, *Thinkertoys*

⁵ See informational diagram on right

We move through life looking at a tremendous quantity of information, objects, and scenes, and yet we *look* but do not *see*.² However, before one starts looking for ideas, he/she needs to know what one is looking for and what his/her goal is.³ The important step to take next is to set the problem or design challenge down in writing. Since our attention is constantly shifting, one may become indecisive about what, if anything, he/she should focus on. Psychologists have demonstrated that people are able to keep only about five – nine pieces of information in his/her mind at a time.⁴ Therefore, keeping sketches and thoughts written down related to one's project is essential in order to 'bake' them into one's shared consciousness. As designers, we rely heavily on the possibility system. Moving ahead with our ideas and information we gathered to create hypotheses and visions. These give us the framework through which to look at things (nature) and also something to work towards (biomimetic design solution). Therefore, our perception is the most important part of our thinking...how we look at the world, what things we take into account and, ultimately, how we structure our world. Perception works as a self-organizing information system, just as within nature, building on the smaller parts and creating larger sub-systems. Such systems allow the sequence in which information arrives to set up patterns; these patterns being the environments in which we encounter and organize to create recognizable systems for processing information. There is a life-cycle with which we process.⁵ As designers, it is pivotal we know this to understand how our viewer is perceiving our design solutions. The more we accept responsibility and dedicate ourselves to generating ideas found within nature, the higher the probability of reaching an innovative solution. Thinking is the ultimate human resource. The quality of our future will depend entirely on the quality of our thinking and of our mindset.





THE DESIGNERS ACCORD

<http://www.designersaccord.org/>

Many organizations are beginning to adopt the biomimetic mindset within their creative processes, understanding the implications it has over people's ability to process information in an easier and more efficient manner. One organization, in particular, has strived to do this since it's origin. With a call-to-action, in July of 2007, dubbed the Kyoto Treaty for design, the Designers Accord was founded as a global coalition of designers, educators, and corporate leaders, working together to create positive environmental and social impact.¹ Since then, the Designers Accord has become one of the fastest moving and most influential organizations within the creative community: It has been adopted by over 170,000 members, representing each design discipline.

In 2008, *Fast Company* wrote that it is "on a path to change the culture of the creative community from bottom to top, and with it, the way everything is made." Creatives from all over the globe are working to integrate the principles of sustainability into all aspects of design: from education, to practice and production, and ultimately consumption. They are catalyzing new thinking by collectively building our intelligence around issues of climate change and social justice, and tackling those challenges with optimism and creativity. The Designers Accord provides access to a community of peers that share methodologies, resources, and experiences around

environmental and social issues in design. This encapsulates the unifying philosophy of the Designers Accord: open source. They advocate inverting the traditional model of competition, and encourage sharing the best practices so everyone can innovate more efficiently, quickly and effectively. This relates to the third design principle of nature: Evolve Solutions, Don't Plan Them. This means design without authorship and letting go with dignity, allowing for open source.



This is an example of one of the Designers Accord's Case Studies. Frog design's color changing, lichen-based wall art is used to detect carbon monoxide or other pollutants in the home.



Another Designers Accord Case Study involving IDEO. This is IDEO's hourglass-inspired interface that visually controls electricity usage at home. When the hourglass empties, the electricity that runs through the house turns off automatically.

¹ Seen here is just a portion of the article on [fastcompany.com](http://www.fastcompany.com). To see the full article, go to <http://www.fastcompany.com/blog/valerie-casey/networked-culture/case-studies-sustainability-designers-accord-introduction>



PROGRESSING

The Future of Biomimetic Design

"At this point in history, as we contemplate the very real possibility of losing a quarter of all species in the next thirty years, biomimicry becomes more than just a new way of looking at nature. It becomes a race and a rescue. Here at the beginning of the twenty first century, environmental reality is setting in, pushing us to find saner and more sustainable ways to live on Earth. Equally important is what is pulling us towards biomimicry— that is, our deepening knowledge of how the natural world works.

Biological knowledge is doubling every five years, growing like a pointillist painting toward a recognizable whole. For the first time in history, we have the instruments— the scopes and satellites— to feel the shiver of a neuron in thought or watch in color as a star is born. When we combine this intensified gaze with the sheer amount of scientific knowledge coming into focus, we suddenly have the capacity to mimic nature like never before."

Janine Benyus

As aspiring designers, we must continue to push the envelope well past just sustainable and green graphic design and think with the biomimetic mindset and attitude, ultimately practicing with greater holistic awareness. There needs to be a basic, mutual understanding by all designers that by putting biological systems and nature's design principles into modern design practices results in ground-breaking, innovative design solutions. This biomimetic design process has the potential, if implemented correctly, to create and revolutionize an entirely new market of technological devices and designs that are unparalleled of those seen today.

¹ Janine Benyus, interview
<http://www.biomimicryguild.com/janineinterview.html>

² Steven Vogel, *Cats' Paws & Catapults*

³ Read more about Janine's thoughts on biomimicry and education at <http://www.fastcompany.com/1741949/innovative-nature-baking-biomimicry-in>

It is incremental that designers apply what they learn from nature and this biomimicry + graphic design process documenting their expansive, growing portfolios with their intellectual property and findings within their own process. There also must be an eagerness and willingness among designers to continue to collaborate with other innovators of different disciplines. One can only hope that corporations and businesses will demand there be BaDT's present at every cross-disciplinary design table in the near future. Nature teaches us the virtues of flexibility. Leaves, large algae, and feathers show us how to economize on material, how to change shape as environmental forces change, how to enlist the environmental forces themselves to produce those changes.² It would be irresponsible of us if we do not choose to listen and learn from nature's time tested ideals since it is there where we will find the answers to the problems we are currently grappling with today.

In regards to biomimicry moving forward within educational institutions for future generations to learn about the power of biomimicry + design, Benyus is most certain that biomimetic design labs are going to start appearing in schools very soon. "The future is that biologists will have a seat at the design table. But it starts with education and then trickles out to the workplace. Looking back, we had human factors, and now that's commonplace in a design conversation. I'm optimistic biomimicry will enjoy the same consideration in the coming years."³ It is a very exciting time as biomimicry continues to gain mainstream acceptance, with institutions and collaborations blossoming. The design industry and the planet need biomimicry integrated into the design process and it is going to take positive, hopeful, eager and willing designers to act on it. As Benyus says, "the design challenge of our century is we need a way to remind ourselves of those geniuses and to somehow meet them again."

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COLOPHON

DESIGN

Margaret McKosky

TYPOGRAPHY

Univers LT Std

Light, Bold, Condensed, Bold Condensed

Memphis LT Std

Medium

PRINTING

Blurb, <http://www.blurb.com/>

PAPER

Pages: Mohawk Fine Paper, 80# Standard Paper

Endsheets: ProLine Light Grey

Linen: ProLine Oatmeal Linen (made of 100% renewable cotton, never bleached, coated or dyed)

GRAPHIC DESIGN + BIOMIMICRY

Final Print Application

School of Design

College of Imaging Arts and Sciences

Rochester Institute of Technology