NOLEGEIN Journal of
Supply Chain and
Logistics Management

ISSN: 2582-0141
Volume 6, Issue 1, 2023
DOI (Journal): 10.37591/NJSCLM

http://mbajournals.in/index.php/JoSCLM/index

Review NJSCLM

Biomimicry and Waste Management

R. Ganesh[1,*]

Abstract

The rapid development of science and technology, as well as the growth of the population and the global problems require the study and solution of these problems through various methods, including many scientific disciplines or techniques. The increase in waste and the unsystematic depletion of natural resources requires new concepts and tools to create new environmentally friendly products. A new "circular economy" strategy is taking the place of the linear economy, which was founded on the "take, make, and discard" tenet. The circular economy seeks to lengthen product lifespans, cut waste, and manage natural resources sustainably. Biomimicry and cradle to cradle are two examples of circular economy trends or techniques. While cradle to cradle aims to reduce waste by utilizing nature's expertise, electronic technologies often attempt to solve problems by emulating natural processes. Understanding nature, its systems and cycles will provide comparisons and models for creating innovative solutions to global problems.

Keywords: Waste, circular economy, biomimicry, cradle to cradle, waste management

INTRODUCTION

Waste as we know is produced only by humans and is a problem of modern society that affects human health and the environment. Since the Industrial Revolution, the global economy has been characterized by a basic model, the "linear model of production and consumption". The linear economic model works on the principle of "take, make and dispose", whereby all products that humans no longer need end up as waste. Products that are cheaply manufactured, used and discarded are common. This linear economic approach leads to unsustainable consumption of natural resources and accumulation of pollution. This approach, not only from an economic perspective, has led to thinking about the unsustainability of the paradigm, that is to say, the unsustainability of modern civilization. On the other hand, the earth's resources are not inexhaustible and are increasingly threatened. Technological growth and development lead to lower production and selling prices, higher living standards for the population, and an uncontrollable imbalance between economic and environmental systems.

*Author for Correspondence
R. Ganesh
E-mail: 20134rg@gmail.com

[1]Ex-assistant Marketing Officer, Marketing Department, Savitribai Phule Pune University (SPPU) University, Pune, Maharashtra, India

Received Date: April 07, 2023
Accepted Date: April 29, 2023
Published Date: May 20, 2023

Citation: R. Ganesh. Biomimicry and Waste Management. NOLEGEIN Journal of Supply Chain and Logistics Management. 2023; 6(1): 5–12p.

The circular economy aims to operate according to the principle of product waste, that is to say, to guarantee a sustainable management of resources, extending the life cycles of products, minimizing waste and using renewable energy. With this new approach there is almost no waste, that is, it is minimized.

As shown in Figure 1, each stage of the circular economy tends to reduce costs, rely on natural resources and reduce waste. The model replaces the idea of "end of life" with restoration, the use of renewable energy and the elimination of the use of

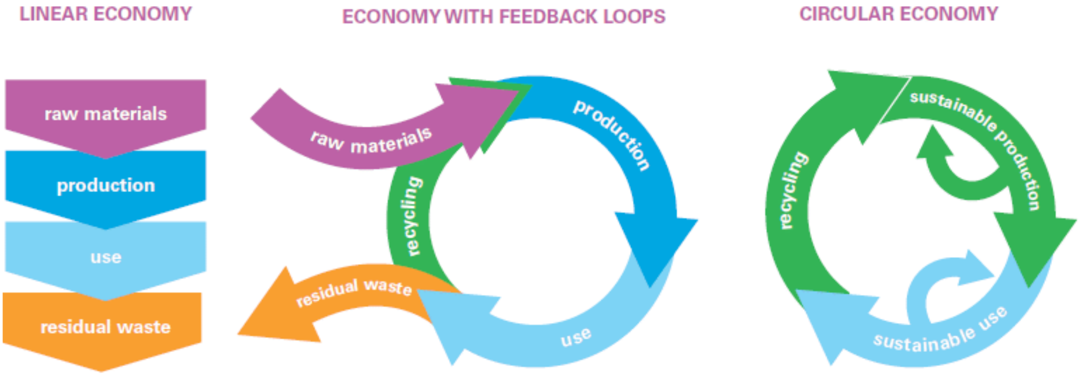

Figure 1. Linear and circular economy.

toxic chemicals. The product is made and used, and when it reaches the end of its useful life its resources are recovered, meaning the process starts from scratch. For example, factory waste becomes valuable for another process and products can be repaired, reused or improved instead of being discarded.

The objectives of the circular economy are to

- Reduce the consumption of natural resources,
- Extend the life cycle of used products and material components,
- Increase the consumption of renewable resources,
- Reduce emissions of harmful substances.

The circular economy aims to improve the quality of life of citizens through the development of new technologies, innovations, designs, standardized products, more efficient use of resources, increased competitiveness, creation of new jobs, easy promotions and new forms of business organization. Companies that adopt the circular economy model means that they act not only in the interest of society and the environment, but also in the interest of consumers and investors [1, 2].

The linear economy generates a lot of waste, which in the long run increases the cost of solving various environmental problems, consumes a lot of resources, and even makes some resources scarce. The circular economy is moving towards “zero waste”, changing product design and packaging, and promoting the concept of turning waste back into resources. The transition from a linear economy to a circular economy aims to consume as little natural resources as possible for all economic actors, to enable renewal through recycling, the introduction of innovative technologies, etc. [3].

In line with circular economy goals, European countries that have taken the initiative to implement a circular economy at national level include the Netherlands, Finland, Germany, Portugal, Italy, France and Slovenia. At the local and regional level, green and circular economies have been promoted in Catalonia (Spain), Scotland, London (United Kingdom), Amsterdam (the Netherlands), Paris (France) and others. The development of the circular economy is not limited to Europe, but includes other countries in the world, especially China, Japan and Canada [4].

We consider the circular economy as a complex holistic approach consisting of multiple development centers or tools (Figure 2).

NEW NATURE-INSPIRED CONCEPT

Biomimicry (bios meaning life and mimesis meaning imitation) is an adaptive approach to solving important and economic problems of nature, that is, by imitating natural phenomena and processes. Electronic devices can also be defined as a collection of innovations inspired by nature. Nature has been an inexhaustible source of inspiration for scientists, experts and artists in various fields.

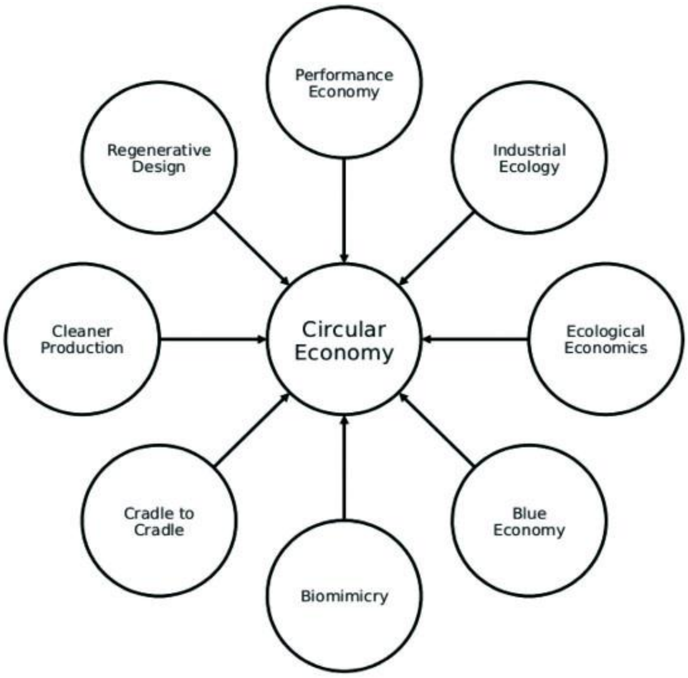

Figure 2. Key concepts closely related to the circular economy [5].

In nature, each organism is unique and perfectly adapted to its environment, life and survival in all conditions. We can see a tree growing from seed using nutrients and solar energy as it grows and develops and eventually dies and becomes food for new life and new beginnings. Through evolution, nature has solved many problems as plants, animals and microorganisms work in harmony or balance. The adaptations and processes that occur in each organism individually and through interactions with other organisms and the environment provide new knowledge and ideas that can be applied in various fields of human creativity, such as architecture. medicine, robotics, textile technology etc. [5].

The mimicry of nature is governed by three main principles:
1. *Nature as a model:* Imitation through the study of models of nature or the evaluation of new forms, processes, systems or technological problem-solving strategies for these models,
2. *Nature as a scale model:* In service of biomimicry for using environmental criteria to judge the sustainability of innovations,
3. *Nature as a guide:* In service of biomimicry for observing and understanding nature as a source of knowledge. Imitating nature is becoming more and more sophisticated with the development of technology, the synthesis of biologically sustainable and environmentally friendly materials, and the acquisition of new scientific knowledge and achievements.

Biomimetic principles are based on the laws of nature:
- Nature works under the influence of sunlight,
- Nature uses only the energy it needs,
- Nature recycles everything,
- Nature works according to the principle of diversity,
- Nature depends on diversity,
- Nature adapts to function,
- Nature does not allow waste.

The application of biomimicry in architecture and design is revolutionary. Humans adapt nature to improve their survival and survival in difficult conditions such as harsh climate, harsh geological features of the soil and inaccessible terrain. Design and build facilities based on the principles of bioelectronics to facilitate the overcoming of natural disasters such as earthquakes, floods, strong winds and increased radiation due to the destruction of the ozone layer. New ideas and innovative solutions in architecture aim to ensure healthy living and working conditions through sustainable design and eco-efficient facilities [6].

The lotus flower, or more precisely, some of its characteristics, has long been used in architecture and design. The German botanist Bartlow when he studied the lotus plant noticed that the leaves are completely clean, or that there are no impurities left on the leaves. At first glance, lotus petals appear smooth, but surface analysis reveals that the surface is rough. Water falling on the leaves in the form of droplets slides off the leaves along with the impurities [7]. This effect of the surface of the lotus leaf is due to its surface microstructure, which reduces the adhesion of dirt particles. The surface of the lotus leaf is highly waterproof and repels water. The water that falls on the leaves forms a ball, that is, it does not adhere to the surface of the lotus. This effect is also demonstrated by other plants such as nasturtium (Tropaeolum), reed (Phragmites), cabbage (*Brassica oleracea*) or columbine (Aquilegia) and some animals (wings of many insects) [8].

The self-cleaning ability of impermeable nanostructured surfaces was discovered in the 1970s by Wilhelm Barthlott, whose trademark is protected as the “Lotus Effect”. This desirable micro- and nanoscale property of highly hydrophobic surfaces is a purely physicochemical phenomenon that can be biomimetically transferred to technical surfaces. The lotus leaf cleaning phenomenon has been used to produce exterior wall coverings based on water resistance and a special microstructure to reduce the adhesion of dirt and impurities and protect exterior walls from microclimate. The original goal was to make the interface as smooth and regular as possible. Another possibility to use the lotus effect is to make self-cleaning awnings, tarpaulins and sails according to the principle of the lotus effect, since they are usually very dirty and difficult to clean. In addition, a hydrophobic glass surface was created. There is a lotus building in China, which is a treasure of modern architecture, and more importantly, it is a low-energy installation.

In nature, there is no such thing as waste; everything serves as sustenance for other systems or species. The materials are recycled and there are no sustainable and bioaccumulative materials. Living things on Earth are created by solar activity [9].

The production systems of the Industrial Revolution were based on the unidirectional or linear flow of materials from cradle to grave, a model of acquisition, manufacture and consumption. The materials are taken from nature and refined, and the products are collected by consumers, distributed, used and then disposed of in landfills or incinerators. Each step in this process often has unforeseen environmental and health implications. The toxicity of many processes and materials has increased with the development of modern industrial processes. Today, it is a legacy of linear models that have a significant impact on the global political landscape, the diseases we experience, the air we breathe, the water we drink, the climate we live in, and more.

Governments and business have embraced a strategy known as “eco-efficiency” to combat widespread environmental degradation, which entails cutting back on waste, pollution, and the depletion of natural resources. Many companies have made significant savings and reduced environmental impact by adopting eco-efficiency. But long-term prosperity does not depend on the health of fundamentally destructive linear economic models. This is based on the efficiency of processes that aim to be sustainable, healthy and renewable [7].

Cradle-to-cradle (C2C) design offers another option. It challenges the notion that human activity inevitably destroys the natural world or that consumer demand is what ultimately leads to environmental issues. Instead, it values plenty, human ingenuity, and optimistic goals. Today, our creations can reflect a new spirit thanks to a growing understanding of our planet. At all levels of human endeavour, cradle-to-cradle design embraces this new environmental consciousness. The intelligence, richness and effectiveness of natural systems—the flows of energy and nutrients that support the biodiversity of the planet—are the foundation of its principles [10].

Natural ecosystems operate according to basic principles that human design can emulate. First of all, there is no waste in nature since excreta from one organism feeds another. Second, solar energy is the source of all life on Earth. Third, diversity is essential to life, which constantly evolves to fill gaps. Cradle-to-cradle design emulates human industry from these natural principles. Imagine a solar-powered world where growth is healthy, waste is nutritious, and production diversity enriches both human and natural communities.

Applying cradle-to-cradle principles to industry results in a circular flow of matter (cradle to cradle rather than cradle to grave), like the nutrient cycle on Earth, eliminating the idea of waste. Each ingredient in the product is created to be both safe and efficient as well as a reliable supply for upcoming items. All substances are nutrients that circulate safely and efficiently in one of two "metabolites" [11]:

- Biological metabolism and
- Technical metabolism.

Life is maintained by a system of natural processes called biological metabolism. These processes involve the decomposition of organic matter and its association with living organisms, cyclically and ultimately driven by sunlight (Figure 3). Substances that contribute to metabolic productivity are vital nutrients. Ideally, human industrial products made from biodegradable and environmentally safe materials participate in biological metabolism by breaking down after use.

Engineered metabolism occurs in nature, and since the release of substances into ecosystems is inevitable, engineered nutrients should ideally cause little or no harm to biological metabolism. Lead is known to be so highly toxic that even small emissions can be harmful to human health and the environment. There are safer substitutes for automotive batteries (such as lithium-zinc) that have comparable performance. Although these alternatives are currently very expensive, they do not carry the environmental and health costs associated with lead [12].

The term cradle to cradle is a new concept of economic modeling using nature-like processes, in which substances are seen as nutrients flowing through biological or technological metabolism to healthy or safe metabolism. This healthy metabolism allows the reuse, improvement, natural reuse and

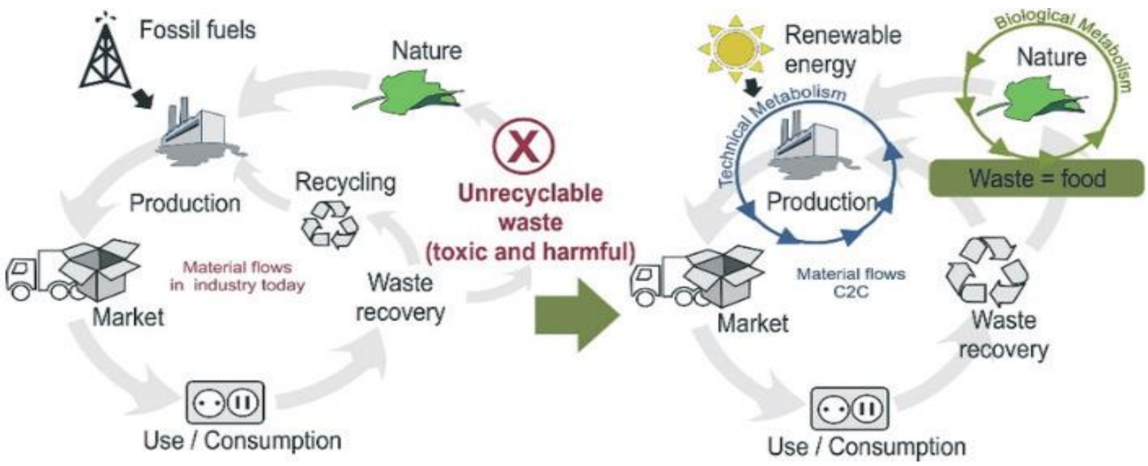

Figure 3. Cyclical metabolisms in cradle-to-cradle design.

preservation of the material. The concept of cradle to cradle shapes materials and objects according to models of natural processes. This new concept sees artificially created materials obtained in other industrial processes as nutrients perpetually permeating the healthy metabolism of the living world. This creates an unlimited life cycle of non-living matter based on a living world, where the biosphere equates to the technosphere.

The concept behind cradle-to-cradle design is that human design may be made more successful by taking cues from nature and utilizing its patterns. Through thoughtful design that reflects the concepts of natural safety, renewable productivity, and waste elimination, industries can transform into sustainable businesses that create economic, environmental, and social value. Cradle-to-cradle design is key to creating a renewable economy inspired by natural systems with social, economic and environmental benefit. Cradle-to-cradle design is based on the following principles:

1. Waste is food
2. Use renewable energy
3. Promote diversity

1. *Waste is food:* The first principle advocates to eliminate the concept of waste and encourage inspiration from nature's endless cycles of nutrients. Instead of experimenting with environmentally efficient ways to reduce the amount of waste, the goal is to design systems whose output can be absorbed by other processes as nutrients. This applies both to emissions during the production stage of the product and to emissions when the product reaches the disposal stage. To ensure that these emissions are subject to a 100% closed cycle, recycled materials must be defined as technical or biological raw material. While biological nutrients should be created to replenish the soil and benefit the environment, artificial nutrients should be created for industrial recycling. Nutrients that are biological and technological shouldn't be combined. Otherwise, we create products that are neither “metabolism” nor biological nor technological. These products can never be truly reused, but can only be recycled into products of lower quality and value [13].
2. *Use renewable energy:* The second principle states that the energy needed to run a closed-loop cradle-to-cradle cycle should come from what is known as “existing solar income”, which is defined as solar, geothermal, wind, hydro and biomass. These sources are consistent with the general understanding of renewable energies.
3. *Promote diversity:* Avoiding one-size-fits-all solutions and designing products and systems with the local context, economy, and culture in mind are the objectives of the last principle. The concept of ecological efficiency suggests that the objective should not be to lessen adverse environmental effects because doing so would result in the isolation of other species.

Cradle to Cradle Example in Practice

Upholstery fabrics that wear out with use can be designed with vital nutrients and can be returned to the ecosystem after use. Climatex® Lifecycle™ fabric is an example of such a product. The fabric is made from a blend of pesticide-free wool and organic ramie (Urticaceae), dyed and treated exclusively with non-toxic chemicals. All process products and inputs have been identified and selected for their human and environmental safety in the context of biological metabolism. Currently, textile waste (process waste) from the Garden Club is used as mulch for growing fruit and vegetables, returning organic nutrients to the fabric to encourage new growth. Nutrients from the Climatex life cycle return to biological metabolism based on their use and elimination after use. The design should facilitate the clean separation of materials from materials that cannot be used as vital nutrients, such as synthetic foams. The materials used for the processing and purification of materials must also comply with biological metabolism. Finally, the nutrient cycling of matter can depend on well-managed composting.

Engineered metabolism industry can also mimic natural processes to create engineered metabolic systems, systems that efficiently recycle industrial materials. Valued for their often “non-renewable” properties, these materials are feeders carefully designed to flow safely and eternally throughout the product life cycle, from cradle to production, use, recycling and 'removal'. Technology metabolism is a human-made, as opposed to a natural, process that is best fueled by the sun through renewable energy.

Another example is the mature lead-acid battery recycling system as a model for metabolic technological development. Customers like automotive batteries for their ability to store and supply electricity, but because they contain toxic elements, they are dangerous to both users and the environment. Financial incentives have been added to encourage the return of used batteries to authorized sites and to obtain credits for new batteries in order to lower the danger of leakage of hazardous materials. Old batteries are delivered to secondary smelters, where the lead, plastic, and acid are physically collected and used to create new ones. recyclable automobile batteries are the most recyclable consumer product in the United States because they contain more than 95% recycled lead and plastic [14].

The Swiss company Rohner uses 16 dyes in its fabrics without any toxic substances. Mixing these pigments can produce any shade. The waste from the sculpture's production process is turned into biodegradable felt. This felt is used in agriculture in the winter and completely decomposes in the spring to produce nutrients.

Since 2017, C&A has been eliminating clothing designs made from non-renewable materials, focusing on bio-based materials that can be reused, recycled and ultimately degraded safely.

The concept of the circular economy is increasingly being applied to the construction sector, and the industry is introducing more and more innovations that involve the use, revitalization and reincorporation of old materials into new forms. Urban agriculture is increasingly used in urban autonomous areas. Fruits and vegetables are grown on the roofs, which means that food is grown in the city, so there is no need to transport food in containers from other areas.

Another example of the application of the cradle-to-cradle concept in architecture is the renovation of the roof of the Ford Motor plant in the United States. Ford chose to build a green roof instead of building a water treatment plant. With 40,000 square meters of green roofs, the grass on the roofs of this artificial park collects and purifies the water present in the outside atmosphere.

The SPARK architect house in Singapore is another example of the application of the cradle-to-cradle concept through the construction of vertical hydroponics. The building creates a bottom-up nutrient waste recycling system, waste heat and electricity treatment systems, and saves costs by building a modern lighting system. The system is completely independent. In addition, the elderly lived in several apartments in the building. These people work in the garden, socialize and learn to grow plants in urban vertical agriculture, which has an important social component [15].

CONCLUSION

In recent years, the world is faced with the need to create new patterns of production and consumption by improving efficiency in the use of resources and achieving “zero waste”. The concept for achieving these goals is the circular economy. The circular economy as a global solution must reconcile the decrease of natural resources with the increase in demand, population growth and intensified consumption. The circular economy uses various tools such as: blue economy, green design, biomimetics, cradle to cradle, performance economy, etc. This article focuses on biomimicry and cradle to cradle where both concepts are based on nature and the capture and use of natural processes and imitation of nature in the creation of new products and services. For a long time, humans have created new products and materials that are out of sync with nature and natural processes. Various human-made materials have been created that nature cannot match, so we have human-made materials that have been breaking down in nature for a long time, for hundreds of years. The new approach, based on nature-inspired design, aims to place people and their actions within natural processes and in harmony with nature.

REFERENCES

1. Ahadian S, Ostrovidov S, Hosseini V, Kaji H, Ramalingam M, Bae H, Khademhosseini A. Electrical stimulation as a biomimicry tool for regulating muscle cell behavior. Organogenesis. 2013;9 (2): 87–92.
2. Avdiushchenko A, Zając P. Circular economy indicators as a supporting tool for European regional development policies. Sustainability. 2019; 11 (11): 3025.
3. Bach V, Minkov N, Finkbeiner M. Assessing the ability of the Cradle to Cradle Certified™ Products Program to reliably determine the environmental performance of products. Sustainability. 2018; 10: 1562.
4. Bonciu F. The European economy: from a linear to a circular economy. Romanian J Eur Aff. 2014; 14 (4): 78–91.
5. Bruel A, Kronenberg J, Troussier N, Guillaume B. Linking industrial ecology and ecological economics: a theoretical and empirical foundation for the circular economy. J Indus Ecol. 2091; 23 (1): 12–21.
6. Braungart M, McDonough W, Bollinger A. Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design. J Cleaner Prod. 2007; 15 (13–14): 1337–1348.
7. Eadie L, Ghosh TK. Biomimicry in textiles: past, present and potential. An overview. J R Soc Interface. 2011; 8 (59): 761-775.
8. Cattermole A. How the circular economy is changing fashion. AATCC Review. 2018; 18 (2): 37–42.
9. Das S, Shanmugam N, Kumar A, Jose S. Potential of biomimicry in the field of textile technology. Bioinspired Biomimetic Nanobiomater. 2017; 6 (4): 224–235.
10. Martin-Palma RJ, Lakhtakia A. Bioinspiration, Biomimetics, and Bioreplication 2013. Proceeding of the SPIE, San Diego, CA. 2013, March 11–13. London, UK: Elsevier; 2013.
11. Geissdoerfer M, Savaget P, Bocken NM, Hultink EJ. The circular economy – a new sustainability paradigm? J Cleaner Prod. 2017; 143: 757–768.
12. Ghisellini P, Cialani C, Ulgiati S. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J Cleaner Prod. 2016; 114: 11–32.
13. Habib MK. Biomimetics: innovations and robotics. Int J Mechatron Manuf Syst. 2011; 4 (2): 113–134.
14. Kaiser B, Eagan PD, Shaner H. Solutions to health care waste: life-cycle thinking and “green” purchasing. Environ Health Perspect. 2001; 109 (3): 205–207.
15. Kennedy E, Fecheyr-Lippens D, Hsiung BK, Niewiarowski PH, Kolodziej M. Biomimicry: a path to sustainable innovation. Design Issues. 2015; 31 (3): 66–73.

