# BIOMIMICRY: DESCRIPTIVE ANALYSIS OF BIODIVERSITY STRATEGY ADOPTION FOR BUSINESS SUSTAINABLE PERFORMANCE

***Sivave Mashingaidze*** *

**Abstract**

Biomimicry is a novel interdisciplinary field that mimics nature's best ideas and processes to solve human problems. The objective of this article was to do a descriptive documentary analysis of literature in biodiversity and to recommend for business adoption as a sustainable performance strategy. The research was however based on nine (9) Life's Principles, which were candidly inspired by nature. The research findings indicated that most business theories and strategies can mimic perfunctorily from nature for them to achieve a sustainable performance. The research was quite a conceptual and therefore did not offer direct practical proposition because its value was a descriptive of the ideas and strategies from nature and to outline its fundamental principles since biodiversity has track record of sustainability without men's interference which humanity can also mimic.

**Keywords:** Biomimcry, Biodiversity, Business, Sustainable, Ecology, Ecomimicry, Biomimetic, Bionics

** College of Economic and Management Sciences, Department of Business Management, University of South Africa.*
*Tel.: 0027 61 769 1986*
*E-mail: mashis@unisa.ac.za or sivave.mashingaidze72@gmail.com*

## 1. Introduction

Biomimicry is an "emerging discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems according to the Biomimicry website and emerging movement founded by science writer Jeanine Benyus, 1997.

Studying nature to get ideas to solve transdisciplinary human problems has recently received new attention from the field of biomimicry (Repperger, Phillips, Neidhard-Doll, Reynolds, & Berlin, 2006). According to (Benyus, 1997) biomimicry focuses ondesigns based in nature to create products, processes, andeven organizations and policies that are sustainable and adapted to nature's ways.

King Solomon the wisest Jewish King who ever lived the surface of the earth spoke along those lines of biomimicry with his sophistry encouraged indolent people to goand watch ants and learn from them, when he said"Go to the ant, thou sluggard, consider her ways, and be wise, which having no guide, overseer, or ruler, provideth her meat in the summer, and gathereth her food in the harvest" (Proverbs 6 vs 6). One would argue from the above biblical verse that humanity has been encouraged since time immemorial to learn from nature for life solutions since nature is endowed with answers. Fortunately biomimicry has only recently emerged on the business radar in the twilight of the 1990s, and was mainly fixated on product design engineering (Benyus, 1997 cited by Pedersen, 2007). As described in this section, it is a transdisciplinary subject that takes inspiration from nature to design innovative products and business processes (El-Zeiny, 2012). Biomimicry, or biomimickry is where the biosphere is mimicked as a basis for design, or a growing area for research in the fields of architecture, engineering and business operations (Pedersen, 2007). Biomimicry is an inspirational source of possible new innovation and business processes and because of the potential it offers as a way to create a more sustainable and even regenerative business environment (Benyus, 1997). It is not a familiar term to many in the business fraternity; hence the objective of this article is to do a descriptive documentary analysis of literature in biology, ecology, paleobiology, and evolutionary biology (biomimicry) as a new strategy for business sustainable performance. Therefore, the review of the literature begins with the definition of biomimicry and why it is important. The article is structured as follows: The researcher first introduces biomimicry a new approach for business sustainability and the look at descriptive documentary analysis as my methodology. Finally the research will briefly touch on the evolutionary history and describe the nine (9) Life's Principles, biomimicry and leadership, which was candidly inspired by nature, will be expounded.

### *1.1 Definition of Biomimicry*

The term "Biomimicry" first appeared in scientific literature in 1962 and grew in the usage in the 1980s in material sciences (Benyus, 1997 cited by Goss, 2009).The term 'biomimicry' is a derivative from the Greek bios; life, and mimesis, imitation (Benyus, 1997). Biomimicry is the imitating or taking inspiration from nature's forms and processes to solve problems for humans (Benyus, 1997). The preceding definition was broken further by (Benyus, 1997) as follows:

1. Nature as model. Biomimicry is a new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems, for example a solar cell inspired by a leaf.
2. Nature as measure. Biomimicry uses an ecological standard to judge the "rightness" of our innovations. After 3.8 billion years of evolution, nature has learned and discovered: What works. What is appropriate? What lasts? What does not last?
3. Nature as mentor. Biomimicry is a new way of viewing and valuing nature. It introduces an era based not on what we can extract from the natural world, but what we can learn from it.

In engineering, multiple terms label the practice of learning from organisms and systems present in the biosphere. These include: bioinspiration, biomimetics, bionics, biognosis and others (Schmidt, 2011).Biomimetics, biomimicry and bionics possess definitions traceable to those responsible for coining the terms. The engineering disciplines recognize Otto Schmitt as the originator of the word biomimetics (Bhushan, 2009). Schmitt purportedly created the term while developing a biologically inspired electrical circuit known in the electrical engineering community as the Schmitt Trigger (Schmidt, 2011). Schmitt defined biomimetics as, "'the mimicry of life,' or biology," and he believed that the products of this mimicry could help solve mankind's problems (Bhushan, 2009).

Biomimetics – "the study of the formation, structure, or function of biologically produced substances and materials (as enzymes or silk) and biological mechanisms and processes (as protein synthesis or photosynthesis) especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones" (Bhushan, 2009).

Bionics – "a science concerned with the application of data about the functioning of biological systems to the solution of engineering problems" or "the study of systems, particularly electronic systems, which function after the manner of living systems" (Bhushan, 2009).

### *1.2 Biomimicry as a panacea to business problems*

It is very evident in today's world that human development is going tangential with nature (Paul, 2010). The world is changing and every business needs to comprehend the global trends to remain workable and survive in the future and biomimicry is the only panacea to this. According to Paul (2010) the current business ecosystem breathes on:

1. Population explosion – growing inequality, aging population, and health challenges
2. Scarcity of resources – rising cost, migration of population
3. Biodiversity – extinction of species
4. Transparency and Awareness– People see what business do
5. Changing values – declining trust
6. Lack of skill

Paul, (2010) further stated that biomimicry increases efficiency and skills to the above business ecosystems and reduce costs, and this can allow humanity to both raise standards of living and preserve the environment and a cost-benefit evaluation points to the merits of biomimicry as reducing three major sources of costs:

1. The economic cost of pollution
2. The economic cost of waste disposal
3. The economic cost of natural resource depletion

### *1.3 What is Biodiversity?*

The Canadian Biodiversity Strategy defines biodiversity as the variety of species and ecosystems on Earth and the ecological processes of which they are a part – including ecosystem, species, and genetic diversity components (Vold, and Buffett, 2008). The United Nations Convention on Biological Diversity provides a similar definition for biodiversity: "the variability among living organisms from all sources including, inter alia [among other things], terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." In short, the term is used to refer to life in all its forms and the natural processes that support and connect all life forms. Biodiversity is not easily defined because it is more than just the sum of its parts, as all of its elements, regardless of whether we understand their roles or know their status, are integral to maintaining functioning, evolving, resilient ecosystems. Complex concepts such as biodiversity are often easier to grasp if reduced to their component pieces. While this approach does not give a complete picture of how these pieces interact and combine to create biodiversity, it helps us understand different aspects of biodiversity (Vold, and Buffett, 2008).

## 2 Research Methodology: Documentary Analysis

For the purpose of this study a descriptive research methodology has been adopted, because it is restricted to factual registration and thatthere is no quest for an explanation why reality is showing itself this way (Tsang, 1997). In principle, descriptive research is not aiming at forming hypotheses or development of a theory (Creswell, 2002). Through document analysis descriptive research isabout describing how reality is in the natural ecosystem. With descriptive research in its purest form explaining and evaluating is left to the reader or to other disciplines (Krathwohl, 1993).

Document analysis is the systematic exploration of literature from various disciplines, biology, ecology, paleobiology, and evolutionary biology, business or other artefacts such as films, videos and photographs. Hanson et al., (2005) argued that documents are unobtrusive and can be used without imposing on participants; they can be checked and re-checked for reliability. This methodology emphasizes an integrated view of speech/texts and their specific contexts. Texts in documentary analysis can be defined broadly as books, book chapters, essays, interviews, discussions, newspaper headlines and articles, historical documents, speeches, conversations, advertising, theater, informal conversation, or really any occurrence of communicative language (Robson, 2002).

Two criteria pivoted the selection criteria of literature that serves as the bedrock forthis research. First, the selected literature for review needed to explicitly describe or explain the biosphere inaccessible terms and also the literature from the texts needed to be general and all encompassing. General texts according to Robson (2002) are respected journals and sections of journals focusing on these disciplines (from biomimicry, biology, ecology, paleobiology, bionics, ecomimicry, biomimetics and evolutionary biology) served as secondary sources for this treatise. Keywords such as principle, biomimcry, business, sustainable, ecology, ecomimicry and bionics were used to query databases such as Web of Science, JSTOR (a digital library founded in 1995 and originally containing digitized back issues of academic journals, and it now includes books and primary sources, and current issues of journals), and UNISA Electronic Databases such as Sage Journal, EBSCO, SABINET.The researcher practically reviewed all the content available on the website of the Biomimicry Institute (Missoula, MT, USA; www.biomimicry.net)

## 3 Evolutionary biomimicry

Biomimicry appears to be a forgotten science more than a truly new one, since many people across history have turned to nature for human design (Yurtkuran, Kırlı, &Taneli, 2013). Leonardo da Vinci for example drew sketches of a flying machine inspired by birds' wings. Hence, biomimicry is relatively an old concept whichhas been revamped (Benyus, 1997).

### *3.1 Early biological analogies: organizations as human bodies*

Bio-spherical resemblance can be traceable back to classic great Greek philosophers. Socrates, Plato and Aristotle compared the polis (city or state) to the human body (Hodgson, 1988and Goggans, 2004). Just like a system is described as a working together of different components of a body to complete a definite goal.The same principle works the same like organs and limbs as they co-operate in the body, citizens – who hold a variety of skills among themselves which are vital to the polis (city or state) – work together in service of the polis (Hodgson, 1988 and Goggans, 2004). In turn, each citizen needs a healthy polis to satisfy their various needs – the relationship between the individual and the organization is based on interdependence. Furthermore, the organisation of the polis (city or state) does not come as the result of a plan, but as an emerging process (Hodgson, 1988 and Goggans, 2004).

The Irish political theorist and philosopher Edmund Burke in the 18th century and the Scottich chemist Andrew Ure in the 19th century also used biological analogies to discuss both political and business organizations (Edwards, 2001). Andrew Ure, in 1835 compared his "three principles of action, the scientific, moral and commercial to the muscular, the nervous, and the sanguiferous system of an animal" and suggested that "three distinct powers concur to their vitality - labor, science, capital; the first destined to move, the second to direct, and the third to sustain(Edwards, 2001). When the whole are in harmony, they form a body qualified to discharge its manifold functions by an intrinsic self-governing agency, like those of organic life (Edwards, 2001, citing Ure, 1835).

In the early 20th century, business management theorist (Emerson, 1918 cited by Vincent, Bogatyreva, Bowyer, & Pahl, 2006) made several biological analogies. He suggested studying the "marvelously perfect and adaptable" nature of trees or cells to understand organizations: "cells, whether in plant or animal life […] know how to organize, to grow, to develop, to coordinate, to cooperate" (Emerson, 1918 cited by Vincent *et al.*, 2006). Emerson also found inspiration in the way natural organizations are adapted to a succession of sudden and rapid changes, and long periods of routine which provided not only for a strong growth but also for renovation (Emerson, 1918 cited by Vincent *et al.*, 2006)

In the dusky of 1950s an American biophysicist Otto Schmidt and US Air Force doctor Jack Steele conducted research on machine engineering inspired by nature, for which they coined the terms biomimetics and bionics respectively (Vincent *et al.*, 2006). However, whereas these approaches do take nature as a 'model', biomimicry as proposed by Benyus, adds the 'measure' and 'mentor' dimensions which refer to sustainability and a profound mindset shift in terms of our metaphysical relation to nature and collective destiny as a species. In that respect, biomimicry can be truly be seen as a welcome novelty (Benyus, 1997. But biological analogies have a long history in politics, economics and management.

### *3.2 Evolutionary Economics inspired by biology*

Charles Darwin and Herbert Spencer's evolution and natural selection theory had a significant influence on early 20th century's economists (Foss, 2006). Darwin and Herbert also notably influenced Alfred Marshall who produced one of the most famous biological analogies which he compared young companies to young trees in the forest that struggle to grow in the shadow of their old rivals. Some die and others grow stronger and eventually "tower above their neighbors" before eventually dying of age (Marshall, 1925, quoted by Foss, 2006). This theory was the basis for neoclassical justification of free markets as advocated by Milton Friedman and put very simply by John D. Rockefeller (Foss, 2006). The growth of a large business is merely a survival of the fittest.

However the neoclassical school which has dominated economics thinking in the Western world in most of the 20th century, and whose Marshall is seen as one of the founders, eventually led to a "a historical, fully adapted, uniform equilibrium" view of the firm (Foss, 2006), in which there could be no variety, no selection, no evolution. Hence biological analogies disappeared from economics until 1970, with peripheral exceptions (Hodgson, 1995). UCLA economist ArmenAlchian did write a provocative paper called "Uncertainty, Evolution and Economic Theory" in 1950, which reintroduced the idea of evolution and variety. But his ideas were not picked up before a few more decades with Nelson and winter's Evolutionary Theory of Economic Change (1982). Their work challenged the neoclassical model of uniformity, rational agents and equilibrium with the ideas of variety, bounded rationality and non-equilibrium that resonate with system thinking to which we now turn (Hodgson, 1995).

### *3.3 Chaos, complexity and systems*

The twentieth century saw the emergence of a new scientific paradigmatic shift with the cybernetics and systems theories, which cover various disciplines among which mathematics, psychology or biology (Freedman, 1992). Major authors include the English psychologist W. Ross Ashby or the Austrian biologist Ludwig von Bertalanffy who introduced his General Systems Theory in 1968 (Freeman, 1982). While traditional science following Galileo, Descartes and Newton – had led to atomism and reductionism and in turn focused on analysis, prediction, and control, this new science emphasized chaos and complexity (Freeman, 1982). Originated in science these new ideas eventually permeated economics, business and organisation management and challenged the established thinking – based in Western economies on Taylorism.

Taylorism was indeed a product of the 19th century scientific regard for reductionism: breakings down things into isolated parts in order to better control them (Freeman, 1982). In the 1960s studies by Scottish researchers Tom Burns and G.M. Stalker, and British organization sociologist Joan Woodward exposed the limits of Taylorism (Freeman, 1982). Their work paved the way to the contingency theory according to which there is no one best way to organize a firm: the optimal management depends on the environment. In the face of an unstable and uncertain environment, Taylor's mechanistic organization – based on the fragmentation of work, the separation of planning from execution, and the isolation of workers from each other – is too rigid to adapt quickly to change – and is outperformed by the organic type of firm, more flexible and open. Co-evolution can be seen as the reunion of the idea of interdependence between the parts and the whole – demonstrated by to body metaphor – and that of evolution (Hodgson, 1995 and Goggans, 2004).

## 4 Biomimicry for business sustainable management

Although the major focus of biomimicry is on the technical design, Benyus' book does comprise a chapter about business management concepts in relation to biomimicry (Benyus, 1997). She referred to Paul Hawken's 'Ecology of Commerce' (1994) where theof concept of industrial ecology was developed by Michael Braungart and William McDonoughin (2002) with 'Cradle to Cradle', which focused on closed-loops systems – where waste equals 'food' or input – and solution-based business models (Benyus, 1997). Beside the application to organization and team management, biomimicry for business management has however not grown as much as its design counterpart. Yet, beyond specific technical solutions, nature provides a powerful and rich source of inspirational metaphors. This requires an understanding of more abstract and conceptual principles that govern nature (Chang, 2010).

However, only recently since the biomimicry movement emerged has business management been addressed through Biomimicry for Creative

Innovation (BCI). Biomimicry for Creative Innovation (BCI) is a collective of professional change agents, biologists and design professionals founded in 2009 that translated the Biomimicry Guild's 'Life's Principles' into a more business-oriented framework (Benyus, 1997). Nature Principles' suggest a set of behaviours and qualities which simply echo the law of the system – the Earth – upon which our lives – let alone our business – depend. They are neither a model nor a theory, but rather a philosophy which reminds us that while humans are a special species on Earth, we are still part of nature and subject to its law (Kaplinsky, 2006).

Benyus holds that nature has nine basic operating principles that can be used as a beneficial model for human behavior and business operations. She further posits these laws, strategies and principles have beenfound to be consistent over generations, and over cultures (Benyus, 1997). More importantly, they can be observedby anyone who is interested in perpetuating a highstandard of living in harmony with nature.

### *4.1 Nine Principles of Ecosystem Biomimicry*

By conducting a comparative analysis of related knowledge of ecosystem principles in the disciplines of ecology, biology, industrial ecology ecological design and biomimicry, a group of ecosystem principles aiming to capture cross disciplinary understandings of ecosystem functioning was formulated (Pedersen and Storey, 2007). It is intended that this biomimicry theory in the form of a set of principles based on ecosystem function could be employed by designers, to aid in the evolution of methodologies to enable the creation of a more sustainable built environment and business management (Pedersen and Storey, 2007). A set of ecosystem principles derived from comparing cross disciplinary understandings of how ecosystems function is detailed by Pedersen and Storey (2007) as follows.

Rewards cooperation and integration-makes symbiotic relationships work because nature is all about connections between relationships. Nature knows that we do not always haveto go it alone (Morgan, 1997). Moreover, nature allows predationand competition to exist through cooperation and natural ecosystems operate on a symbiotic, complex network of mutually beneficial relationships (Morgan, 1997). Working together is a rewarding and necessaryphenomenon in the natural ecology. Teams should be holistic and cross-functional, the same applies to business, people should be broadly trained rather than specialized so that they are interchangeable, and equipment should be general purpose and organized in cells that produce a group of similar products rather than specialized by process stage (Morgan, 1997, Hayes 1994). This idea is central to Business Process Reengineering, as promoted by Hammer (1990), discussing on Morgan's Six Models of Organization or holographic organization (Morgan, 1997) and to lean management, as observed with some of the most successful Japanese manufacturers (Hayes and Pisano, 1994,). In these organisations, capabilities must be distributed, according to the 'whole-in-parts' concept (Morgan, 1997). Bonabeau & Meyer (2001) commended on the collective behaviors of (unsophisticated) agents interacting locally, the agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave whether its local or to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Natural examples include swarm intelligence including ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling.

Nature always fits form to function, efficiently and elegantly. Zari (2007) and Reap (2005) describe the characteristic of form fitting to function as the use of limited materials and metabolic energy to create only structures and execute only processes necessary for the functions required of an organism in a particular environment.' Geometry and relative proportions found in nature are offered as examples of materials and energy efficiency by various authors (McKeag, 2013). Nature builds something that works because it was built within the confines of available resources. Also, the shape that somethingtakes depends upon what it is intended to do. Furthermore, nature's designs are organic andonly as big as they need to be to fit their function, rather than being linear (squares andblocks) and oversized, with a focus on form (Chang, 2010). Nature optimizes rather than maximizes. Organisms in nature co-evolve, work as teams, adapting to the changes of others (for example they fit form to function). Bio-Teaming catering to the pressing needs to face the major challenge present in today's organizations with respect to speed and responsiveness of teams. Thompson, a team dynamic expert has done an extensive research on understanding the methods of interactions and how teams achieve optimal co-ordination through non-verbal communication (Thompson, 2013). And according to his findings nature's team transmit required information relating to threats and opportunities in the surrounding atmosphere. For example, a honeybee does the waggle dance to indicate other bees about the presence of good nectar spot and each member takes independent actions to grab the opportunity (Thompson, 2013).

Nature depends on and develops diversity of possibilities to find the best solution(s), rather than a one-size-fits-all, homogeneous approach. Nature also depends upon randomness, more so than reason, because randomness creates anomalies that open

opportunities for diversity (Chang, 2010). This randomness of entropy (the breakdown of order) allows for flexibility (Chang, 2010). A wide variety of plants and animals create the bank of diversity. The entire habitat is used, not just bits and parts of the system. Also, a system must be as diverse as its environment in order to remain viable remarked Chang (2010).

Systems respect regional, cultural and material uniqueness of a place. Systems are flexible, allowing for changes in the needs of people and communities - allowing for emergent diversity. Organizations' should obviously not only be aware of external stakeholders. Sensing and responding to their needs and motivation of their employees will improve their engagement and consequently organization's performance. Furthermore, decentralization of decision-making to employee level greatly enhances the organization's ability to sense and respond to changes in its environment as employees' diversity and creativity is a source of innovation in terms of process and product (Morgan, 1997).

Nature recycles and finds uses for everything. Being adaptive requires a smart management of natural and technological resources. There is a "need for a fundamental conceptual shift away from current industrial system designs, which generate toxic, one-way, "cradle-to-grave" material flows, and toward a "cradle-to-cradle" system powered by renewable energy in which materials flow in safe, regenerative, closed-loop cycles" (Mc Donough *et al.*, 2003). This concept is directly inspired from nature where there is no waste as such, since waste is food. So "in closed-loop production systems, modelled on nature's designs, every output either is returned harmlessly to the ecosystem as a nutrient, like compost, or becomes an input for manufacturing another product" (Lovins *et al.*, 1999). Benign manufacturing will ensure that biological output can be harmlessly recycled, and 'design for disassembly' will ensure that recycling any output will be technically and economically feasible (McDonough and Braungart, 2002). Everything becomes recyclable; everything has ause. Waste should be a good thing because it will be reused again for another purpose. Naturewants waste; it needs it to sustain itself (waste equals food or sustenance). Nature does not generate waste, per se; it does not foul its own nest because it has to live in it. In closed systems, each co-existing element consumes the waste of another as its lifeline! From this perspective, the word waste goes away because waste means to fail to take advantage of something (Lovins *et al.*, 1999).

Nature requires local expertise and resources. Just as nature requires a rich bio-diversity toadapt to change and to grow, local ecosystems require a rich range of interlocking resourcesand the involvement of many local species to create a vibrant natural community (Morgan, 1997). Locals are familiar with the boundaries within which they are living and are familiar with other specieswho share this space and who have developed their own adaptive expertise. Nature does notneed to import from outside. If it is not there, it cannot be used. Natural ecosystems are tiedto the local land; hence, sustainability requires reliance on local expertise and indigenous knowledge. Species that make up ecosystems tend to be linked in various relationships with other organisms in close proximity (Morgan, 1997). They typically utilize resources and local abundances from their immediate range of influence, and tend to be well adapted to their specific microclimatic conditions (Morgan, 1997).

Nature avoids internal excesses and overbuilding by curbing excesses from within. Nature has no ego to drive it like human beings. Nature remains in balance with the biosphere, that part of the earth and its atmosphere in which living organisms exist, that is capable of supporting life. Social insects can also teach a great deal about innovation and leadership. Their foraging strategies demonstrate a balance between exploitation of existing sources and exploration for new ones, an emerging and democratic decision-making process and a collective support to the chosen options (Bonabeau and Meyer, 2001). Honeybees' swarming – the splitting of the nest in two when the colony becomes too large – further suggests that organisations cannot grow forever. They will reach a point of diminishing returns when they should spin off some of their operations. Interestingly, there is no social-insect equivalent to mergers, only spin-offs (Bonabeau and Meyer, 2001).

Nature taps into the power of limits and manages not to exceed limits. Species flourish withinthe boundaries that surround them, and do not seek elsewhere for resources, as they useexisting materials sparingly (Morgan, 1997). Nature depends upon its constant internal feedback mechanismsfor information on how to maintain balance. It makes the most efficient use of its surrounding resources and uses limits as a source of power, a focusing mechanism, always conscious of maintaining life-friendly temperatures, harvesting within the carrying capacityof the boundaries and maintaining an energy balance that does not borrow against the future (Morgan, 1997). Learning to live with finite resources isa source of powerful creativity in nature as limits create power. This idea is the opposite of seeing limitsas a dare to overcome the constraints due to scarcity and to continue our expansion (Morgan, 1997). Nature teaches us to flourish within boundaries. For example, mycorrhiza fungi grow in a fungal mat in the ground between the trees that have access to both sun and water, distributing these necessary nutrients between the trees (Morgan, 1997). Mimicking the symbiotic relationship between the fungi and its associated trees, the relationship between the national body and the chapters would evolve from hierarchical to supportive, ensuring the

flow of information and resources and leveraging local initiatives (Walker, 2010).

Nature runs on the natural sunlight. In the natural ecosystem all energyis sunlight and nature knows how to gather energy efficiently. Leaves follow the sun and photosynthesis is 95% efficient (Leitch, 2013). Plants use the sun to turn light into sugar, the natural food thatthe plant lives on - and then humans eat the plant. The photosynthetic process also useswater and releases the oxygen that everything absolutely must have to stay alive (Leitch, 2013). But, naturedoes this by using contemporary sunlight rather than heirlooms of sunlight (fossil fuels).The sun also acts as a timing and directional orientation or spatial organization mechanism for example biological rhythms such as diurnal and annual (or longer) cycles are determined by the sun‘s gravitational effect and the rotation of the earth(Leitch, 2013).

Migration patterns or flowering seasons in some species in response to these cycles are examples of the role the sun (or the earth‘s relative position to it) has in timing mechanisms in ecosystems.

If the built environment was based on this one principle alone as is advocated by sustainable design theory in general, where its energy was sourced from contemporary sunlight (including wind, hydro and biomass) and it was cited and organised according to climate, environmental impact would be considerably less and there may be consequent significant positive physical and psychological health impacts (Lovins *et al*., 1999).

Nature uses only the energy and resources that it needs. Lovins *et al*., (1999) who did a research on the ecology draws on the interest ratherthan the entire natural capital at its disposal. According Lovins et al., (1999) nature does not draw-down resources, meaning itdoes not deplete resources by consuming them unnecessarily. In order to make optimal andmaximum use of the limited habitat, each organism finds a niche, using only what it needsto survive and evolve. With the rise of the environmental crisis, resource depletion, pollution and climate change, environmental management has become a hot topic for business and most initiatives must aim at reducing negative impacts to the environment. Rather than addressing the cause of the problem the designers must goals and using practices that sustain a fundamentally flawed system" (Mc Donough et al., 2003). As reactive eco-efficiency is replaced by proactive eco-effectiveness, business evolves to solutions-oriented and closed loop models (Lovins et al., 1999). The only sustainable approach is a net positive impact on nature. Ultimately, business must restore, sustain, and expand the planet's eco-systems so that they can produce their vital services and biological resources even more abundantly" (Lovins et al., 1999)

### *4.2 Nature as Model, Measure and Mentor*

Biomimicry is a new way to view and value nature (Benyus, 1997). According to Benyus, if people want to consciously emulate nature's genius, they need to look at nature differently and as teacher not an enemy. In biomimicry, people look at nature as model, measure, and mentor. Consulting life's genius brings natures wisdom to bear on today's pressing, messy, wicked problems (Benyus, 2002).

#### *4.2.1 Nature as model*

People would draw on nature to model new forms of behavior. Nature can provide insights into the quest for new ways to frame day-to-day life (Paul, 2010). In nature, there is no waste, and there are no borders separating things. There are just nested systems wherein each part of the system supports the existence of the other parts. Modeling this interconnectedness and interrelatedness would respect the needs of the other species. As Benyus (2002) affirms, that humans are one votein a parliament of 30 million other species (Biomimicry, Guild, 2007). Humanbeing's long standing arrogance (hubris) would nolonger be the model for human behavior. Communities modeled on nature learn how to stay put withoutbankrupting their ecological capital. They learn howto optimize rather than maximize (Bhushan, 2009). The latter focuseson increasing measures such as revenue, profits, andmargins while optimizing involves making a systemor design as effective or functional as possible.

#### *4.2.2 Nature as measure*

Ausubel (2005) posited that people would turn to nature for guidance, standards and to use to judge the rightnessof their innovative behaviors and decisions.Are they life promoting? Does the resultant action fit with nature? Will the results or the impact last in a positive way? (Ausubel, 2005). These questions are judged using an ecological standard (Benyus, 1997).What Benyus (1997) refers to as the Nine Laws of Nature, Life's Principles (discussed earlier)? When a natural ecosystem reaches maturity, it is populated by mature living organisms that act in life affirming ways, grounded in the nine laws of nature (McDonough & Braungart, 2002). Onemeasure of rightness is ensemble or living in groups. In nature, an ensemble is a group of complementary parts thatcontribute to a single effect. Ensemble living meansorganisms (humans and other species) learn to maintain a dynamic stability, like dancers, continuallyinteracting without harming or compromising eachother (stepping on each other's toes in the dance).The parts of the ensemble that manifest (rise upfrom the whole) are still enfolded in the whole (Ausubel, 2005).

#### *4.2.3 Nature as mentor*

McDonough & Braungart (2002) stated that people's relationship with nature would change from master to teacher and mentor. This new relationship would mean people have to steward nature if they want to continue to have something from which they can learn a source of ideas, innovation and inspiration (Robinson, 2004). Nature is a source of knowledge fit for imitation. Mentors are trusted friends, counselors or teachers, usually a more experienced person. Nature has had 3.8 billions of years to evolve and gain experience of living systems in evolving complex, efficient, resilient and adaptive systems (Benyus, 1997). Humans would do well to watch and learn rather than exploit and destroy as the answers are there in nature if peopletake the time to discover and apply innovations (Robinson, 2004). Nature has figured out what works, what is appropriate and what last and has a spirit of cooperation, flexibility and diversity that has made her a reliable and long-term survivor. As mentees, humans would be guided by humility (rather than arrogance) as they begin to learn from" nature so they can learn to fit in alongside the rest of nature (Vincent et al., 2006).

## 5 Biomimicry and Leadership Lessons

McKeag (2009) stated that there are a surprising number of behaviors that occur in nature and that can be related to business organizational structures and we only need to look at some of the interesting habits of one of the most common creatures in the world to seehow complex structures can be developed by many hands making light work. There is a great need for better leaders. Certainly if one wants to be successful, one should develop one's leadership skills. Animals can be good examples of leaders for they lead their groups by influencing, showing examples, guiding and constantly communicating with their followers. A few examples are given in the succeeding subsections for illustrative purpose.

### *5.1 Eagle*

One leadership lesson drawn from nature is the helicopter vision of an eagle. It is said that the eagle soars or flies high when it is hunting. From the way of the eagle, the leader can learn the need to have a high vantage point, giving vision to the people (Ozirney, 2009 cited by Williamson et al., 2010).

When eagles are 30 years old, they go through a process of renewal. Finding a hidden place high in the mountains, the old eagle with curved beak begins to claw at its face, and tear out the old feathers that by now become less airborne. As a result, it bleeds badly. But this is vital for the eagle in order to renew its strength. If the eagle did not do this, it would not be able to live to its normal 40 years (Ozirney, 2009 cited by Williamson, et al., 2010). It is thus vital for the eagle to undergo the change process to gain its strength and this builds the eagle's resilience. By the same token, mankind simply needs to accept the change process, learn and grow. It is part of life and living.

### *5.2 Ant society*

According to (Johnson and Heimann, 2000 cited Wyles, 2012) the ant is a very busy creature living in a complex system. Collectively, a colony of 40,000 ants has the brainpower of one human being and at the top of the colony is the queen ant, which has a whole army of worker ants that serve her and look after her precious eggs (Johnson and Heimann, 2000 cited Wyles, 2012). To not do so would put the existence of their entire colony at risk. In addition to protecting and serving the queen, worker ants have different roles and responsibilities. Some build, some are foragers, some are defenders, some are explorers for new nest sites and others have the role of tidying and putting out the rubbish. Relating this to the business world, with a chief executive at the top and numerous workers with different roles to play to ultimately keep the organization profitable and surviving in a hostile environment called 'businesses. The workers are committed to their role, because the company provides them with the ability to buy food and shelter, and with a sense of purpose. They have a shared goal whose primary objective is profitability and, ultimately, their survival. Occasionally, in the ant kingdom, the Slave Maker Ant will raid the nests of other ants and steal their pupae. When these new ants hatch, they work as slaves within the new colony. We could perhaps call this an acquisition (Johnson and Heimann, 2000 cited Wyles, 2012).

### *5.3 Mentoring matriarchs in elephants*

According to a research done King (2013), elephants recognize the importance of mentoring within their social structure, the most obvious being the matriarch of a herd of elephants. The matriarch is usually the oldest and most experienced female elephant; the rest of the herd is usually made up of her daughters and their calves. She influences the herd more than any other group or individual. In a crisis, they will rely on her to make the major decisions about their course of action. As the first and eldest elephant, the matriarch is instrumental in teaching her daughters how to care for their young, who will then help care for their younger siblings, training and preparing them for when they have their own calves. Sometimes, the matriarch is not a born leader and another will step up to the task – an elephant with the qualities required to nurture, teach, build confidence and earn respect. For elephants this is never about overpowering an individual to achieve a leadership position, as in some other social structures within nature. Rather, it may present through a challenge to the authority of the

matriarch or a decision being made by the rest of the herd. It would be great if all teams worked as smoothly as this, yet the reality is that conflict can easily occur if two people are jostling for leadership position. The key to avoiding this situation is to set clear boundaries and have clear roles and responsibilities. This clarity within the team cements it and allows members to get on with the activity that is essential to the project.

### *5.4 The wolf pack*

Towery (1997) did a research on wolf's pack and discovered that wolves have a very sophisticated group dynamic within every pack. Wolves naturally organise themselves into packs to maintain stability and assist with hunting. He stated that the groups are usually between three and seven, are always led by an alpha male and alpha female, and often comprise their offspring until they mature and venture elsewhere.

The attitude of the wolf is always based upon 'what is best for the pack' and he knows explicitly what needs to be achieved for its survival (Towery, 1997). While there are alpha males and females, each member of the pack understands exactly what is expected of them. In truth, there are usually no more than five to eight wolves howling in a pack. The secret is that the wolves are always careful not to duplicate each other. Each wolf assumes a unique pitch, respecting the individuality of the other members of the pack. This is also true for team communication: by expressing their own uniqueness, while respecting and encouraging the uniqueness of others, the unity of the team becomes a strong, formidable force. However, for the wolf pack, there are strong consequences for failure, if they don't work together, they will be lonely and go hungry (Towery, 1997).

In business organizations, too, the consequences of failure should be clear, yet the reality is that there are often few consequences for a lack of achievement or failure to deliver. Therefore, as well as the purpose of the team being made clear, so too must be what constitutes failure (Johnson and Heimann, 2000 cited Wyles, 2012). Without both aspects being defined, responsibility may not be taken by every individual, causing resentment and further conflict. When individuals take responsibility for their input to the group, great things can happen. At the performing stage of a team, members of the group are self-motivated and knowledgeable and can handle the decision-making process without supervision. Dissent is expected and allowed, as long as it is channeled through a means that is acceptable to the team. When the team has ironed out its differences, it can be a formidable force against competition.

### *5.5 Achieving more through communication and teamwork (bio-teams)*

By examining the insect world, Thompson (2013) discovered that the gathering of information can make a colony more productive. Scientists have found that a foraging bee that has found a good food source will perform a dance for other bees in the hive, which indicates the location of the food source. This information allows the other bees to tap into the food source, thereby becoming more productive within the hive. Pooling this information helps the whole colony achieve more and this can easily be related to the purpose of working in teams. Each person has a role to play within the team and they can achieve more collectively than they can by working separately. A popular animal analogy to this 'together everyone achieves more' concept is the *Lessons from Geese* prose, which was believed to have been first written by Robert McNeish in 1972 (cited by Thompson, 2013). He had observed geese for many years and was particularly interested in their flight formation and how they flew such great distances during migration. He noted that, as each goose flaps its wings, it creates uplift for the bird that follows. By flying in a V formation, the whole flock has a far greater flying range than if each bird flew alone. When the lead gooses tires, it rotates back into the formation and another goose flies to the point position, so that different geese take it in turns to keep up the speed of migration (Thompson, 2013). In our business world, the appointed leader does not always need to be the person to give pace to the project: there may be different leaders at different stages of its development. The most important point is that the team understands the direction in which it is heading and that it can achieve its goal quicker and more easily when its members work together and are willing to accept and give help whenever it is needed.

### *5.6 Snake*

Hayes (2007) affirms that snakes such as pythons are said to have swallowed dogs or even huge animals such asbuffaloes; this is because of their flexible jaws which can open up to accommodate thesize of their prey. Here, we can liken this to the confidence and ambitions of a leader.The leader is usually big-hearted and magnanimous, wanting to move the people towardsthe vision he or she envisages. Snakes also shed off or change their skins often; here, leaders need to lead change by being fluid in accepting and managing change. Creating a sense of urgency, they motivate their people to accept and implement the change. Leaders celebrate successes, no matter how little; and they also get their people to see the benefits of the change (Hayes, 2007). This is to keep the change momentum going while moving towards

realizing the change and it is the key to the citadel of business success.

### *5.7 When the Emperor says adjourn*

Williams (1995) who did a research on Penguins work as teams discovered that when a penguin republic has done a good job they adjourn. In an organization it could be when sales targets are being consistently met, or when all product glitches have been ironed out. Emperor penguins live in the Antarctic and they are the only animals whose breeding season is in winter (Williams, 1995). The teamwork involved in ensuring their young ones survivessuch harshestcold winter conditions. After laying her eggs, the female transfers full responsibility for the project of nurturing them to her male partner, while she disappears to feeding grounds for two months for vacation. During this time, the males spend much of their time sleeping and huddling the young ones together gently rotating as a group, so that they take turns on the outside to warm the kids. A single penguin would perish from the cold and lose his offspring. Two months later, and after the chicks have hatched, the females return and the males then take their turn to feed – their job is done – but they return approximately 24 days later to help feed the chicks and support the mother by taking turns with her to visit the feeding ground (Williams, 1995). After about two months, the chicks have theirjuvenile plumage and can start their independence, although they may be topped up with food by their parents for a short time, before full independence. The parenting is done and it is then time for the next project to start.

## 6 Critiques

The documentary literature review analysis has also discovered some schools of thought who arethe idea that technically, the business environment is much more chaotic in terms of resources than nature (Iansiti & Revien, 2004). Sunlight and other resources, for example biological nutrient flow in nature are “fairly constant or at least follow predictable cycles”, while “inputs like technology in business ecosystems are constantly changing” (Iansiti & Revien, 2004) “Nature presents itself as being objective and real in every aspectwhereas organizations, and their environments can, to some extent, be understood as socially constructed phenomena” (Morgan, 1997). Therefore life of man in societyis incidentally a biological fact, and has characteristics that are not reducible to biology and must be explained in the distinctive terms of a cultural analysis” (Hofstadter 1992, cited by Levallois, 2011).

## 7 Conclusion

The documentary literature review analysis has shown and demonstrated that Nature’s Principles as a whole appear well compatible with business literature and form a comprehensive yet conceptual framework which business can make use for their sustainability. In the light of this article, nature appears to be endowed with solutions in a holistic framework that are highly relevant and recommendable for current business operations. Literature review has shown that most business theories can mimic perfunctorily from nature, among which: Total Quality Management (TQM), Learning Organizations, Strategic Innovation Management, Sustainable Supply Chain Management, Core Competences and Strategic Intent, Management by Values, Natural Capitalism, Cradle-to-Cradle and Solutions-based business models (Finchman and Rhodes, 2004).

## 8 Recommendation and way forward

Paul (2010), based on few of the examples stated that it will be interesting to study on how businesses can take advantage of biomimicry in improving their management and how they can move towards calling themselves a “bionic enterprise” as a survival strategy for business sustainability. The examples also provide a hint that businesses can create conditions conductive to life or rather society at large. Further research and development can definitely bring break through solutions and strategies in: Going Green in business, Human Resource Management, Project Management and Marketing intelligence. On a peripheral and tangential note, biomimicry can be one of the quintessential tools which businesses can use to enhance their corporate social responsibility (CSR) model and environmental management.

## References


1. Ausubel, K. (Eds.) (2005). Nature's operating instructions. San Francisco: Sierra Club Books.
2. Benyus, J. M. (1997). Biomimicry–Innovations inspired by nature, 2002. William Morrow, New York.
3. Bhushan, B. (2009). Biomimetics: lessons from nature–an overview.Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 367(1893), pp. 1445-1486.
4. DeLuca, D., Hutchins, G., Kok, J., Williamson, P., (2010). The Firm of the Future – A Business Inspired by Nature, by BCI and Atos Origin, Available on http://atosoriginblog.blogspot.com/2010/11/firm-of-future-is-business-inspired-by.html.
5. Edwards, S. (2001). Factory and fantasy in Andrew Ure. Journal of design history, 14(1), pp. 17-33.
6. El-Zeiny, R. M. A. (2012). Biomimicry as a Problem Solving Methodology in Interior Architecture. Procedia-Social and Behavioral Sciences, 50, pp. 502-512.
7. Erin Leitch. (2013). What nature can teach us about doing business in a down economy | Retrieved May 16, 2013, from http://www.greenbiz.com/slideshow/2013/01/11/namib-desert-beetle-leverages-ower-attraction.
8. Felin, T., & Foss, N. (2006). Individuals and organizations: thoughts on a micro-foundations project for strategic management and organizational analysis (Vol. 3, pp. 253-288). Emerald Group Publishing Limited.

9. Freeman, C. et al., (1982/2004). Technical Innovation and National Economic Performance,Aalborg, Aalborg University Press, pp. 49–102.
10. Goss, J. (2009). Biomimicry: Looking to nature for design solutions. CORCORAN COLLEGE OF ART+ DESIGN.
11. Goss, J. (2009). Biomimicry: Looking to nature for design solutions. CORCORAN COLLEGE OF ART+ DESIGN.
12. Hanson, W. E., Creswell, J. W., Clark, V. L. P., Petska, K. S., & Creswell, J. D. (2005). Mixed methods research designs in counseling psychology. Journal of counseling psychology, 52(2), 224.
13. Hayes, R. H. and Pisano, G. P., (1994). Beyond World-Class Manufacturing, Harvard Business Review.
14. Heald, M. (1970). The social responsibilities of business: company and community 1900-1960. Transaction Publishers.
15. Hodgson, G. M. (1988). Economics and institutions. In Journal of Economic Issues.
16. Huang, Y. M., & Liu, C. H. (2009). Applying adaptive swarm intelligence technology with structuration in web-based collaborative learning. Computers & Education, 52(4), pp. 789-799.
17. Iansiti, M. and Levien, R. (2004). Strategy as Ecology, Harvard Business Review, March 2004, pp. 68-78.
18. Johnson, P., Heimann V, O'Neill K "The Wolf Pack: team dynamics for the 21st century" Journal of Workplace Learning vol. 12, no 4, pp. 159-164 (2000).
19. Kaplinsky, J. (2006). Biomimicry versus humanism. Architectural Design, 76(1), pp. 66-71.
20. Ken Thompson. (2013). Bioteams. Retrieved May 15, 2013 from http://www.mkpress.com/bioteams/.
21. King, L.E. (2013). Elephants and Bees: Could honey bees be effective deterrents for Asia's crop-raiding elephants? Sanctuary Asia Magazine. October 2013.
22. Krathwohl, D. R. (1993). Methods of educational and social science research: An integrated approach. Longman/Addison Wesley Longman.
23. Leitch, E. (2013). What nature can teach us about doing business in a down economy Retrieved July 25, 2014, fromhttp://www.greenbiz.com/slideshow/2013/01/11/namib-desert-beetle-leverages-power-attraction.
24. Levallois, C. (2011). Why were biological analogies in economics "a bad thing"? Edith Penrose's battles against social Darwinism and McCarthyism. Forthcoming in Science in Context.[online] Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1797582 [accessed on 15th July 2011].
25. Lovins, A.B., Lovins, L.H. and Hawken, P. (1999). A Road Map for Natural Capitalism. Harvard Business Review, May-June 1999, pp. 145-158.
26. Mc Donough, W., Braungart, M. (2002). Cradle to Cradle, Remaking the Way We Make Things. North Point Press.
27. McKeag, T. (2009). How Termites Inspired Mick Pearce's Green Buildings. Retrieved October 2010, from Greener Design: http://www.greenbiz.com/blog/2009/09/02/how-termites-inspired-mick-pearces-green-buildings.
28. Morgan, G. (1997). Images of Organizations, New Edition. Sages Publications.
29. Pedersen Zari, M. (2012). Ecosystem services analysis for the design of regenerative built environments. Building Research & Information, 40(1), pp. 54-64.
30. Rebecca Paul. (2010). Design Inspiration from Nature – Biomimicry for a Better Planet. Retrieved May 29, 2013, from http://inhabitat.com/finding-design-inspiration-in-nature-biomimicry-for-a-better-planet.
31. Repperger, D. W., Phillips, C. A., Neidhard-Doll, A., Reynolds, D. B., & Berlin, J. (2006). Actuator design using biomimicry methods and a pneumatic muscle system. Control Engineering Practice, 14(9), pp. 999-1009.
32. Robinson, J. (2004). Squaring the circle. Ecological Economics, 48, pp. 369-385.
33. Robson, C. (2002). Real word research. Oxford: Blackwell.
34. Schmidt, J. C. (2011). What is a problem? On problem-oriented interdisciplinarity. Poiesis and Praxis: International Journal of Technology Assessment, 7(4), pp. 249-274.
35. Tom McKeag, (2013) .Three ways to bring nature-inspired ideas to market.
36. Towery, T. L. (1997).The wisdom of wolves:Nature's way to organizational success Wessex House Publishing.
37. Tsang, E. W. (1997). Organizational learning and the learning organization: a dichotomy between descriptive and prescriptive research. Human relations, 50(1), pp. 73-89.
38. Vincent, J. F. Bogatyreva, O. A., Bogatyrev, N. R., Bowyer, A., & Pahl, A. K. (2006). Biomimetics: its practice and theory. Journal of the Royal Society Interface, 3(9), pp. 471-482.
39. Vincent, J. F. Bogatyreva, O. A., Bogatyrev, N. R., Bowyer, A., & Pahl, A. K. (2006). Biomimetics: its practice and theory. Journal of the Royal Society Interface, 3(9), pp. 471-482.
40. Vold, T. and D.A. Buffett (eds.). (2008). Ecological Concepts, Principles and Applications to Conservation, BC. 36 pp. Available at: www.biodiversitybc.org
41. Wahl, D. C. (2006). Bionics vs. biomimicry. In C. A. Brebbia (Ed.), Design and nature III: Comparing design in nature with science and engineering. Southampton, England: WIT Press, pp. 289-298.
42. Walker, A. (2010). Biomimicry Challenge: IDEO Taps Octopi and Flamingos to Reorganize the USGBC. Fast Company, 10th May 10, 2010. [online] Available at: http://www.fastcompany.com/1643489/biomimicry-challenge-ideo-uses-nature-to-reorganize-the-usgbc [accessed on 15th July 2011].
43. Williams, Tony D. (1995). The Penguins. Oxford, England: Oxford University Press. ISBN 0-19-854667-X.
44. Yurtkuran, S. Kırlı, G., &Taneli, Y. (2013). Learning from Nature: Biomimetic Design in Architectural Education. Procedia-Social and Behavioral Sciences, 89, pp. 633-639.
45. Zai Kang Chang, (2010). BIOMIMICRY: Tool for Innovation at All Levels of Organization, © 2010 Strategic Sustainability Consulting. [online] Available at http://www.scribd.com/doc/45066610/White-Paper-Bio-Mimicry-040710 [accessed on 15th July 2011].
46. Zari, M. P. (2007). Biomimetic approaches to architectural design for increased sustainability. In The SB07 NZ Sustainable Building Conference, Auckland, New Zealand. Retrieved February (Vol. 8, p. 2013).
47. http://en.wikipedia.org.wiki/Emperor
48. http:// www.biomimicry.net
49. http://en.wikipedia.org.wiki/Emperor
50. http://www.elephantsforever.co.za/privacy-policy.html#.U9eOxPmSx8E
51. http://www.andrewselephants.com/matriarchelephant.html.