BIOMIMICRY FOR BUSINESS?

A business literature and critical review of nature's principles applied to business practice, as suggested by *Biomimicry for Creative Innovation*.

Submitted by Eric Dargent to the University of Exeter as a dissertation towards the degree of Master of Business Administration.

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Declaration

I certify that all the material in this dissertation, which is not my own work has been identified and that no material is included for which a degree has been conferred upon me.

Date:

Signature:

Abstract

Biomimicry is a new interdisciplinary field that takes inspiration from nature for human applications. Since its emergence in the late 1990s, it has primarily focussed on product design. Biomimicry for Creative Innovation (BCI) – a collective of design, transformation and process specialists – has produced a framework for business based on biomimicry principles. The purpose of this paper is to establish bridges between this framework and the existing business literature, as well as to offer a critical perspective on how it is articulated and how it can inform business management. The business literature review was based on the references and theories suggested during the University of Exeter MBA 2010-2011 and conducted over a four week period which implies limitations to the theoretical basis.

In the light of this research, BCI's framework appears widely supported by the literature. It is applicable across a broad range of functions and business needs – strategy, operations, marketing, innovation, networking, product design, human resources management, accounting etc. – but is quite conceptual and therefore does not offer direct practical implications. Its value is to outline the fundamental principles of nature, which have a 3.8 billion years track record of sustainability. This research suggests that while Nature's Principles seem highly challenging to human organisations, they provide a much needed comprehensive framework based on which to create a wide variety of strategies for business sustainable performance.

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1. Introduction

This paper was written as my MBA dissertation. The University of Exeter, UK, embarked in 2010 on a journey to redesign its MBA in the context of heavy social and environmental pressures on business. During the year, Giles Hutchins, Global Director for Sustainability Solutions at Atos Origin, and co-founder of 'Biomimicry for Creative Innovation' (BCI), introduced their approach of business inspired by nature. BCI's framework seemed to offer a very insightful and comprehensive framework for sustainable business practice and resonated with many concepts discussed throughout the MBA. It is however based on Life's Principles, i.e. directly inspired by biology. The objective of this paper is to understand if BCI's framework is supported by business theory and to offer a critical perspective. It is therefore not based on the generation and analysis of primary data against theory as most MBA dissertations but rather conceptually assesses a new theoretical framework – which background is not in business – against the existing business theory.

The paper is structured as follows: I first describe my methodology and introduce biomimicry – a new approach for sustainable innovation inspired by nature – before conducting a literature review of the general management theory taught in the MBA and of resilience theory. This literature review is structured around BCI's six principles and comes to the following conclusions: the framework is widely supported by a variety of business theories and relevant across a large variety of business topics but lacks practical implications. It is also argued that because business thinking is work-in-progress and because of the wide diversity of situations faced by businesses, there cannot be one single comprehensive and definite model to manage business. However, the business environment is increasingly complex and chaotic, and the system theory and biomimicry suggest 'complex adaptive systems' are the fittest to this context. Therefore I then discuss the relevance of considering organisations as such systems and underline limitations in terms of human behaviour and business strategy. I then focus on the articulation of BCI's six principles and offer a critical perspective which underlines the challenge in presenting nature's principles and their implications for business in a concise and accessible way. All these insights are finally tied together to stress the relevance of biomimicry for business as a philosophy that

frames the necessary paradigm shift in the face of the sustainability challenge. I conclude with a critical reflection on my approach.

2. Methodology

The basis of this project is the work of BCI. Practically, I reviewed all the content available on their website (biomimicry-bci.squarespace.com), had several conversations with Denise DeLuca and Giles Hutchins and got also access to some of their unpublished work-in-progress.

I based my literature review on the lectures, theoretical references and recommended readings given in the course of the 2010-2011 University of Exeter Full-Time MBA, and especially the following modules:

- the Marketing Imagination, Dr Malcolm Kirkup
- Managing Strategic Resources and Operations , Pr Steve Brown
- People in Organisations, Morgen Witzel
- Global Strategic Analysis and Management, Dr Ajit Nayak
- Critical Perspectives on Leadership, Dr Richard Bolden and Pr Jonathan Gosling
- Strategic Innovation Management, Pr John Bessant
- Strategic Supply Management, Pr Mickey Howard
- Ecoliteracy, Dr Sally Jeanrenaud and Jean-Paul Jeanrenaud

I screened this general management theory for approaches relevant to the themes suggested by the BCI framework. In addition to that, I reviewed biomimicry and resilience literature, within the scope of business and organisation management.

3. What is biomimicry?

Biomimicry has only recently appeared on the business radar. As described in this section, it is an interdisciplinary field that takes inspiration from nature to design innovative products and processes.

3.1. Innovative design inspired by nature

The term 'biomimicry' was coined by Janine Benyus. In her seminal '*Biomimicry, Innovation Inspired by Nature*' (1997), she offers the following definition:

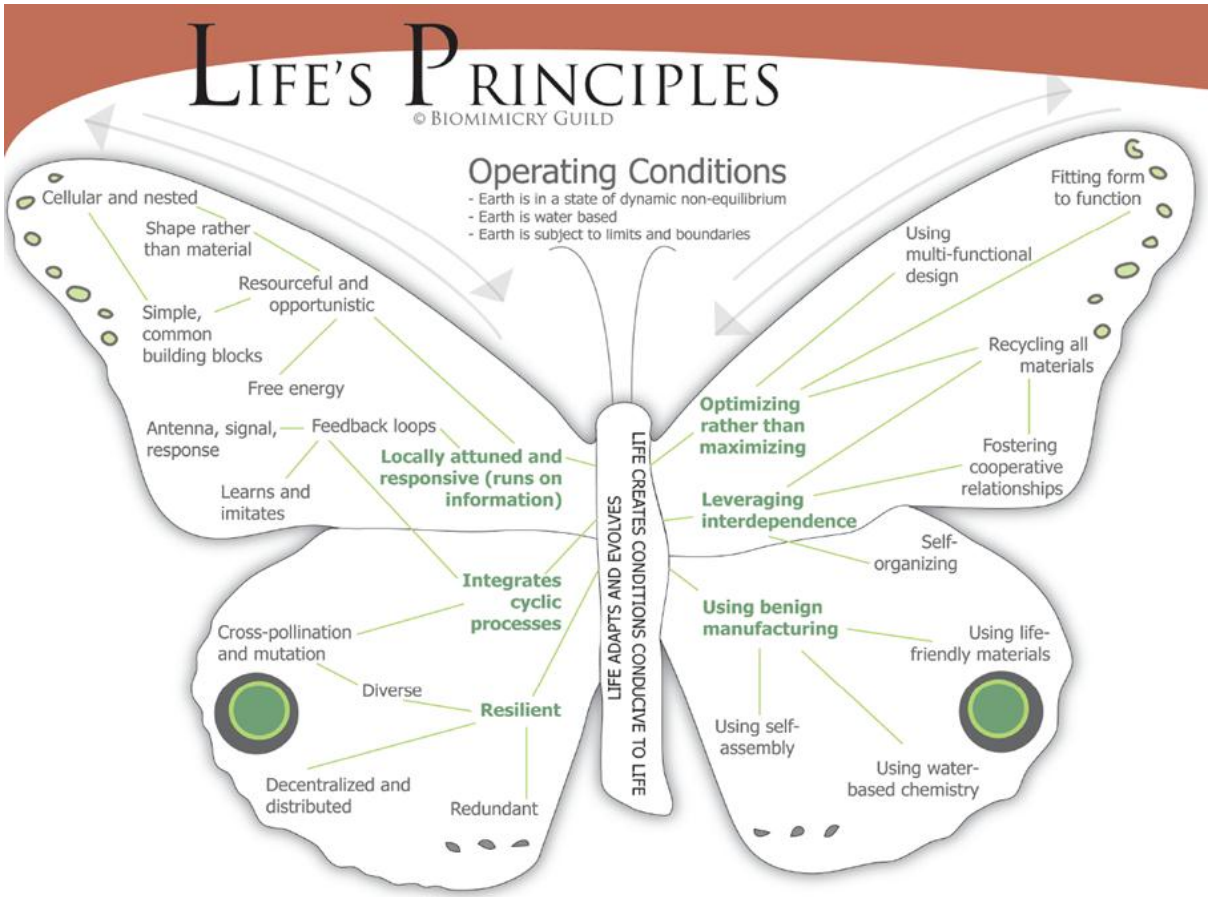
"From the Greek bios, life, and mimesis, imitation.

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, e.g. 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: What works. What is appropriate. What lasts.
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."

Despite Benyus's assertion, 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. Leonardo da Vinci for example drew sketches of a flying machine inspired by birds' wings. In the late 1950s 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. 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 co-founded a consultancy and an educational organisation – respectively the Biomimicry Guild and the Biomimicry Institute – and biomimicry has grown and cross-pollinated as an interdisciplinary field whereby biology meets design, engineering or architecture – an approach referred to as the "biologist at the design table". The focus has been primarily on the design of material products – similarly to biomimetics – and to a lesser degree to processes, with sources of inspiration ranging from tangible designs found in nature to concepts or general observations of nature. To provide guidance to biomimetic designers, the Biomimicry Institute developed a framework based on the principles and conditions under which life operates: "Life's Principes" (see below).



Examples of biomimetic innovative designs include:

- A high-speed train front-end inspired by the kingfisher's beak to travel more efficiently into different air pressures (tunnel and open-air). The design of the Shinkansen Bullet Train of the West Japan Railway resulted in a quieter train and 15% less electricity use even while the train travels 10% faster. (biomimicryinstitute.org)

- A low-energy building which air conditioning system is modelled on termites' self-cooling mounds. The Eastgate Building, an office complex in Harare, Zimbabwe, uses 90% less energy for ventilation than conventional buildings its size. (biomimicryinstitute.org)

- A high-performance underwater modem for data transmission, used in the tsunami early warning system throughout the Indian Ocean, inspired by dolphins' unique frequency-modulating acoustics and developed by a company called EvoLogics. (biomimicryinstitute.org)

- A carpet tiles range which random design is inspired by the aesthetics of leaves on a forest floor despite their variety. As a result the carpet tiles can be installed in any direction which reduces installation time and allows replacement of single tiles without damaging the overall look of the floor. The 'Entropy' product line became InterfaceFLOR's fastest bestseller (Zai Kang Chang, 2010, p. 14).

3.2. Organisation management inspired by nature

While biomimicry has mainly focussed on product design, there have also been applications in organisation and team management. Examples include 'swarm intelligence' and tree-fungi symbiosis.

Swarm intelligence is the collective decision-making process observed with social insects like ants, termites or bees. Eric Bonabeau and Christoph Meyer (2001) argue that there is much to learn from their main behavioural features:

- Flexibility: the group can quickly adapt to a changing environment.
- Robustness: even when one or more individuals fail, the group can still perform its tasks.
- Self-organisation: the group needs relatively little supervision or top-down control.

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, p. 113). 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, pp. 113-114).

The 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. This inspired the re-organisation strategy of the United States Green Building Council –founder of the LEED certification system – which struggled connecting its 80 local chapters. 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).

3.3. Biomimicry for business management

Although its main focus is on technical design, Benyus' book does comprise a chapter about business management and refers to Paul Hawken's '*Ecology of Commerce'* (1994). Hawken's concept of industrial ecology was developed by Michael Braungart and William Mc Donough

in 2002 with '*Cradle to Cradle*', which focused on closed-loops systems – where waste equals 'food' or input – and solution-based business models. Beside the application to organisation 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 (Zai Kang Chang, 2010, p. 8).

In that respect, taking inspiration from nature to inform organisation and business management is not a novelty, similarly to design inspired by nature. Biological analogies have a long history in politics, economics and management. This is briefly reviewed in Appendix 1.

However, only recently since the biomimicry movement emerged has business management been addressed. 'Biomimicry for Creative Innovation[1]' (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: 'Nature's Principles' (see Table 1, page 13). BCI has also proposed a 5 stage transformational process (Appendix 2) and a case study template (Appendix 3). The objective of this paper is to look at how 'Nature's Principles' are supported by business literature and to offer a critical perspective on the framework.

[1] http://biomimicry-bci.squarespace.com

Table 1. BCI Nature's Principles

Build Resilience

"It's more effective to build resilience than to correct poor risk-based decisions that were made with partial information. Nature builds resilience by:

- Using change and disturbance as opportunities rather than fearing them as threats.
- Decentralizing, distributing, and diversifying knowledge, resources, decision-making, and actions.
- Fostering diversity in people, relationships, ideas and approaches."

Optimize

"Optimising delivers better results than maximizing or minimizing. Nature does this by:

- Creating forms that fit functions, not the other way around
- Embedding multiplicity into both functions and responses
- Creating complexity and diversity using simple components and patterns"

Adapt

"Being adaptive pays back better than "staying a fixed course". Nature adapts by:

- Creating feedback loops to sense and respond at all levels of the system.
- Anticipating and integrating cyclic processes.
- Being resourceful and opportunistic when resource availability changes."

Integrate Systems

"With limited resources and a changing environment, it's better to be systems-based rather independent. Nature works with whole systems by:

- Fostering synergies within communities.
- Fostering synergies within energy, information and communication networks
- Creating extended systems to continuously recycle wastes into resources."

Navigate by Values

"In uncertain times, it's better to be based on a compass of values than a fixed destination point or set of pre-defined metrics. Nature reflects values by:

- Knowing what's really important to the communities in which you live , interact, and impact.
- Using values as the core driver towards positive outcomes.
- Measuring what is valued rather than valuing what is measured."

Support Life

"In the long run, it takes less effort and less resource to support life-building activities than to be damaging or toxic and pick up the cost later. Nature supports life-building activity by:

- Leveraging information and innovation rather than energy and materials
- Creating support for individual components that can support the whole ecosystem, and support the ecosystem so that it can support the individual.
- Making products water-based, renewable, bio-based, and biodegradable."

4. Business literature support to the BCI framework

This section will review successively review the six 'Nature's Principles' – Build Resilience, Optimize, Adapt, Integrate Systems, Navigate by Values, Support Life – in the light of existing business theory .

4.1. Build Resilience

According to BCI:

"It's more effective to build resilience than to correct poor risk-based decisions that were made with partial information. Nature builds resilience by:

- Using change and disturbance as opportunities rather than fearing them as threats.
- Decentralizing, distributing, and diversifying knowledge, resources, decision-making, and actions.
- Fostering diversity in people, relationships, ideas and approaches."

4.1.1. What is resilience?

Around 500 B.C. the Greek philosopher Heraclitus noted that "you cannot step twice into the same river, for other waters are continually flowing on" (Morgan, 1997, p. 251). Change is inevitable and constant. Organisations must therefore accept the idea that "there is no sustainable 'optimal' state of an ecosystem, a social system, or the world" (Walker and Salt 2008 cited by Robinson, 2010, p. 14). Moreover, major trends like globalisation, technology and climate change are increasing the pace of change as well as the occurrence of "unplanned low probability high impact events" (iJet survey mentioned by Braes and Brooks, 2010, p. 16) or "black swan events" as Nassim Taleb called them (2007). In this context the concept of resilience is getting more attention from academics and practitioners.

Most definitions of resilience describe a capacity to continuously adapt to constant and foreseeable change as well as deeper trends and to overcome major disruptive shocks (Walker and Salt 2008, cited by Robinson, 2010, p. 13, Lengnick-Hall & Beck, 2005 cited by Braes and Brooks, 2010, p. 17, Hamel and Välikangas, 2003, p. 53). The idea of *capacity* means that resilience is neither a plan nor a checklist (TISN, 2007 cited by Braes and Brooks, 2010, p. 18,), but is rather "embodied in organisational routines and processes" (Braes and Brooks, 2010, p. 17). Underlying these definitions is the ability to turn disturbances into opportunities, to "be open to unexpected problems and solutions because they contain the seeds of new development" (Morgan and Zohar, n.d., see also Seville, 2007, p. 1). The objective of resilience is alternatively defined as retaining the same identity or function – sometimes limited to the organisation's profitability (Hamel and Välikangas, 2003, pp. 53-54) – or merely as survival, which opens the door to various interpretations.

The literature suggests that key factors for resilience are redundancy, distribution, variety and the organisation's ability to be self-challenging and decentralized. These concepts are all covered in this section. Other key factors are partnerships and values which are covered in the 'Integrate Systems' and 'Navigate by Values' respectively.

4.1.2. Self-challenging

Central to resilience is the organisation's awareness of its situation and key vulnerabilities (McManus, 2008, p. 129): its strengths, weaknesses, the opportunities and threats it faces and could face. This requires an ability to "[face] up to the brutal facts", according to Jim Collins (2001, cited by Robinson, 2010, p. 28) and especially the most challenging ones – "the things that you don't like about what you see" when you look in the mirror (Nayar, 2010, p. 9).

Organisations therefore need an ability to self-reflect on their operational abilities, to "[challenge] status quo and taken-for-granted norms and practices" (Deming, 1986). This requires a commitment to continuous improvement across the entire workforce – the Japanese *kaizen* philosophy – which is at the heart of Total Quality Management, as promoted by Edwards Deming and Joseph Juran (Morgan, 1997, p. 92).

Organisations must also be wary of their cognitive bias and become entirely free of "denial, nostalgia, and arrogance" (Hamel and Välikangas, 2003, p. 54) – what Margaret Hoffernan calls 'wilful blindness' (2011). This requires an ability to self-reflect on "the paradigms, metaphors, mind-sets, or mental models that underpin how the organization operates [and] to develop new ones when appropriate' (Morgan, 1997, p. 92). This *double-loop learning* is central to *learning organisations* as promoted by Argilys, Schon and Senge.

This self-reflective practice also requires organisational members to access fresh viewpoints. Human brains and organisations alike are indeed attracted to what is familiar and similar (Heffernan, 2011). Diversity in selecting partners as well as recruiting staff is therefore challenging but vital to counteract cognitive bias and avoid complacency (Tidd and Bessant, 2009). Diverse and challenging opinions will also be found outside of the box of the organisation (Lempel, cited by Mintzberg et al., 2009, p. 229), as developed in the 'Adapt' section. In big organisations it may also require top managers to counterbalance the filters of their own hierarchy and procedures (Hamel and Välikangas, 2003, p. 58). Eventually, cognitive bias is also a result of silo mentality, as described in the 'Optimize' section.

Continuous self-improvement not only requires an ability to self-reflect but also a culture of experimentation, of trial and error, where individuals or small units have room to innovate and failure is accepted. "Resilient organisations take risks, but considered risks, and make decisions based on clear business logic." (Robinson, 2010, p. 28, see also Morgan, 1997, p. 94, Tidd and Bessant, 2009). Companies like 3M or Google offer vivid examples of such philosophies.

4.1.3. Decentralisation and emergence

Self-improvement through *kaizen* and *double-loop learning* requires engagement across the organisation. Engagement and individual initiatives are however discouraged by the old plan-command-and-control paradigm. Based on Weber's theory of bureaucracy and Taylor's scientific management, the traditional Western management implies a mechanistic chain of orders, specialised tasks and a separation of thinkers – who decide and plan – from doers – who execute. This model was adapted to a stable and predictable environment, which is widely recognized to be increasingly exceptional (Finchman and Rhodes, 2005, p. 486). In a

complex and unpredictable environment, authors like Mintzberg, Lampel or Senge suggest that planning – prescriptive and rigid – should give way to both mapping – which is descriptive and accommodates change – and emergence. Whereas planning required centralisation, mapping entails a variety of perspectives and understanding of local nuances – i.e. decentralised knowledge. Emergence implies purposeful self-organisation through decentralised decision-making. Let us take a closer look at the two essential concepts of emergence and decentralisation.

The chaos and systems theories taught that small changes can have big effects, which was translated in business terms into the concept of 'leverage': the idea that "small, well-focussed actions can sometimes produce significant, enduring improvements" (Freedman, 1992, p. 37). Gareth Morgan and Asaf Zohar (n.d.) studied change management in companies like Taco Bell or Semco and demonstrated how, even when aspirations are great, change is more likely to emerge through "small scale initiatives that [build] upon each other and [develop] momentum along the way". Change can be radical if there is a gap between the organisation and its environment – whether because of strategic drift or because of major disruption – or it can be incremental as the organisation is constantly adapting to its changing environment. Adaptation should thus be an emerging process, happening through decentralization.

Giving more autonomy to lower levels of hierarchy allows harnessing their hands-on experience, innovations and passion while decreasing workload and complexity at the top (Robertson, 2010, Womack and Jones, 1996, Bernoff and Schadler, 2007). Vineet Nayar talks about "[unleashing] the power of the many, and [loosening] the stranglehold of the few, thus increasing the speed and quality of innovation and decision making where it matters most – in the value zone – every day" (2010, p. 13). The US steel manufacturer Nucor provides a classic example. In 1998, this Fortune 500 company had 6,900 employees, sales of $ 4.3 billion but headquarters of only 22 people. The company required very succinct KPI reports from their plants and encouraged staff to invest in technology and drive innovation. The idea of empowerment is at the heart of 'lean', as promoted by Womack and Jones (1994, 1996), and goes hand in hand with *kaizen*. It is hence in Japan but also in Germany that such a management philosophy can be most widely observed. Both industries have a

tradition of skilled and engaged workforce and harmonious social relationship (Finchman and Rhodes, 2004, pp. 682-689). *Kaizen* further entails investing in people's development through training.

Decentralised decision-making is not only crucial to emerging change but also in the face of unpredicted disruptive crises (Sheffi, 2005). At a local level, cells or individuals can react fast, be opportunistic and resourceful – what Coutu calls the "uncanny ability to improvise" (2002, p. 48).

4.1.4. Leverage and catalyst leadership

The context of emergence and decentralization obviously requires a new type of leadership. The role of leaders should be to set a direction for the future and create the conditions that enable people to self-reflect (cf *kaizen* and double-loop learning) and take initiatives by questioning, challenging and instilling a culture of experimentation, according to Gareth Morgan who calls these leaders "strategic termites" (Morgan, n.d., *Strategic Termites*). This is perfectly illustrated by the leadership philosophy of Indian giant Tata. "Tata wants its people to be able to act without always having to receive direct orders", says Satish Pradhan, chief, group human resources at Tata Sons. "We are not here to make decisions for people" he says. "Our role is to help people become better able to make the right decisions. We don't want credit for what they do. We want them to be able to say, 'We did this ourselves'" (Witzel, 2010, p. 134). Nucor CEO John Correnti gives another illustration of leadership in service: "Our company is the pyramid upside down; 6,800 people do not work for me, I work for 6,800 people" (quoted by Anthony and Govindarajan – 2007, p. 19).

4.1.5. Variety[2]

Variety is another key resilience factor as highlighted by the literature. According to system theory and the principle of requisite variety – originally formulated by the English cybernetician W. Rosh Ashby – "internal diversity of any self-regulating system must match the variety and complexity of its environment if it is to deal with the challenges posed by that environment" (Morgan, 1997, p. 112). The 'Self-challenging' subsection previously showed how variety helps organisations get a more accurate and comprehensive understanding of themselves and their environment. It is also crucial in terms of responses to this environment. Hamel and Välikangas thus translated the principle of requisite variety into strategy: "If the range of strategic alternatives your company is exploring is significantly narrower than the breadth of change in the environment, your business is going to be a victim of turbulence" (2003, p. 59). The implication is that to increase their resilience, organisations should test a wide range of low-risk strategic experiments – or *stratlets* – instead of focussing on building a grand strategy. "The arithmetic is clear: It takes thousands of ideas to produce dozens of promising stratlets to yield a few outsize successes - success is always an exception" (Hamel and Välikangas, 2003, pp. 59-60).

4.1.6. Redundancy

The last main factor for resilience is redundancy without which systems are "fixed and completely static" and therefore can't adapt to constant change or respond to major disruptions (Morgan, 1997, p. 108-112, see also Robinson, 2010, p. 15). Excess resources in the form of inventory, capacity or lead times firstly give room for innovation and development. They allow experimentation without jeopardizing other aspects of the business (Melnyck et al., 2010, p. 36, Tidd and Bessant, 2009). They secondly act as a buffer in the event of supply chain disruption (Melnyck et al., 2010, p. 36-37, Christopher & Rutherford, 2004, p. 28, Christopher, 2004, p. 18, Sheffi, 2005).

[2] Variety and diversity are used as synonyms. They both refer to the quality of a group of units that belong to the same category but exhibit differences and uniqueness.

Redundancy does not entail only the idea of back-up through excess resources but also that of diversity of adequate responses to the same need or situation. Safety resources can thus also be created by distributing capabilities – as covered in the 'Optimize' section – and by diversifying the supplier base, as suggested in the 'Integrate Systems' section.

4.2. Optimize

According to BCI:

"Optimising delivers better results than maximizing or minimizing. Nature does this by:

- Creating forms that fit functions, not the other way around
- Embedding multiplicity into both functions and responses
- Creating complexity and diversity using simple components and patterns"

The old business paradigm was based on the linear manufacturing of products that were pushed to the market, with an emphasis on volume and profit – maximisation of sales and minimisation of costs. The new paradigm is focused on solutions and flexibility, and requires a balance of versatility and specialisation.

4.2.1. Pull strategies

Firms traditionally target a market segment and manufacture products which they then *feed* to the market. The emphasis is often on cost and volume, with the objective of maximizing gross profits. This product-focus was challenged by Hamel and Prahalad whose core competency approach (1990) has hugely influenced modern strategic thinking. Hayes and Pisano likewise suggested that "in today's world, where nothing is predictable and unfamiliar competitors emerge from unexpected directions at the worst possible time, a company should think of itself as a collection of evolving capabilities, not just as a collection

of products and businesses, which provide the flexibility needed to embark in new directions. Corporate strategy must provide a framework for guiding the selection, development, and exploitation of these capabilities" (1994, p. 86, see also Brown and Blackmon, 2005). Inspired by Japanese *lean* manufacturers who had shifted their focus to speed and flexibility, this responsive (pull) strategy requires a deep commitment to collective learning and working across organisational boundaries.

4.2.2. Solutions-based business models

The second major paradigm shift relates to the traditional linear process – referred to as "take, make and waste" – whereby companies extract materials and energy, transform some into a product while generating waste and sell that product to customers. Customers use the product and discard it when it is worn-out or obsolete. The materials and energy embedded in the product are lost to both the producer and the consumer, and there is little room for adapting the product to the customer's specific need (customisation) or to the constant change in taste or technology (upgrade). In a solutions-based business model, "value is instead delivered as a flow of services – providing illumination, for example, rather than selling light bulbs. This model entails a new perception of value, a move from the acquisition of goods as a measure of affluence to one where well-being is measured by the continuous satisfaction of changing expectations for quality, utility, and performance" (Lovins et al., 1999, p. 146).

The advantages of this new model are many. It focusses on providing a customised and upgradeable solution, and is therefore likely to increase customer satisfaction and build long-term relationships. Beside improving customer value, it is also likely to improve the bottom line, as the company retains ownership of the materials and either keeps them in a closed loop or sell the waste as an input to another organisation – as described in the 'Adapt' section. It therefore "aligns both parties' interests, offering rewards for doing more and better with less" (Lovins et al., 1999, p. 154). Finally, as highlighted by James Womack from the Lean Enterprise Institute, it reduces "the volatility in the turnover of capital that lies at the heart of the business cycle and therefore '[brings] a welcome stability to businesses" (Lovins et al., 1999, p. 155).

InterfaceFLOR, the carpet tiles manufacturer, has been pioneering this 'cradle-to-cradle' approach and leases floor-covering service for a monthly fee. Solutions-based business models are increasingly adopted across a wide range of industries among which elevators (Schindler), air conditioning (United Technologies Carrier), chemicals (Dow) (Lovins et al., 1999, p. 154).

4.2.3. Versatility and distribution

A solutions-oriented business model requires an organisation that is itself outcome-focused. Traditional mechanistic organisations have two major flaws that divert them from delivering a proper service – both of which derive from reductionism. First, they are organised in functional departments which favours silo mentality (Morgan). Secondly they are stifled by the rules and procedures that organise the flow of processes between functional departments and across hierarchical layers.

An outcome-focused organisation needs to break down barriers between departments as recommended in Deming's seminal *Out of the Crisis* (1986), and be structured around teams that are responsible for the whole process from design to delivery. This idea is central to Business Process Reengineering, as promoted by Michael Hammer (1990), to Morgan's Model 5 organisation (n.d., *Six Models of Organization*) or holographic organisation (Morgan, 1997, p. 106) and to *lean* management, as observed with some of the most successful Japanese manufacturers (Hayes and Pisano, 1994, p. 82). In these organisations, capabilities must be distributed, according to the 'whole-in-parts' concept (Morgan, 1997). Teams should be holistic and cross-functional, people should be broadly trained rather than specialised so that they are interchangeable, equipment should be general purpose and organised in cells that produce a group of similar products rather than specialised by process stage (Morgan, 1997, p. 106, Hayes and Pisano, 1994, p. 82).

4.2.4. Specialisation and integration

The 'whole-in-parts' concept emphasises versatility but can also result in a replication of similar autonomous subsystems, and therefore a lack of diversity. Yet, complex environments require a high level of specialisation (Lawrence and Lorsch, cited by Finchman and Rhodes, 2005, p. 480). The co-existence of diverse specialised cells or individuals within one system (i.e. differentiation) is a potential risk of conflict and like functional silos can hamper the organisation's adaptability. A potential contradiction therefore arises between the need for distribution and versatility on the one hand and the need for specialisation and diversity on the other. But distribution needs not result in clones. "Different spin-offs may develop distinct competencies" to adapt to their local specificities, according to Morgan (1997, pp. 107-108) whose brain-inspired holographic organisation is likewise specialised *and* generalised. Both variety and redundancy thus need to be built at a local level (Morgan, 1997, p. 112-114). This is the basis of 'flexible specialisation', a term coined by Piore and Sabel to describe new forms of work organisations that challenged mass production and are particularly widespread in Germany (Finchman and Rhodes, 2004, p. 581).

Specialisation also ties back to functions, which should be "support departments, committed to enhancing the work of the teams, who are their clients" (Morgan, n.d., *Six Models of Organization*). Project-based teams may indeed not have the opportunity to develop and upgrade their knowledge and skills and in turn rely on functional departments, which would act both as internal schools, R&D and networking platforms (Womack and Jones, 1994, p. 99).

4.3. Adapt

According to BCI:

"Being adaptive pays back better than "staying a fixed course". Nature adapts by:

- Creating feedback loops to sense and respond at all levels of the system.
- Anticipating and integrating cyclic processes.
- Being resourceful and opportunistic when resource availability changes."

Adapting to an ever changing environment means having the capacity to sense and respond to these changes. It entails an ability to engage with a variety of stakeholders to access material and information resources. We will now take a look at the concept of leveraging stakeholders' feedback and focus on customers, suppliers and employees before addressing smart natural and technological resource management.

4.3.1. Leveraging stakeholders' feedback

As suggested by the chaos theory, it is impossible for an organisation to get a precise appreciation of its environment because it is highly complex and constantly changing. "The number of trends and issues that can have an impact on your organization is so large that it is impossible to take all of them into account in developing strategies for change" (Morgan, 92). Organisations' perception is moreover distorted by their own cognitive bias and culture.

To better sense their environment, organisations need to "become skilled in breaking the boundaries separating [them] from [their] environment, to engage and experience the environment as fully as possible" (Morgan, 1997, pp. 91-92). Engaging with a variety of stakeholders allows access to different viewpoints and even creating "miniature representations of the environment that allow companies to confront problems holistically and in a manageable way" (Morgan, 92, see also Robinson, 2010, p. 26).

While this will be enough to respond to incremental change, anticipating radical change in the environment requires understanding the deeper social trends, and picking up weak signals. This entails 'outside of the box' investigation – i.e. engaging with remotely connected organisations/individuals. Weak signals however often result in information greatly challenging for the organisation's existing business model, process or product and are therefore ignored (Tidd and Bessant, 2009). The hallmark of the most innovative companies is the ability to pick up these weak signals and create completely new industries or business niches (Hamel and Prahalad, cited by Morgan, 1997, p. 91).

Leveraging connections to create vital knowledge is also referred to in the 'Integrate Systems' and 'Build Resilience' sections.

4.3.2. Responding to customers

Organisations interact with a variety of stakeholders who all have specific needs. It would be highly challenging to rank them by importance, but customers arguably would not come last. Indeed, it appears crucial for a company to understand customers' expectations so as to respond as closely to these expectations as possible through product or service design and distribution. This is the nature of marketing, which has developed into a highly sophisticated field, and goes beyond merely sensing customers' needs to actually influence their behaviour. Yet marketing doesn't always get the full attention of top decision-makers (McGovern *et al.*, 2004).

Sensing and responding to customers' needs is central to the *lean* philosophy, which recommends delivering 'just-in-time' the exact quantity required by customers. Lean manufacturing operations and their supply network are also organised according to the same 'pull' system. A production cell waits for a signal – '*kanban'* in Japanese – from the cell down the line to produce the next unit. High responsiveness is linked to decentralised decision-making and is covered more extensively in the 'Build Resilience' section. It is also key to solutions-based business models, whereby companies sell a service and guarantee a constant level of performance, and must therefore readily sense any variance and respond to it. Solutions-based business models are addressed in the 'Optimize' section.

4.3.3. Leveraging customers and suppliers for innovation and promotion

Being responsive to customers allows adapting to their needs in the production and delivery phases. Adaptability in product design requires another form of customer relationship. Product development should come as the result of matching 'need' information, which lies with customers, and 'solution' information which lies with suppliers. Traditionally, this task has been conducted by suppliers through costly and uncertain market research and R&D (Thomke and von Hippel, 2002). Resourceful organisations transfer it to their customers, by giving them the lead on product development. In 2002, C.K. Prahalad stated that "the most fundamental convergence [was] between the role of producer and the role of consumer

[rather than on technologies]". Customer-led innovation happens in heavy industry like machinery as well as in consumer goods like T-shirts or computers. Beside customers, "companies rely increasingly on their suppliers as a source of new products and processes or improvement in existing ones" (Melnyck et al., 2010, p. 34). There is an overall trend to open innovation to external contributors, which lowers product development costs and gives access to a much larger variety of ideas. Procter & Gamble moved from 'Research and Development' to 'Connect and Develop', 50% of its 2009 innovations included ideas from external sources (Huston and Sakkab, 2006, Panduwawala et al., 2009). Even cars are now designed using crowd sourcing (cf Local Motors in the US - www.local-motors.com).

Innovation is not the only gain from fully leveraging customers or suppliers' potential. Word-of-mouth has been recognized as a powerful marketing tool: as Kumar *et al.* demonstrated, some customers are more valuable through their referrals than their direct purchase (2007). Smart companies will leverage their connections to access more, cheaper or even free resources.

4.3.4. Employee engagement

Organisations 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 organisations' performance, as addressed in the 'Support Life' section. Furthermore, decentralisation of decision-making to employee level greatly enhances the organisation's ability to sense and respond to changes in its environment, as covered in the 'Build Resilience' section. Furthermore employees' diversity and creativity is a source of innovation in terms of process and product (Morgan, 1997, p. 112-114), as explained by Nucor chairman Ken Iverson: "Technology is advancing too quickly on too many fronts. No small group of executives can possibly keep fully informed" (cited by Anthony and Govindarajan – 2007, p.19).

4.3.5. Natural and technological resources

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, p. 435). 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, p. 146). 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).

The closed-loop can happen within one organisation as evoked in the 'Optimize' section or within a system in the case of industrial ecology as evoked in the 'Integrate Systems' section.

4.4. Integrate Systems

According to BCI:

"With limited resources and a changing environment, it's better to be systems-based rather independent. Nature works with whole systems by:

- Fostering synergies within communities.
- Fostering synergies within energy, information and communication networks
- Creating extended systems to continuously recycle wastes into resources."

System theory has permeated business thinking which now considers "loosely interconnected" organisations (Iansiti & Levien 2004, p. 76) that are parts of complex business ecosystems. "Drawing the precise boundaries of an ecosystem is an impossible

and, in any case, academic exercise" (Iansiti & Revien, 2004, p. 71), but it is likely to include suppliers of outsourced finance, technology, products and services, complementors, competitors and customers, regulatory agencies and media outlets (Iansiti & Revien, 2004, pp. 70-71, Moore 1996 and Lewin & Regine 1999, cited by Peltoniemi and Vuori, 2004, p. 272 and p. 275). Moreover traditional organisational boundaries have been blurred by outsourcing or joint-ventures. Business theory has in turn come to highlight the importance of interdependence and co-evolution, recognising that firms' performance and ultimately survival depend on the health of the systems which they belong to regardless of their own strength (Iansiti & Revien, 2004, p. 69). This leads businesses to reconsider their interactions within these different systems. This section will first look at the relationships between buyers and suppliers, before moving to relationships with other business entities and finally with the non-business world.

4.4.1. The buyer-seller relationship

Traditional business relationships are 'win-lose' with "companies that [use] their leadership positions to extract advantage from upstream and downstream partners" (Womack and Jones, 1994, p. 102). But pressurising suppliers for lower prices doesn't bring sustainable competitive advantage and comes at the expense of quality or lead-times (Kramer and Porter, 2011, p.70). Supply *chains* have also become supply *networks*. They are far more complex and their interdependencies greater than ever before, calling for a higher level of collaboration (Christopher, 2004, p. 18).

Business theory is thus considering the advantages of moving away from the mere price-based transaction – *decommoditization* – to develop partnerships. The Japanese industrial tradition and the *lean* philosophy – in which "supplier relationships should be long-term and cooperative" (Hayes and Pisano, 1994, p. 82) – offer myriad examples of such practices. 'Grow with Toyota', the car manufacturer's slogan behind its supply management philosophy is just one example. Collaboration, trust, transparency, and commitment to improving the relationship (*kaizen*) are highlighted as the keys to strong, stable and mutually beneficial partnerships (Sheffi, 2005, Carlisle and Parker 1991, p. 5, Pagell and Wu, 2009, p. 52, Christopher, 2004, p. 19, Sako, 1992, Lamming, 1993, Senge, 2010).

Strong partnerships can however be a double-edge sword, since the "unexpected failure of one [core supplier] could be disastrous" (Sheffi, 2005). Organisations need to have a deep knowledge of their partners to anticipate disturbances, and even support their partners to avoid any disruption. This further emphasizes the importance of transparency and collaboration (Melnyck et al., 2010, p. 37) and suggests that firms also need an extensive network to quickly find alternative sourcing should disruption be inevitable.

Organisations' success depends on the health of their suppliers but also of their customers, which may be more difficult to assess in the case of a high number of small customers. The financial crisis of 2007-2010, or the IT industry crisis in the US in the early 2000s showed that entire industries can collapse because of the unsustainable practice by suppliers that destroyed their own customer base (Heffernan, 2011, Hamel and Välikangas, 2003, p. 55).

4.4.2. Keystone and niche organisations

The concept of interdependence is central to the *lean enterprise* as advocated by Womack and Jones: "a group of individuals, functions, and legally separate but operationally synchronized companies" (1994, p. 93). Whereas they argue that the lean enterprise is only a theoretical construct, it seems very close to *business ecosystems* as observed and described by authors like Moore, Iansiti and Levien. As in nature, *business ecosystems* comprise keystone organisations/species and niche organisations/species. Keystone organisations control assets – distribution, technology or brand – that are vital to their ecosystems. This central position enables them to bargain for a higher share of the total value produced by the ecosystem (Moore, 1993, p. 81). Niche players represent the bulk of the ecosystem and make its diversity. They are responsible for most of the value creation and innovation and provide the system with an "ability to absorb external shocks" (Iansiti & Levien, 2004, p. 73-77). They depend on keystones' assets and are often locked-in because of the investments they have made in building a relationship with the keystones. The latter in turn depend on the value created by niche organisations and need to invest to maintain and improve structural assets, encourage connections and innovation (Iansiti and Levien,

2004, p. 73). Keystones therefore exert “a strong influence over the co-evolutionary processes” (Moore 1996 cited by Peltoniemi and Vuori, 2004, p. 272).

Moore in 1993 gave the example of two keystones in the IT industry: Apple and Tandy. Tandy was vertically integrated, controlled the whole value chain and discouraged any independent initiative outside of its control. It ultimately stifled its own ecosystem whereas Apple encouraged independent players to join its ecosystem and leveraged their innovations (p. 77).

4.4.3. Networking

As in the buyer-seller relationship, the concept of interdependence is central to the keystone-niche relationship. Beside these critical relationships, there is a room for a wide range of mutually beneficial interactions. They can be broadly described as *networking*, in favour of which Tidd and Bessant suggest four major arguments: collective efficiency, learning and risk-taking, and the intersection of different knowledge sets (2009, p. 283). This also refers to the notion of clusters, as described by Porter (1998).

Firms join forces with competitors or organisations outside of their direct industry when they share common interest. They may need to mutualise costly investments or structural initiatives like market research, influencing regulations or public opinion. They may also share customer segments with *complementors*. In their book ‘Co-opetition’ (1997), Brandenburger and Nalebuff coined this term to “refer to organizations that sell products that enhance the value of another firm’s products to customers. Examples are companies that sell computer hardware collaborating with software companies and gas stations linking with fast-food companies” (Scott Armstrong and Clark, 1997, pp. 92-95).

Another type of networking is industrial ecology, which like clusters implies physical proximity: companies “co-operate by using each other’s waste material and waste energy flows as resources” (Korhonen et al. 2001, p. 146). This in turn reduces the amount of raw materials or energy extracted, as well as the waste stream. Such ‘cradle-to-cradle’ industrial practices are also addressed in the ‘Adapt’ and ‘Support Life’ sections.

4.4.4. Beyond business stakeholders

Beyond commercial interests, business theory recognized that firms operate in wider socio-ecological systems, which are themselves nested in greater systems, and are all part of one finite system: the planet. According to John Kay, 'business exists to serve social purposes and enjoys short term legitimacy and long term survival only to the extent that such business meets these purposes'. Corporations, he highlights, are complex organisations interacting with a complex environment, and responding to various and sometimes conflicting interests (Kay, 2010, pp. 154-155). Some businesses were established on philanthropic principles, such as the Indian giant Tata. For founder Jamsetji Tata "in a free enterprise, the community is not just another stakeholder in the business, but it is in fact the very reason for its existence" (cited by Witzel, 2010). However because of an increasing focus on sheer financial performance, a vast majority of companies has gradually lost touch with their social purposes, creating tensions at the social and environmental levels (Kramer and Porter, 2011). Corporate Social Responsibility initiatives have started tackling the issue and are now transforming business strategies thanks to a growing concern about sustainability. Business leaders are now advised to develop "shared goals with a broad set of stakeholders – customers, interest groups, and even competitors and adversaries" (Lubin and Esty, 2010, p. 48), supply chain managers to "collaborate with nontraditional members such as NGOs, regulators, competitors and members of the community" (Pagell and Wu, 2009, p. 52) and "[treat] these entities as knowledge suppliers, not potential sources of trouble" (Pagell and Wu, 2009, p. 50, Prahalad and Hammond, 2002, p. 10, Senge, 2010). Businesses are hence invited to look beyond their business ecosystem to the wider systems on which they depend. This has been very well articulated by Porter and Kramer around the concept of *shared value* (2011), which advocates strategic Corporate Social Responsibility or philanthropic initiatives that improve the firm's supply framework conditions (infrastructure, health and education etc.), and serve both the suppliers' communities and the firm's interests. Not engaging with stakeholders bears the risk of not being part of the system co-evolution and being phased out. According to WWF International Head of Corporate Relations Jean-Paul Jeanrenaud (2010), none of the timber companies which refused to participate in the development of the FSC label (Forestry Stewardship Council) are still in business today, while all of those who did participate are still operating.

4.5. Navigate by Values

According to BCI:

"In uncertain times, it's better to be based on a compass of values than a fixed destination point or set of pre-defined metrics. Nature reflects values by:

- Knowing what's really important to the communities in which you live , interact, and impact.
- Using values as the core driver towards positive outcomes.
- Measuring what is valued rather than valuing what is measured."

"Nobody has yet succeeded in deliberately arranging all the activities that go on in a complex society": Kay cites Hayek (2010, pp. 150) and points to the outperformance of western economies over soviet planning. In a complex environment, action and relationships are not planned and controlled by rules and procedures. Business theory suggests they are instead guided by culture and values (Kanter, 2008, p. 48, Finchman and Rhodes, 2005, p. 533, Albert, Ashforth, & Dutton, 2000, cited by Schneider and Somers, 2006, p. 357). We will also see in this section how values translate into value, how they need to remain adaptive and finally address the idea of measuring values.

4.5.1. Values provide guidance

Values refer to an understanding of what matters to the communities – at a collective and individual level – and to natural ecosystems in which an organisation operates. This leads to an appreciation of what contribution to make to the broader system – values as purpose and vision: "Employees once acted mainly according to rules and decisions handed down to them, but they now heavily draw on their shared understanding of a mission" (Kanter, 2008, p. 44). This refers to Hamel and Prahalad's idea of strategic intent (1989): a simple concise goal that is easily understood and can be sustained through turbulence.

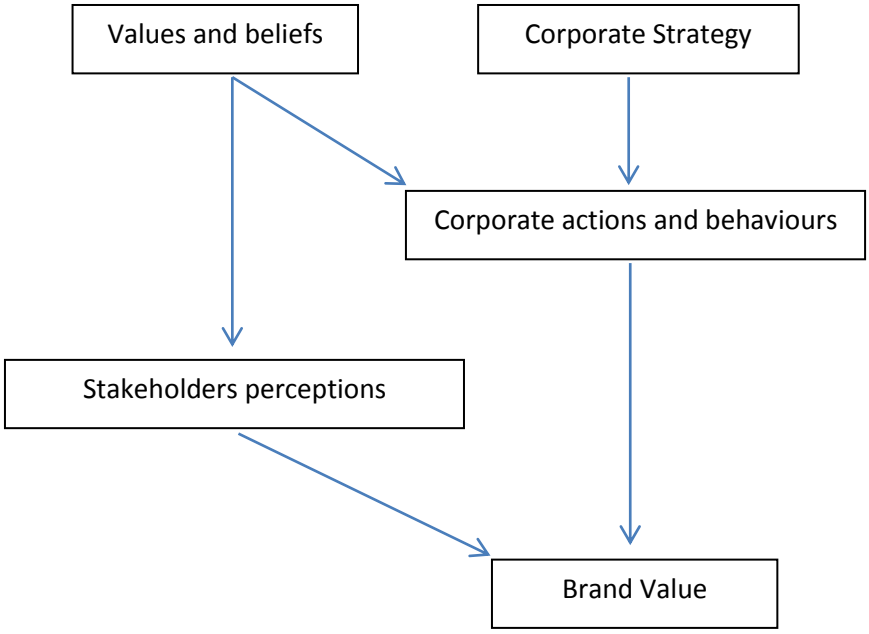
It also leads to a sense of what not to do to avoid causing harm – values as a space for action. According to cybernectics theory on systems, "successful system evolution has to be

guided as much by the "avoidance of noxiants" as the pursuit of desired ends. […] Whether we examine the Ten Commandments or contemporary legal systems, we find the principle of avoiding noxiants defining a space of acceptable behaviour within which individuals can act, innovate, or self-organize as they please" (Morgan, 1997, p. 98). In organisations, culture and "touchstone values" define this space (Pagell and Wu, 2008, p. 51).

Hence, values guide actions and foster consistent decisions taken at field level in a variety of cultural contexts. They compose the corporate DNA and act as a strong integration factor, "which permits collaboration among diverse people" (Kanter, 2008, pp. 45-48), and can be found in any part of the whole organisation which fosters resilience (Morgan, 1997, p. 102). Values further protect organisations from mission-drift (Robinson, 2010, p. 6) and provide "a rationale for longer-term investments where the immediate business case is mixed or unclear" (Kanter, 2008, p. 51). Consequently, leaders of culturally innovative companies are "obsessed with developing values and acting as role models" (Deal and Kennedy referred to by Finchman and Rhodes, 2005, p. 532).

4.5.2. Values translate in value and sustainability

Values also act as a filter and a "connective tissue" (Palmisano, cited by Kanter, 2008, p. 50). They help organisations to be more effective in selecting and shaping sustained relationships with external stakeholders as well as employees (Kanter, 2008, p. 49, Witzel, 2010, p. 17). As described previously, they entail a clear sense of mission and of limits to action. Values therefore make the organisation useful (*valuable*) to its stakeholders – employees, suppliers, customers or investors – who will be more likely to help it adapt and to support it in the face of upheavals. Values thus increase organisation resilience and also translate into value (Heffernan, 2011) as demonstrated at Tata by Witzel who highlighted the "straight line relationship […] between the *values* that Tata espouses and lives by, and the *value* of the brand" (Witzel, 2010, p. 19).



(Brand creation at Tata, Witzel, 2010, p. 18)

Placing core values before profit is a factor of business success and sustainability, as demonstrated by studies conducted by the oil company Shell in the early 1980s (mentioned by Arie de Geus, 1997, cited by Senge, 2010) and by Collins and Porras on 'visionary companies' in 1994 (cited by Carter and Rogers, 2008, p. 368).

4.5.3. Values should remain adaptive

There is a risk that an organisation's culture and values become too strong and therefore too rigid. They would "discourage adaptation by encouraging narcissism and a lack of reflexivity, exemplifying a frozen system" (Schneider and Somers, 2006, pp. 357-358, citing Hatch & Schultz, 2002). Organisations must avoid the 'the-way-it's-always-been-done-here' syndrome (Morgan, 1992). On the other hand, if culture and values are too malleable, the organisation might be subject to mission-drift. There is a fine balance to be found, which can be influenced by encouraging or discouraging factors that strengthen culture and values – symbols and ties within the organisation – and factors that weaken them such as bonds with external organisations (Schneider and Somers, 2006, p. 358).

Values – as purpose and space for action – should foster an evolving approach of the future and help organisations find the right balance between continuity and change, exploitation and exploration (Morgan, 1997, p. 102, Schneider and Somers, 2006, p. 358).

4.5.4. Measuring value

Businesses which values translate into a *triple bottom line* strategy need a new set of metrics to measure costs and benefits in order to refine their strategy, set up reward schemes as well as communicate results (Lubin and Esty, 2010, p. 49, Pagell and Wu, 2009, p. 53). This appears to be very challenging even for leading organisations and no reporting standards have yet been widely adopted. Companies leading the way in "expanded sustainability reporting" like Timberland (Lubin and Esty, 2010, p. 49) may thus influence future standards and find themselves ahead of competition.

It is however questionable if social and environmental impacts can always be measured. For example in health services quality measures may come at the expense of emotional and interpersonal relationships that are yet crucial. There is a risk of focussing on what is measurable at the expense of the rest. New reporting initiatives like 'Accounting for People' have lately introduced the idea of 'narrative accounting' for non-measurable features. This issue is also a question of culture, as illustrated by Ouchi (cited by Morgan, 1997, p. 96), who reported in 1981 the cultural clash between the American 'Management by Objectives' and the Japanese management by philosophy and values.

4.6. Support Life

According to BCI:

"In the long run, it takes less effort and less resource to support life-building activities than to be damaging or toxic and pick up the cost later. Nature supports life-building activity by:

- Leveraging information and innovation rather than energy and materials
- Creating support for individual components that can support the whole ecosystem, and support the ecosystem so that it can support the individual.
- Making products water-based, renewable, bio-based, and biodegradable."

Applied to business, *life* can be metaphorically seen as the health and survival of business organisations, which links to the 'Build Resilience' principle for their internal capacity to adapt and bounce back after disturbance and the 'Integrate Systems' principle for their interdependence. *Life* can also be taken quite literally and refer to health and safety – and arguably to people's engagement – as well as environmental stewardship: pollution prevention and sustainable resource management.

4.6.1. People

Most companies would state today, at least publically, that their people are their main assets, which has not been the case throughout industrial history. Since the revolutionary Hawthorne studies, employee engagement has been widely researched. Although human motivation is a highly complex topic subject to a broad range of definitions, it is now accepted that cooperation is the type of relationship – or psychological contract – between a company and its staff that will generate the highest level of engagement (Handy, 1993, p. 47, Finchman and Rhodes, 2005, pp. 199-200). It requires an alignment of values and objectives (as suggested in the 'Navigate by Values' section) and of course mutual respect. Employee engagement is shown by their support to the corporate brand, which only

happens if the company behind the brand supports them (Hatch and Schultz, cited by Witzel, 2010, pp. 125-126).

This philosophy of mutually beneficial relationships with employees is also relevant when expanded to the wider community of which employees and the firm are part, as illustrated by the holistic leadership under which Indian corporation Tata was grown: 'If workers shared in the fruits of their own labours, they would be better motivated, work harder, increase production and generate more wealth. This would be good for the company, for workers themselves, and for India. Increasingly, as time passed, [Jamsetji Tata – Tata's founder] blurred the distinction between the economic and social responsibilities of the business" (Witzel, 2010, p. 130). This ties back to the idea of *shared value* (Porter and Kramer, 2011) mentioned in the 'Integrate Systems' section.

4.6.2. Planet

With the rise of the environmental crisis – resource depletion, pollution and climate change – environmental management has become a hot topic for business. However, most initiatives aim at *reducing* negative impacts: doing 'less bad'. Rather than addressing the cause of the problem – the deep design flaws – this is instead "setting goals and using practices that sustain a fundamentally flawed system" (Mc Donough et al., 2003, p 435). Consequently, such initiatives end up being offset at the macro-level by population and economic growth, and the increase in extraction, production and pollution: less damage is caused per unit produced, but more units are produced overall. Yet, the whole economy hinges on healthy ecosystems' resources and services. While in the industrial system machinery is an easy substitute for labour, "no technology or amount of money can substitute for a stable climate and a productive biosphere. Even proper pricing can't replace the priceless" (Lovins et al., 1999, p. 158). 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, p. 148). Big corporations are taking steps in this direction, and increasingly so as the reputational risk of being perceived as eco-unfriendly is now

overtaken by the risk of medium term supply shortage (Knight, 2010). As reactive eco-efficiency is replaced by proactive eco-effectiveness, business evolves to solutions-oriented and closed loop models, as discussed in the 'Optimize' section.

5. Conclusion to the literature review

The above literature review demonstrates a wide support to Nature's Principles as a whole. The framework clearly resonates with the major trends underlying the evolution of the business environment from the stable, rigid and simple era of Taylorism and bureaucracies to an era of networking, complexity, unpredictability, hyperflexibility and resource limitations. Nature's Principles relate to a wide set of business theories, and in particular:

- Total Quality Management (TQM) – Deming, Juran
- Lean – Womack and Jones
- Learning / holographic organisations – Senge, Morgan
- Business ecosystems – Moore, Iansiti and Levien, as well as Brandenburger and Nalebuff with 'Co-opetition'
- Innovation – Christensen, von Hippel, Bessant,
- Sustainable supply chain management theory (SSCM) – Carter, Rogers, Pagell and Wu, and more recently Porter and Kramer with 'Shared Value'
- Core competence, strategic intent, evolving capabilities – Hamel and Prahalad, Hayes and Pisano
- Management by values – Kanter, Morgan, Witzel
- Natural Capitalism, Cradle-to-Cradle and Solution-based business models – Hawken, Lovins and Hunter Lovins, McDonough and Braungart

Beyond this general finding, more specific conclusions can be drawn from the literature review. Firstly, these theories cover many aspects of business management – finance being the most notable exception – and refer to business practices that range from widespread to emerging, and 'yet-to-be-applied'. The relevance of lean and TQM has for instance long

been proven in the Japanese industry. The strategic role of values or the importance of networking, diversity and redundancy for innovation has also been clearly demonstrated. Models like the learning organisation, the lean enterprise (in the sense of a coordinated ecosystem) or cradle-to-cradle are however still to be applied at a greater scale to prove their feasibility beyond their conceptual appeal. The variety of these approaches and of their 'maturity' highlights that business practice and thinking are work-in-progress and challenges the idea of a comprehensive and definite business theory.

Secondly, there are contradictions between some of these theories, and between a specific model and Nature's Principles. Lean for example requires the elimination of excess (*muda* in Japanese), and standardised processes. It therefore clashes with the ideas of redundancy and diversity – which are central to Nature's Principles and to innovation theory. Being obsessed with operational excellence and incremental improvement, lean organisations thus have a difficulty to innovate radically (Melnyck et al., 2010, p. 36, Womack and Jones, 1994, p. 98). These contradictions show the necessary trade-offs of business management and therefore the challenge of defining a 'silver bullet' model that would be relevant across the wide range of real-life situations.

Thirdly, 'Nature's Principles' are very broad and conceptual. They not only cover organisational management and 'soft' issues but are also relevant to 'harder' issues like operations, design and production. However, although the literature review showed that they can be linked to practical approaches, it appears challenging to draw a clear set of practical recommendations or evidence of these overarching principles.

Fourthly, there seems to be a need for disambiguation around the concept of *values*. The literature review suggests that *guiding values* define both a space for action – 'what not to do' – and a purpose and vision – 'what to do' now and in the long term. Values as a space for action refer to ethics and therefore to a set of universal principles – with potential local variations, which is debatable but is outside the scope of this paper. Values as purpose and vision are however specific to each organisation. In Nature's Principles, 'Navigate by Values' mentions '*Knowing what's really important to the communities in which you live , interact,*

and impact' and '*Using values as the core driver towards positive outcomes*' and does not seem to make a distinction. This could be explained by one of the fundamental differences between humans and the rest of nature: the potential for human individuals or organisations to intentionally shape their environment. This topic is developed in Appendix 1 which briefly reviews the history of biological analogies.

In conclusion:

The literature review demonstrates that Nature's Principles as a whole appear well supported by the business literature and form a comprehensive yet conceptual framework. This however does not mean they would outline an inclusive and definite 'silver bullet' model that would be relevant across industries, situations or organisational types. The very possibility of defining such a model is indeed illusionary.

6. Organisations as 'Complex Adaptive Systems'?

Whereas organisational models and strategies are widely debated in the business literature, there is a clear consensus in around the evolution of the business environment: it is becoming increasingly complex, unstable and unpredictable. From system theory to biomimicry, the literature does point to *complex adaptive systems* as the fittest to this type of environment. Human organisations should in turn behave more and more as such: leverage self-management of myriad interdependent agents, sense and respond to feedback from their environment, learn from experience and embed learning in their structure, reap the advantages of specialisation without getting stuck in rigidity (Freedman, 1992, p. 32).

Actually, the business environment appears much more chaotic than what *complex adaptive systems* are exposed to in nature, at least for two main reasons. Firstly in terms in resources: sunlight and biological nutrient flows in nature are "fairly constant or at least follow predictable cycles", while "inputs like technology in business ecosystems are constantly changing" (Iansiti & Revien, 2004, p. 76). Secondly, as noted by Gareth Morgan

(1997, p. 60), whereas in nature we find that organisms are endowed with a harmonious pattern of internal and external relations as a result of evolution, incongruence and conflict are more common in the human realm – arguably because of our egos and free will. The fact that businesses face a 'super-chaotic' environment can be seen as strengthening the case of *complex adaptive systems* for business organisations. The concept of emergence associated with such systems however faces several practical issues.

Firstly, emergence is linked to decentralised decision-making. But discretion gives power and in turn offers opportunities for personal benefits: top executives enjoy higher salaries as well as perks and prestige. Decentralising decision-making would require that they potentially give up these advantages. Furthermore, even in the perspective of managers' dedication to the greater good, they tend to be reluctant to let go of control in fear of chaos or inefficiency. As mentioned in the 'Navigate by Values' section, if the values, vision and culture are too weak, the organisation lacks cohesion and functional unity – distributing power could then lead to anarchy. There is of course a paradox in this anxiety and lack of trust, as control is quite illusionary in the face of change and complexity. Moreover people do not necessarily demand autonomy. Some are quite happy being led, and do not want any responsibility. It can also be argued that not everyone is capable of autonomous decisions. And facing this chaotic and stressful environment, a lot of people actually need strong and heroic leaders, of whom our history is replete, for the better and often for the worse. A catalyst leader that distils inspiration and empowers in such a subtle manner that she becomes transparent might be for many a factor of anxiety. Indeed, in the event of a crisis, despite a shared sense of purpose and values, individual agents may give unsynchronized and diverse responses, which coordination will take too long to address the situation effectively. A more assertive centralised type of leadership would then be required (Mintzberg et al., 2009, pp. 234-240).

Beside decentralised decision-making, emergence is also linked to learning which requires a "degree of openness and self-criticism that is foreign to traditional modes of management" (Morgan, 1997, p. 117). It can also be argued that these qualities are not necessarily widespread with people in general. Critical self-reflection requires stepping out of one's comfort zone, which is neither easy at the organisational nor at the personal level.

Emergence would thus require a higher level of intellectual maturity, moral integrity and courage that appears beyond the scope of business management. Besides, at the practical level learning entails experimentation which is expensive and diverts resources from productive operations. There is a time to learn and explore, and a time to exploit (Mintzberg et al., 2009, p. 238). At the cognitive and operational level, there must be balance of change and continuity.

Finally, a major concern with the concept of emergence is incrementalism. Emergence implies constant adaptation through myriad interactions with the environment at local level. Such an opportunistic behaviour bears the risk of tactical manoeuvring (Mintzberg, 2009, p. 234) and therefore of strategic drift, if the values and vision are too weak as mentioned above. There is also a risk that organisations cannot anticipate deeper trends and produce radical innovation – this tension between incrementalism and disruptive innovation was already underlined with lean organisations). Whereas adaptation is short-term, evolution is longer term. In nature it seems to happen more at species level or serendipitously at individual level. In business, an individual organisation has the potential ability to come up with a radical innovation that will make established players obsolete overnight (cf Schumpeter's creative destruction, see Appendix 1). While it can be argued that any organisation is likely to face such a challenging situation – which makes the case for resilience – attack can also be seen as the best form of defence: organisations need a capability for radical innovation, which appears less likely to come as the result of an emerging process.

However, emergence needs not be the *modus operandi* of all organisations. The contingency theory (cf Burns and Stalker, and Woodward - see Appendix 1) teaches that the specificities of the local environment may require different sorts of organisational structure and culture. Likewise, many different types of behaviour are observed in nature. Type III ecosystems – complex adaptive systems like a redwood forest – are cyclical but Type I ecosystems – like flour beetles – are linear (Benyus, 1997, pp. 238-251). Both contribute to the overall health of the greater system, the biosphere. Reproduction strategies are similarly varied, with r and K species: the former create a great number of offspring but invest very little energy in them whereas the latter give birth to very few offspring and put

lots of time into ensuring their survival (like humans). So should all organisations behave like redwood forests and r species? Big multinational corporations have such a reach that they can easily touch the limits of the greater economic social and natural systems. Do smaller companies not have more room for specific organisational structure and behaviour? Similarly, smaller firms cannot afford to test many small-scale strategies like big corporations, but do they not sometimes offset this handicap with their passion and high level of specialisation? Surely nature's principles as suggested by BCI are universal but as individual species have specific patterns of behaviour, so should individual organisations. Business ecosystems, as described by Moore, Iansiti and Levien, suggest that niche organisations make the diversity of the ecosystem, generate the most value and drive innovation. Is this because they operate under different modes than 'complex adaptive systems'?

In conclusion:

While the *complex adaptive system* model appears in theory adapted to the new business environment it also seems quite idealistic with regards to human behaviour and the required 'power' and 'mindset' shifts. Furthermore, it may be more relevant to big corporations than to small companies, and may not produce the conditions conducive to radical innovation.

7. Critical assessment of BCI's Nature's Principles

The literature review has provided an overall understanding of 'Nature's Principles' and their relevance to business, and suggested to refer to the *complex adaptive system* model which we just discussed. We will now take a critical perspective on how the framework is formulated and articulated.

Firstly, 'Nature's Principles' are very much intertwined. In the 'Support Life' principle, the suggestion of "*Making products water-based, renewable, bio-based, and biodegradable*"

could as well be part of 'Navigate by Values' as it implies "*knowing what's really important to the communities in which you live, interact, and impact*", and the suggestion of "*Creating support for individual components that can support the whole ecosystem, and support the ecosystem so that it can support the individual*" relates to "*Fostering synergies*" as suggested in the 'Integrate Systems' principle. It could also be argued that resilience comes as a result of all other principles.

Furthermore, there seems to be redundancies. For instance, in the 'Optimize' principle, "*Creating complexity and diversity using simple components and patterns*" in organisation management would imply cross-functional teams and broadly trained staff, which would also fall under "*Embedding multiplicity into both functions and responses*". In the 'Build Resilience' principle, "*Fostering diversity in people, relationships, ideas and approaches diversity*" is likewise implied by the previous suggestion "*Decentralizing, distributing, and diversifying knowledge, resources, decision-making, and actions.*"

Beyond Nature's Principles, the interconnectedness and redundancies of concepts is also found with BCI work as a whole that features other frameworks presenting similar concepts in different ways. Some have been included in the same document, which can add to the confusion. For instance the guidelines for "*The Firm of the Future - a Business Inspired by Nature*" produced by BCI and Atos Origin feature the six Nature's Principles, but also the three core values – Social justice, Environmental excellence, Economic adaptability and resilience – as well as the six attributes of the Firm of the Future – Governance, Culture, Leadership Style, Operations, Supply Chain/Business Ecosystem, Products & Services. The case study template suggested by BCI uses still another framework: Context, Goals, Resources, People, and Networks. This confusion may come from the open and networked way BCI operates, which allows each individual and organisation to re-interpret and re-express the principles in their own way. There could be indeed many ways to organise, model or framework the behaviours and qualities suggested by Nature's Principles. But the confusion may also be linked to the holistic nature of the framework, as we now discuss.

This lack of separateness between principles and between their underlying concepts – which shows in Nature's Principles and in the variety of frameworks published by BCI – can prove

confusing but ties back to the holistic approach of biomimicry. Just like different functional departments in the organisations need to collaborate and mingle for the organisation to perform effectively, the fields of business management and the principles of nature are interconnected. As our current thinking is heavily influenced by centuries of reductionism, we often find holistic thinking puzzling. The complex nature of business reality and the holistic approach of biomimicry can arguably question the very possibility to reduce it to a model.

In conclusion

Nature's Principles are very much intertwined, and as a whole feature redundancies. While this may be subject to improvement, it also comes from the holistic nature of biomimicry. There is surely a challenge in presenting nature's principles and their implications for business in a concise and accessible way.

8. Conclusion

In the light of this paper, BCI 'Nature's Principles' appear to provide a holistic framework that is highly relevant to current business issues and trends. They're supported by a large variety of business theories, among which: Total Quality Management (TQM), Lean, Learning Organisations, Business Ecosystems, Strategic Innovation Management, Sustainable Supply Chain Management (including 'Shared Value'), Core Competences and Strategic Intent, Management by Values, Natural Capitalism, Cradle-to-Cradle and Solutions-based business models. These approaches cover both hard and soft issues of business management, range from proven to emerging, and are also sometimes contradictory. But a holistic approach is required in the face of complexity and chaos – as found in both business life and nature – which suggests that it is illusionary to seek one comprehensive and definite 'silver bullet' model for business management. Indeed 'Nature's Principles' fail to offer a concise, accessible and practical framework. But that would be an attempt to answer the wrong question and is not BCI's motivation. While "traditional

management practice based on a mechanical frame of reference thrives on blue-prints and how-to manuals, […] we need to remain more open than this" (Morgan, 1997, p. 117).

'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. If we don't live and do business within the constraints of the system, we will be expelled. That is the daunting challenge of sustainability. There is indeed a significant gap between Nature's Principles and our current business practice, rooted in our scientific and cultural heritage as well as in our imperfect human nature which gives us the freedom to break the rules of nature. In that regard, 'Nature's Principles' may appear idealistic but is there an alternative? Biomimicry suggest that we can learn to play by the rules of nature, which offer a very rich source of inspiration to challenge our current unsustainable business practice and invent new strategies. 'Nature's Principles' are universal but there is room for specific individual behaviours and indeed we as individuals and business people need to invent our future in a great variety of ways. We ought to accept that we are stepping into the unknown and let go of the need to find an answer or a goal to achieve. We should rather recognize that we are on a journey not towards the optimal organisation or business model, but towards the understanding of business as a process, constantly interacting, adapting and morphing to maintain balance in a changing environment.

Further research could investigate alternative formats to present 'Nature's Principles' in a more palatable way, and facilitates their use in a practical business context. Biomimicry is too complex to be presented in a linear way and through models: could it be told through a set of stories, mixing case-studies and biological metaphors? Could it come as a set of yin-yang concepts suggesting balance between paradoxical qualities and behaviours: pull & push, exploit & explore, focussed & adaptive, collective & individual, versatile & specialised, radical & incremental, distributed & diverse…?

More focussed research would also be much welcome, for example:

- How can biomimicry inform finance – which as mentioned in this paper does not seem obvious?
- How can the concept of abundance – net positive impact – translate in practice?
- How can technology be used to enable biomimetic business practice rather than serving the old paradigm?

9. Critical self-reflection

I am one of the many whom, as Janine Benyus described, "responded with a universal enthusiasm to biomimicry, a sort of relief upon hearing an idea that makes so much sense." I was equally inspired by BCI approach that Giles Hutchins introduced to the Exeter MBA in 2011. My intention while embarking on this project was to go beyond this intuitive enthusiasm and investigate how biomimicry compares with business theory.

There are obvious limitations to my dissertation, starting with my own bias. Being a self-confessed biomimicry enthusiast, I may have lacked objectivity throughout this work. It may have influenced my selection of theories, and narrowed my critical perspective when assessing the framework.

Another limitation comes from the breadth of the topic which eventually covers almost all aspects of business management – surprisingly I did not find any obvious linkage between biomimicry and finance, but again this may have been biased by my moderate interest for financial topics. Because of the time constraints, I could not support every aspect of the framework with a wide-enough theoretical basis and take a critical perspective by debating contradictory references.

Furthermore, the sources that I accessed suffer firstly from the Exeter MBA filter, which scoped my bibliography, and secondly from the general slant of business management literature which is heavily influenced by North-American – and to a lesser extent British –

authors, and tends to focus on bigger firms. Almost a third of my sources come from the Harvard Business Review, illustrating this bias.

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APPENDIX 1: A brief history of biological analogies

Human societies have a long history of turning to nature to understand their own behaviour and find solutions to their own issues. This section offers a brief account of biological analogies, starting with the body metaphor which was introduced as a political theory in Ancient Greece and travelled through the years to the 20th century. We will then look at the evolutionary theory before addressing the systems theory and its recent implications for organisations and sustainability.

Early biological analogies: organisations as bodies

Biological analogies can be tracked back to classic Greek philosophers. Socrates, Plato and Aristotle compared the *polis* (city or state) to the body (Hodgson, 1995, Goggans, 2004, Witzel, forthcoming). Just like organs and limbs co-operate in the body, citizens – who hold a variety of skills among themselves which are vital to the *polis* – work together in service of the *polis*. In turn, each citizen needs a healthy *polis* to satisfy their various needs – the relationship between the individual and the organisation is based on interdependence. Furthermore, the organisation of the *polis* does not come as the result of a plan, but as an emerging process (Goggans, 2004).

Biological analogies were later found with medieval thinkers like Thomas of Aquin or John of Salisbury according to whom "The prince is the head of the state; the senate or other representative body is its heart; the soldiers and agricultural workers are the equivalent of the limbs, and so on" (Witzel, forthcoming). The Irish political theorist and philosopher Edmund Burke in the 18th century, the Scottich chemist Andrew Ure in the 19th century also used biological analogies to discuss both political and business organisations. Ure 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 - labour, science, capital; the first destined to move, the second to direct, and the third to sustain. 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." (Witzel, forthcoming, citing Ure, 1835).

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

Biological analogies were further found during the 2nd half of the 19th century and the first half of the 20th in the work in political economists like Albert Schäffle in Germany or John A. Hobson in the UK.

Evolutionary Economics

Charles Darwin and Herbert Spencer's evolution and natural selection theory had a significant influence on early 20th century's economists. Darwin himself who published *On the Origin of Species* in 1859 is "said to have been strongly inspired by the work of Malthus on population as well as the broadly evolutionary theorizing of the Scottish Enlightment" (Foss, 1994, p. 1115). Evolutionary thinking can be seen in Joseph Schumpeter's creative destruction, according to which an industry at equilibrium can be destroyed by innovative entrepreneurs who create a new industry. "Competition [is therefore described] as an engine of progressive change", of evolution (Nelson and Winter, cited by Foss, 1994, p. 1129). Darwin and especially Spencer also notably influenced Alfred Marshall who produced one of the most famous biological analogies. He compared young companies to trees 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, 1994). This theory was the basis for neoclassical justification of free markets (Foss, 1994, p. 115), as advocated by Milton

Friedman and put very simply by John D. Rockefeller (in Hofstadter, 1944, cited by Levallois, 2011, pp. 13-14): "The growth of a large business is merely a survival of the fittest … The American Beauty rose can be produced in the splendor and fragrance which bring cheer to the beholder only by sacrificing the early buds which grow up around it. This is not an evil tendency in business. It is merely the working out of a law of nature and a law of God".

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 "ahistorical, fully adapted, uniform equilibrium" view of the firm (Foss, 1994, p. 1125), 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 Armen Alchian 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.

Chaos, complexity and systems

The twentieth century saw the emergence of a new scientific paradigm with the cybernetics and systems theories, which cover various disciplines among which mathematics, psychology or biology. Major authors include the English psychologist W. Ross Ashby or the Austrian biologist Ludwig von Bertalanffy who introduced his General Systems Theory in 1968. 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 (Freedman, 1992, p. 26). 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: breaking down things into isolated parts in order to better control them (Freedman, 1992, p. 28). In the 1960s studies by Scottish researchers Tom Burns and G.M. Stalker, and British organisation sociologist Joan Woodward exposed the limits of Taylorism. Their work paved the way to the contingency theory according to which there is no one best way to organise a firm: the optimal management depends on the environment. In the face of an unstable and uncertain environment, Taylor's *mechanistic* organisation – 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.

This biological analogy was both a novelty in the context of the 20th century Western economics and a return to the ideas of the classic Greek philosophers and their followers. It was however taken further as science progressed to describe *complex adaptive systems*. In the 1980s, studies like those conducted by the Santa Fe Institute in the US identified the characteristics of systems like tropical forests, colonies of ants, and even the human brain – which are the most successful ecosystems in nature according to Mitchell Waldrop, author of *Complexity* (1992) (Freedman, 1992, p. 30). These *complex adaptive systems* are self-managed: members of the system act independently from one another and without a central control and yet engage in cooperative behaviour to produce complex outputs of a higher-order that benefit the group. They are also "capable of 'learning' through feedback from the external environment [and] 'embed' that learning in their actual structure. For instance, the more a set of neurons is involved in some piece of mental work – like recognizing a face or solving a mathematical problem – the stronger the actual chemical connection among the neurons (and the easier for the brain to make the connection the next time)" (Freedman, 1992, p. 32). Embedded learning does not mean that they are "locked into previously useful behaviors that since have become obsolete": the system remains adaptive. Its *modus operandi* is "flexible specialization" (Freedman, 1992, p. 32). The 'complex adaptive systems' approach leads to innovative business theory like Peter Senge's *Fifth Discipline* (1990) or Gareth Morgan's holographic organisation, inspired by the brain and described in *Images of Organisations* (1986). Their models imply "cross-functional teams, self-managed work groups, and the networked organization" (Freedman, 1992, p.

28) and have been greatly referred to in this paper. It is however difficult to say that the thinking of Senge or Morgan has been directly or merely influenced by 'system biology'. System thinking is interdisciplinary by nature, and Senge's 'learning organisation' obviously owes a lot to organisational psychology and in particular to the work of Chris Argyris and Donal Schon in the 1970s.

System thinking informed business internal organisations and also put them in the context of *nested* systems. Organisations comprise sub-systems – subsidiaries or departments which themselves comprise teams and individuals – and are themselves part of greater systems – industries, nations, the Earth. The economy is thus "comprehended as a living ecosystem" (Rothschild, 1990, cited by Peltoniemi and Vuori, 2004, p. 270). Key phenomena observed in nature are also central at business life, among which competition, specialisation, co-operation, exploitation, learning, growth, interdependence, adaptation, self-organisation, emergence and co-evolution (Peltoniemi and Vuori, 2004, p. 268). 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. It was defined by Bateson "as a process in which interdependent species evolve in an endless reciprocal cycle – in which changes in species A set the stage for the natural selection of changes in species B – and vice versa' (Moore 1993, p. 75). A typical example in business is the co-evolution of microprocessors and software" (Peltoniemi and Vuori, 2004, p. 278).

Since organisations can be seen as *complex adaptive systems* which are themselves part of greater systems, it is no surprise to find in David Korten's 'living economy' – which he argues is vital to our societies' sustainability – the same qualities advocated by Senge or Morgan for organisations: cooperative self-organisation, self-reliant local adaptation and managed boundaries. "In our species' immaturity" says Korten (2011) "our dominant cultures have forgotten that our individual and collective well-being depends on the well-being of the whole. We must now step to a new level of species maturity, redesign the culture and institutions of our economic system to mimic the structure and dynamics of the biosphere, and learn to live by life's rules." As we will see in this paper, biomimicry principles for business build on this thinking and suggest a comprehensive framework for sustainable

business management. They can be regarded as the latest product of centuries of biological analogies.

Critiques and limits to the metaphor

Biological analogies have revealed strong parallels between organisational behaviours and patterns and those observed in nature, especially in terms of interdependence and co-evolution. But of course metaphors have their limits. Technically, the business environment is much more chaotic in terms of resources than nature. Sunlight and biological nutrient flows in nature are "fairly constant or at least follow predictable cycles", while "inputs like technology in business ecosystems are constantly changing" (Iansiti & Revien, 2004, p. 76). Furthermore, there are some deeper and fundamental differences. "Nature presents itself as being objective and real in every aspect […] whereas organizations, and their environments can, to some extent, be understood as socially constructed phenomena" (Morgan, 1997, p. 69). Therefore "life of man in society, while it is incidentally a biological fact, has characteristics that are not reducible to biology and must be explained in the distinctive terms of a cultural analysis" (Hofstadter 1992, 176 cited by Levallois, 2011, pp. 12, see also Mitleton-Kelly, 2003, in Peltoniemi and Vuori, 2004, p. 278-279).

Iansiti and Levien argue that business ecosystems are aiming at delivering innovations, where natural ecosystems are aiming at pure survival. (2004, cited by Peltoniemi and Vuori, 2004, p. 273). It could be argued that innovation is itself a means to survival but this nonetheless raises the issue of intentionality. Biological analogies led to the adaptation imperative and the idea of natural selection which "undermine the power of organizations and their members to help make their own futures" (Morgan, 1997, p. 69). It can indeed be hard for a small or isolated organisation to shape its environment but "organizations, unlike organisms, have a choice as to whether they are to compete or to collaborate." And they can collectively shape their environment (Morgan, 1997, p. 69-70). The concept of conscious choice or direction is thus central to understanding the limits of biological analogies, as advocated by the philosopher Maurice Lagueux, according to whom "social sciences would

surrender their *raison d'être* to the natural sciences without an analysis of intentionality" (Lagueux,1998, cited by Levallois, 2011, p. 10, see also Moore, 1993, pp. 85-86).

The question of conscious choice is however different whether looked at from an organisational or individual perspective. Biological analogies that saw the organisation as a 'being' distinct from its parts were hence criticized for neglecting individual rights and freedom. It is interesting to note that this was seen in two distinctive forms of environment: the free market and totalitarian regimes. Penrose strongly criticized in the 1950s the view of firms as organisms which would grow organically and not as the result of a conscious human decision – "in the usual case [of] the businessman's search for profits" (Penrose, 1955, cited by Levallois, 2011, p. 6). Biological analogies can indeed lead to invoking natural law to legitimise the organisation of society (Morgan, 1997, p. 71). Social Darwinism for instance was used as an ideology to support "the early development of capitalism in which small firms competed for survival on a free and open basis" (Morgan, 1997, p. 71). The idea of self-sustaining business ecosystems could also justify the absence of government intervention.

The other issue surrounding the organisation's intention is functional unity: the commitment of parts to functioning for the good of the whole. According to Morgan, this seems to be the general rule in nature, whereas it is more of an exception in human organisations, where "the different elements […] are often capable of living separate lives and often do so" (1997, p. 70). Self-interest politics and power games – which are part of human nature – can hence be seen as dysfunctional in organic organisations. It can however be argued that functional unity is obvious in the body metaphor but less so at the ecosystem level, where interdependencies are 'looser' and organisms enjoy some autonomy. The recognition of potentially conflicting opinions within an organisation further led to another major criticism: because organic organisations follow the superordinate goal of their own survival, they would disregard the individual interests of their members who need to align their objectives with those of the organisation. They would be totalitarian in essence.

This is disputable and might come as the result of the misuse of centralised power. The few who are given power by the many to rule the organisation and serve common good might

use it to instead serve their own interests and impose their own views (Goggans, 2004). This can be seen in politics with fascist regimes or in economics with the financial capitalism solely focussed on maximizing shareholders' value. The balance between emergence, distribution and common good appears quite challenging.

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APPENDIX 2: Biomimicry for Creative Innovation 5E Cycle

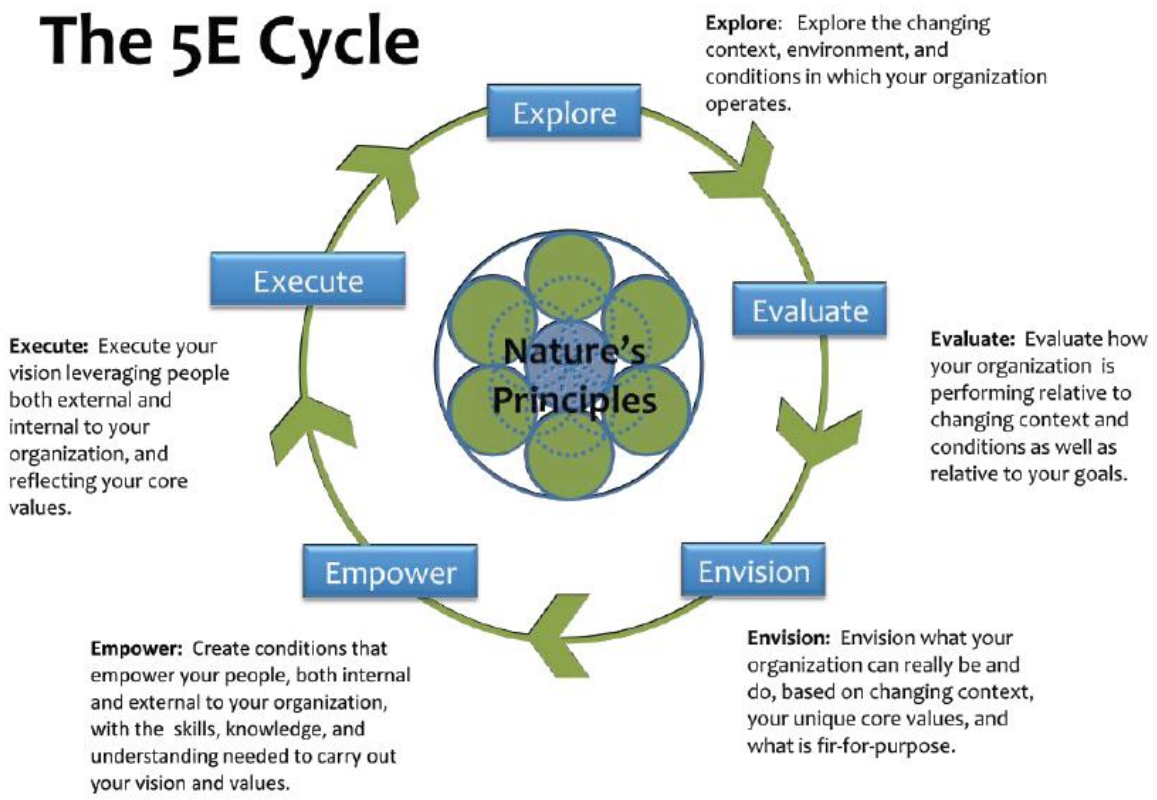
Excerpts from:

BCI Basics – April 2011. Available on http://biomimicry-bci.squarespace.com/bci-basics/

BCI's 5E Cycle is a dynamic continuous process that helps businesses, teams and public sector organisations transform themselves with processes and products inspired by nature – and then keep changing. The E5 Cycle, and each step within it, is based on Nature's Principles; we recognize that Nature sets the rules for sustainability and also provides guidance and inspiration that organizations can use to succeed under dynamic change and within the limits of the Earth.

The E5 Cycle starts with an exploration and inquiry into the complexity, dynamics, and reality of the context in which organisations operate – seeing the world as it is and without blinders on. Continuously exploring and understanding the changing face of reality helps people more accurately evaluate how their organization is performing now and what changes may be needed to make it fit for the future.

Understanding reality and how good performance actually is when measured against a 'true scale' helps people start to envision what is really possible for their organization – with far more possibility than most imagine – working with core values and risks, and finding new possibilities from change. Leaders of the future will empower people, internal and external to the organization, to execute a vision that they've helped shape and create conditions conducive to optimal performance. As in nature, the successful processes are a never-ending dynamic cycle of feedback and response, continuously adapting and evolving.



(from *BCI Basics* – April 2011. Available on http://biomimicry-bci.squarespace.com/bci-basics)

APPENDIX 3:

Biomimicry for Creative Innovation - Case study template

Excerpts from BCI Case Study Template – internal document, unpublished.

CONTEXT

- Context is the external environment in which a business operates. Context includes the greater economy, local and global natural environment, state of technology, local and global socio-demographic and cultural trends, politics, stakeholders etc. Context is largely outside of the influence of an individual business but impacts every part of a business.
- The Earth and human systems are in a state of dynamic non-equilibrium. Many of the highest impact changes are unpredictable. We are responsive to change, adaptable and resilient.

→ Look for evidence of being responsive to change, adaptable and resilient; able to thrive in dynamic non-equilibrium.

GOALS

- Goals are what a business determines for itself about what it strives to achieve. Goals drive actions and decisions.
- We strive to optimise abundance for our business and for natural ecosystems.

→ Look for evidence of having "Pure Vision", imagining what good looks like for their business and for their wider ecosystems.

RESOURCES

- Resources are material and energy resources used by a business and by all other businesses, consumers, governments and other organisations operating in the same context. The availability and cost of resources are largely outside of the influence of the

business but impacts every part of the business. Resource choices made by the business will impact the context.

- All resources are limited. We are resourceful ad opportunistic, use renewable or local and abundant resources, leverage free energy, recycle energy and materials within our business and natural ecosystems, use only life-friendly water-based chemistry and manufacturing.

→ Look for evidence that product- and process-design is targeting a neutral or beneficial environmental impact.

PEOPLE

- People are the internal human resources of a business and how they are organised, including the roles they play, the relationships they have. People contain the knowledge, skills and understanding needed to run a business and accomplish its goals.
- We seek to optimise our individual and collective human resources by creating conditions conducive to optimal productivity, creativity and collaboration. We seek diversity and encourage cross-pollination. We are decentralised and distributed with embedded redundancy. Our organisational structure fits form to function and reflects multiple relationship types and leadership approaches. We recognise our employees as holistic individuals that are seamless parts of our business and natural ecosystems.

→ Look for evidence of organisational structures and conditions that create optimal productivity, creativity and collaboration.

NETWORKS

- Networks are the collection of other businesses and organisations with which a business interacts.
- We foster and support synergistic relationships within a business ecosystem which also allows for healthy competition alongside collaboration. We leverage the free energy of the system. We seek to optimise ourselves while creating abundance within the system.

→ Look for evidence of ecosystem behaviour where free energy is leveraged.