Biomimetics

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Biomimetics is a growing field that has the potential to drive major technical advances [1]. It might substantially support successful mastering of current technical challenges.

In biomimetics, materials, processes and systems in nature are analyzed, the underlying principles are extracted and subsequently applied to science and technology. This approach can result in innovative new technological constructions, processes and developments. Biomimetics can aid researchers and developers to manage the specific requirements in materials, systems or product design, especially to create products and processes that are sustainable and perform well, to integrate new functions, to reduce production costs, to save energy, to cut material costs, to redefine and eliminate "waste", to heighten existing product categories, to define new product categories and industries, to drive revenue and to build unique brands.

I. Changes in the Research Landscape

Science currently goes through a major change. Biology is becoming the new Leitwissenschaft and a new field that can be called „Biological Physics“ is emerging, as in biology more and more causation and natural laws are being uncovered and as in physics natural flows and equilibria (that are of uttermost importance in biology) are increasingly being acknowledged [2]. We slowly come close to the point where we might – at least partially – be able to answer the question "What is life?" in scientific terms, and to understand the difference between animated and non-animated matter.

II. Biology meets the Hard Sciences

Biology has changed from being very descriptive to a science that can be acknowledged and understood (in terms of concepts) by researchers coming from "hard sciences" such as chemistry, physics, engineering (Figure 1). The "hard sciences" rely on experimental, empirical, quantifiable data or the scientific method, and focus on accuracy and objectivity [3]. The languages of the various fields of science increasingly get compatible, and the amount of collaborations and joint research projects between researchers coming from the "hard sciences" and biologists have increased tremendously over the last years.

Recurrent concepts in biomimetics are integration instead of additive construction, optimization of the whole instead of maximization of a single component feature, multi-functionality instead of mono-functionality and development via trial-and-error processes. Such concepts can easily be transferred to technology, and can even be applied by engineers with no knowledge of biology at all [1][2][4].

In some fields of biology, such as biochemistry and physiology, the amount of causal laws is high, whereas in fields such as developmental biology and ecology, we are just at the beginning. The biomimetic approach might change the research landscape and the engineering culture dramatically, by the blending of disciplines (interdisciplinarity). The term "technoscience" denotes the field where science and technology are inseparably interconnected, the trend goes from papers to patents; the scientific "search for truth" is increasingly replaced by search for applications with a potential economic value. Although the trend in many scientific fields goes towards applications for the market, a lot of disciplines will stick to the traditional picture of science. An open question left to the future is whether the one development or the other (technoscience or pure science) is an advantage for the future of humans [2].

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III. The Biomimcry Innovation Method

One highly successful method in biomimectics is the Biomimicry Innovation Method from the Biomimicry Guild in the United States of America. This method is applied here to identify Nature's best practices regarding inspiring approaches to address major global challenges that humankind is currently facing. “15 Global Challenges” have been defined and tracked since 1997 in the State of the Future reports [5]. The challenges are updated annually. The 15 Global Challenges in the 2008 State of the Future report [6] of the Millennium Project are Sustainable Development, Water, Population and Resources, Democratization, Long-Term Perspectives, Information Technology, the Rich-Poor Gap, Health, Capacity to Decide, Peace and Conflict, Status of Women, Transnational Crime, Energy, Science and Technology and Global Ethics. Six of these Global Challenges (Sustainable Development, Water, Information Technology, Health, Energy and Science and Technology) could possibly benefit from biomimetic approaches. Best practices in Nature identified to face these challenges comprise highly diverse organisms, biological materials and processes. Detailed investigations on the relevant properties of the best practices are presented, and the underlying principles are extracted. Such principles are then incorporated into biomimetic devices, systems and processes with increased performance.

IV. The Three Gaps Theory

For accelerated scientific and technological breakthroughs to improve the human condition the “Threegaps-theory” (see Figure 2) is introduced [2]: Three gaps denoted inventor gap, innovator gap and investor gap have to be bridged. “Inventor gap” denotes the gap between knowing and not knowing that has to be overcome. The “innovator gap” denotes the gap between knowledge and application of the knowledge. The “investor gap” denotes the gap between the application and the creation of the product. To improve current conditions, we do not primarily need basic knowledge but we need solutions and products. Since development always takes a path from the primitive via the complex to the simple, effective or efficient solutions can be envisaged, depending on the time frame provided and the acceleration wanted.

We should aim at having a context of knowledge. To prevent being trapped in the inventor, innovator or investor gap, a cross dialogue is necessary, a pipeline from “know-why” to “know-how” to “know-what”, from the inventor who suggests a scientific or technological breakthrough to the innovator who builds the prototype to the investor who mass produces the product and brings the product to the consumer. Currently, and this is the main problem, at universities worldwide huge amounts of knowledge are piled up with little or no further usage. We know a lot, we can do relatively little. We need a joint language and a joint vision.

There are two ways to bridge the three gaps: “pull” und “push”. In the “push” way an “evangelist” walks around and prays how wonderful the idea is. The “push” way is generally applied in times of peace, and is very slow. In the “pull” way there is a vision and an innovation is urgently needed. Here, no “evangelists” but “scouts” are the main actors. “Scouts” search for technologies, rigorously demand them and a multitude of people are hired for early realization of the new technology.

The driving force of the “evangelist” is the dream; the driving force of the scout is the vision. The main difference between vision and dream is that the dream could become something, and in the vision the outcome is clear, and the path is to be determined. To establish a merging of dreams and visions, “scouts” and “evangelists” have to be brought together. In this way, the development starts: the pile of knowledge comes to the drain (vision), the vision assimilates the knowledge, and the knowledge slides off the paper.

The “evangelist” is always a specialist; the “scout” is always a generalist. To build a car, to build a locomotive, thousands of ideas are needed; generalists are needed. Somebody who has a specific solution for a flywheel has to be a specialist. To advance our system, more visions and a platform for “evangelists” as well as interdisciplinary working groups with generalists as heads, coordinating the specialists, are needed.

At the moment, we do not have such structures. The problem is insufficient communication between customers of knowledge and its generators, between inventors, innovators and investors - the three gaps mentioned above. Industry lacks visions, science cannot promote its knowledge; there is no platform.

Biomimetics can on one hand help to bridge the gap between the fields in promoting an inter- and transdisciplinary working mode beyond the borders of classical science and industry, and on the other hand contribute to fundamental research that fulfils the old aim of increasing the knowledge without being immediately turned over into an economic asset.

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Figure 1. The increasing amount of causal laws in biology generates promising areas of overlap with hard sciences such as physics, chemistry and engineering.

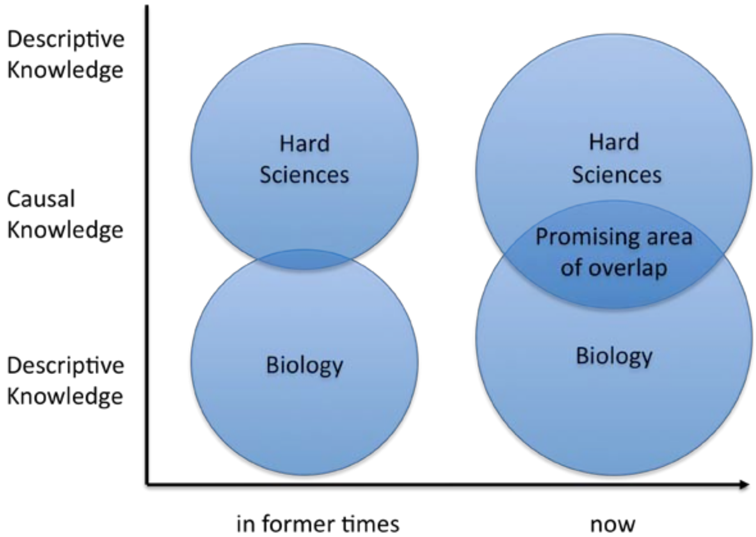

Figure 2. The three gaps theory regarding inventors, innovators and investors [2].