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# **SUSTAINABILITY IN SCIENCE, ARCHITECTURE AND DESIGN**

**Lessons from Attenborough,  
Loos and Biornametics**

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## **ABSTRACT:**

*Biomimetics is per se not sustainable. It is a design method, and as such, it is free from values. However, when we are learning from nature for our engineering and artistic endeavours, why should we just be constrained to patterns, structures, materials or processes – why not transfer the most amazing property of life itself – sustainability?! This paper is dealing with sustainability on three interdisciplinary levels: first, to set the stage, the state of the planet is described. Earth's biosphere is approaching a critical state shift. We humans are currently causing a 6th mass extinction. In the 5th, 55 millions of years ago, 80% of all species died out. Second, Adolf Loos's famous 1908 article "Ornament and Crime" is critically dealt with regarding its inspirational potential to sustainability. Loos builds the bridge to the third level: Biornametics, architecture defined by natural patterns, a new methodology that interconnects scientific evidence with creative design in the field of architecture. It takes on the history of one of the composed parts of this word "ornament" referring to Loos and extends into another, "biomimetics", the strategic search for nature's solutions in order to gain innovation. The emergence of patterns in nature at all scales of existence of organisms as one of the most important signs of life – order – is not arbitrary, but highly interconnected with boundary conditions, functional requirements, systems requirements, material and structure. In bringing all these three levels together the authors show that the exploration of aesthetic and functional interpretation for a new sustainable architecture, contributing to improving the state of the planet, is indeed possible.*

## **Keywords:**

architecture, biomimetics, biornametics, ornament, science, sustainability, the state of the planet, tipping point

## 1. Introduction

The State of the World 2010 report by the Worldwatch Institute is all about sustainability (Worldwatch Institute 2010). The review in "Publishers Weekly" speaks for itself:

"In this year's volume, the D.C.-based Worldwatch Institute think-tank considers, in several dozen pieces, how "cultures of consumption" can be transformed into "cultures of sustainability." Many ideas take inspiration from diverse traditions: religions can be called upon to embrace their own deepest values and renounce materialism, while establishing new holidays, rituals and taboos incorporating strategies for sustainability (Earth Day, "Green funerals," new days of fasting, etc.); practices honoring elders as transmitters of ancient wisdom can be spread beyond regions where they still thrive (Africa, India, etc.); thousand-year-old Asian farming methods can be revived. Ideas for restructuring education include replacing the "Three Rs" with the "Seven Rs" ("reduce, reuse, recycle, respect, reflect, repair, and responsibility") and emphasizing "environmental education" in higher learning. The largest-scale changes include shifting societal goals from "maximizing growth of the market economy to maximizing sustainable human well being"; ensuring that the burden of reduced production falls on the wealthiest, not the poorest; and building sustainable cities like Vauban, a 5,000-household German community that uses 100 percent renewable energy. Though many solutions in this visionary volume require a pie-in-the-sky "whole Earth community" legal system prioritizing "the right to life" over "the right to conduct business," it should give leaders and laypeople much to consider." (Copyright © Reed Business Information, a division of Reed Elsevier Inc., <http://www.amazon.com/State-World-2010-Transforming-Sustainability/dp/039333726X/>, last accessed June 9, 2012).

This article is undertaking the endeavour to bridge the current state of the planet with possible sustainability aspects in Adolf Loos's article "Ornament and Crime" and Biornametics, an interdisciplinary design approach that has recently been developed at the University of Applied Arts in Vienna, Austria in the framework of an art-based research project, bringing together architects, designers, artists, mechanical engineers and physicists. Each of these three aspects is introduced and treated in due detail, until in the final section, the three strings are interwoven, resulting in a picture full of hope: we can make the world a better place by achieving sustainable biomimetic architecture.

Biomimetics is the strategic search for nature's solutions in order to gain

innovation. Efficiency and intelligence are intrinsic to 'design' in nature. The hypothesis underlying this innovation method is that living nature has evolved in a process of continuing adaptation to a complex changing environment, and that the exploitation of highly optimised solutions is likely to deliver innovations that provide more intelligence and better efficiency than our standard methods.

With biomimetics we use living nature as our teacher, and with today's technology we are ready to think, work and act in inter- and transdisciplinary ways. This will pave our way towards sustainability, for the sake not only of humans but the whole biosphere.

## **2.Setting the Stage: The State of the Planet**

Our planet is not in a good shape. In three programmes called "State of the Planet", presented on BBC by David Attenborough at the beginning of the new millennium, the situation is explained in alarming words (Attenborough and Broome 2000). In the following the authors of this entry (who come from architecture and physics) present a condensed version of the themes treated in these programmes, along with references to primary scientific literature.

Increased population and industrial activities might very well have brought us on the verge of yet another mass extinction of species (Barnosky et al 2011, Rogers and Laffoley 2011) and might anytime result in an unfortunate state shift in the Earth's biosphere (Barnosky et al 2012). This will not be the first mass extinction: it will be the 6th. But – it will be the one that is caused by human activity. If we want to ensure quality of life for all people on Earth, and for the ones following us, we need to ensure it sustainably.

The scale of the damage to the natural environment is enormous. Life can adapt (and has always done so) to local damage. But what about the global damage we are currently doing on a planetary scale? We are limited in space (we just have one planet), we are limited in resources, and the Earth has a maximum capacity to bear life.

Some numbers illustrate the dramatic situation: The Australian theoretical ecologist Sir Robert May, past president of the Royal Society, estimates that scientists have identified, described and named about 1.5 million species on Earth. The American oceanographer Sylvia A. Earle, who was chief scientist for the U.S. National Oceanic and Atmospheric Administration, says that coral reefs harbour biodiversity larger than the tropical rainforests, and that

only 5 percent of the oceans have already been explored.

Biologists have always appreciated the interconnectedness of nature, and now, slowly, also scientists from other disciplines and the general public have gained awareness of this fact. Due to the complexity of the biosphere the impact of extinction of so many species can not at all be pre-estimated. The Pulitzer Prize winner and ant specialist Edward O. Wilson (ranked by Time Magazine as one of the 25 most influential people on the planet) says that there is an estimate of a minimum of 5 million and a maximum of 100 million of species on this planet (Wilson 1994, 143). The threat to them by human activity can only scarcely be estimated. At the moment we have an extinction rate that is elevated 100 to 1000 fold compared to the one before humans entered the scene (Lawton and May 1995).

The palaeontologists Peter D. Ward and Charles R. Marshall, director of the University of California Museum of Palaeontology, say that the meteor impact in Mexico 55 millions of years ago wiped out 60-70% of the world's species (Marshall and Ward 1996, Pope et al 1998). This meteor was just about 10 miles wide. Being now on the verge of the next mass extinction we must state that human impact on the planet equals a massive meteor impact.

The concept of keystone species, introduced by Paine in 1969 (Paine 1969) even worsens the prospects. When the number of individuals of a so-called keystone species decreases, huge effects on the whole ecosystem are the result. As species do not exist in isolation a major crisis may occur if an important species disappears. Which species are keystone species is hard to tell, hard to calculate and hard to predict – when it comes to complex, interdependent systems, we are still very much at the beginning of scientific understanding.

One famous example for a keystone species are sea otters in kelp beds (Estes and Palmisano 1974, Duggins 1980): sea otters live in or close to kelp forests which are home to many other animals, including sea urchins. When the otters were nearly extinct because they were hunted too much for their furs, much less otters were eating sea urchins. So the urchins were reproducing much faster, and taking over the ecosystem by excessively feeding on the kelp, especially its insertions into the seabed. As the kelp was gone so were all the species that depended on it, including many fish and shrimp species that had used the kelp forests as breeding grounds. Species are doing as lot for the environment that is important for humans. They are creating the soil, the water, the air – for free.

There are five human activities that yield the current mass extinction. We are damaging life's diversity in 5 ways: Overharvesting of animals and plants, introduction of alien species, destruction of habitats, habitat fragmentation and pollution.

We have to think and brainstorm where we can contribute with sustainable architecture, with sustainable design, to the preservation of life's diversity. 50 000 years ago we had big herds of big animals on all continents apart from Antarctica. Even on the area of current Los Angeles camels, lions, cheetahs and elephants were living (says Pulitzer Prize winner Jared Diamond, interdisciplinary scientist and author). Is it a coincidence that these big herds disappeared when humans started to spread out there? Sir John H. Lawton, British ecologist, chair of the Royal Commission on Environmental Pollution and former head of Natural Environment Research Council, says that humans are switching predators - making us so dangerous for life's diversity.

### **2.1.Overharvesting of Animals and Plants**

Overharvesting inevitably affects all other species that interact with the overharvested species or depend on them. We can only harvest something sustainably if it regrows faster than we cut it down/catch it/kill it/harvest it. At the moment, tropical trees are cut down ten times faster than they can regrow (Longman and Wilson 1998). Also concerning the oceans, we are very fast approaching the limit: 70% of the fish species are removed at or above the rate at which they can reproduce. Sylvia Earle says that we are getting to good, with our acoustic methods, we can locate each and every tuna in the sea; we take too much out of the seas.

To give an idea about the impact of people on the planet: Each year half of the plant growth on Earth is used for just one species – us!

### **2.2.Introduction of Alien Species**

One example for the effects of the introduction of plants and animals to places where they have never lived before are the lowlands of Hawaii – there is no single native birds species anymore there. All birds there are introduced, and there is nearly any native population of indigenous birds left. Most that are left are isolated on the mountaintops. Another example is Hawaiian snails –many of them are already extinct. Rats or introduced alien snail species killed them.

Rhododendron for example is an invasive species that lives in symbiosis with

a root fungus that poisons the earth, and does not allow any other plants to live there - while the rhododendron is living there, and even up to seven years after it has been cut down! In the Snowdonia National Park in Wales this is a huge problem (see, e.g., Dehnen-Schmutz and Williamson 2006).

### **2.3. Destruction of Habitat**

The Anasazi Indians in Pueblo Bonito where once a thriving and rich community. Now, their land is a desert, all the people are gone, the water table is so low that no crops can be grown anymore. The Anasazi were cutting down all trees in their region, changing the landscape with long lasting effects (for more details on this collapsed society, see Diamond 2005, 136-156). Finally, the packrat led to the collapse in Chaco Canyon (Diamond 2005, 145-147). The destruction of habitats is doing more damage to biodiversity around the world than any other human activity.

Reading all this, and thinking about it, one might start to ask if we, the human species, are deliberately destructive. Edward O. Wilson indeed says: "We are evil." The effect of the modern industrial human behaviour on the rest of life is enormous. We are destroying the environment very efficiently at the present time. According to Wilson, we conquer wilderness and we utilise wilderness, and we expand our population to gain security, to gain control and to alter. For millions of years this went well, with no major harm done. However, then we developed modern industrial capacity. We developed the techno-scientific capacity to eliminate entire habitats quickly and efficiently. We are destroying the very foundation in the environment on which humanity was built.

### **2.4. Habitat Fragmentation**

The conservation biologist Thomas E. Lovejoy, the one who introduced the term "biological diversity" in 1980 (!!) (Lovejoy 1980), states that one road is enough to bisect a rainforest. The effects of habitat fragmentation and habitat loss are very well summarized in Fahrig 2003. She states that habitat loss is always detrimental for biodiversity, whereas with fragmentation, this is not necessarily the case (Fahrig 2003).

### **2.5. Air Pollution, Global Warming and Climate Change**

Global warming and climate change pose major challenges to life on Earth. Actually, sustainability and climate change represent the first global challenge (of 15) identified by the UN Millennium Project in their annual State of the Future Report (Glenn, Gordon and Florescu 2011). Engineers now start to actively address climate change (see, e.g., the Special Section

on Engineering in a Changing Climate 2010, i-ii and 505-580). Nobel Prize winner Stephen H. Schneider from Stanford University liked to state that change in itself is not necessarily destructive when it happens slowly. He was talking about our current biological crisis and kept on stressing the importance of education, awareness and sensitivity. The great challenge of the next century according to him can be phrased like this: How to provide a good living standard to an ever growing number of human beings without inflicting grave impoverishments on the planet? How can a change in our behaviour prevent a great loss of species over the next century? We do have the ability to make a difference!

## 2.6.The Importance of Biodiversity/Summary

Over half of the species on Earth will become seriously endangered or extinct over the next 100 years (Barnosky et al 2011, Rogers and Laffoley 2011). We must find ways of reducing the pressures that we are putting on the planet.

Walter J. Lusigi, retired Senior Advisor with the Global Environment Facility Secretariat, says that it is not enough to conserve the species. We have to conserve the species plus the environment. The conservationist John Hanks established in Africa the Peace Parks Initiative, Trans-Frontier Conservation Areas providing habitat for wildlife across borders.

Biological diversity is not just a bunch of conservationists saying “We love these animals.” It is about quality of life, it is about human survival. The commercial value of a range of species can make a huge difference for local communities living in marginal areas. Protected areas are important. But we need to develop methods to live with nature, not separating humans from nature.

In this regard, the 3D corporate tourism method (Gebeshuber and Majlis 2011), a concept for innovation in nanomaterials engineering, is of importance: Scientists from around the world are visiting virgin rainforest and are doing biomimetics there. They discover, develop and design new approaches inspired by nature, with the help of local communities and scientists. They give value to the forest itself, and for them, the virgin rainforest is a treasure box, full with unconventional, interesting solutions – and sustainable. And not just for them – via the transfer to engineering and the arts this treasure box is of benefit for the whole society.

We have 8 million commercial flights every year (status: June 2011).

Sir John H. Lawton says that it is in the interest of rich developed nations to help developing nations to pay for the protection of forests, to pay for the protection of wild life (see, e.g., Edwards and Abivardi 1998). Armanda Vincent from the Fisheries Centre at the University of British Columbia in Canada for example, the initiator of Project Seahorse, does exactly this: she and her team pay indigenous people for bringing her seahorses (which are subsequently sold to the market, mainly for traditional Chinese medicine), but the collecting is continuously monitored and care is taken that no area is overfished (Ban and Vincent 2009). Stephen H. Schneider says that although coral reefs are just 1% of the ocean, they are home to 25% of the fish. One solution to global warming is the use of more sustainable energy sources, not burning past fossil fuels. And fewer people who consume less energy and have less extravagant patterns of consumption. We currently experience a major increase in the human population: 100 years ago, we had 2 billion people. In 2012 we exceeded 7 billion (US Census Bureau 2012), and this number is continuously rising. How to bring population growth and resources into balance is the third of the 15 major challenges of humankind as identified in the 2010 State of the Future Report by the UN Millennium Project, a project that was commissioned by the United Nations Secretary-General in 2002 to develop a concrete action plan for the world to achieve the Millennium Development Goals and to reverse the grinding poverty, hunger and disease affecting billions of people (Glenn, Gordon and Florescu 2010).

We need to develop ways to minimize the damage. How many species can we afford to lose in this immense increase in human population without seriously compromising the future? We need strategies how to scale down our excesses in consumption.

We have to learn a new ethics method that allows us to care as much about the Brazilian rainforest as about our own local reserve. And we need to think beyond just a few years or just one generation: What do we want to leave to future generations? Which kind of world? The future of life on Earth depends on our ability to take action. Many individuals are doing all they can, but real success can only come if there is a challenge in our societies and our economics and in our politics.

### **3.Aspects of Sustainability in A. Loos "Ornament and Crime"**

Adolf Loos (1870-1933) wrote his famous and highly influential essay "Ornament and Crime" in 1908 (Loos 1997). Loos was a Viennese architect, a man of high taste and refined intellect. A pioneer of modern architecture,

he had a radical, innovative outlook on life. Reading his essay with regards to architecture, sustainability and design stimulates the mind, and directs it into new areas. Below, we summarize the thoughts that came to our minds when reading "Ornament and Crime". It might be that the conclusions we draw from his words are not at all his own intentions. It is also not the intention here carry out an analysis in a historical context. The intention here is to have a stimulus from a famous piece, and let the mind wander to come up with new connections, ideas and possible applications regarding sustainability in science, in architecture and in design. This section introduces intriguing sentences (in the original German original version, and in the English translation, from <http://technical-english.wikidot.com/text-1-2>) and the ideas stemming from them.

The initial thoughts of the physicist in our author collective after having read Loos's classical work for the first time, and after just having watched Attenborough's "State of the Planet" BBC Series, was not concerned with sustainability in architecture or design, but with something that might be termed "sustainability in science". Today, scientists are expected to write a lot. Advancement in science, the position in the scientific hierarchy, promotions, social standing, etc. are valued according to the output of the scientists (Pendlebury 1991). Science culture is increasingly quantity driven (Hamilton 1990). Many of the plenitude of scientific papers published aren't even read or discussed (Hamilton 1991). They are not placed in journals with a certain readership in mind, but in journals with a certain "impact factor", a number, in mind. Numbers are the ornament of our time (sic!). We decorate our science with numbers, and the problem is, these numbers are, just as the ornaments of Loos, not sustainable. You get what you measure. If you decide to count 'Scopus papers' (Scopus is a bibliographic database owned by Elsevier that covers titles from thousands of international publishers, including 18 500 peer-reviewed journals – status May 2012, and a 'Scopus paper' is a paper that is listed in Scopus – the more Scopus listed papers you have, the higher your esteem in certain universities and research institutions), people try to publish papers that are listed in Scopus. If you then switch to ISI (Institute for Scientific Information, now belonging to the Healthcare & Science business of the multi-billion dollar Thomson Reuters Corporation, listing over 16 800 journals, status June 9, 2012) people are increasingly publishing in ISI journals, especially if universities base promotion, advancement and salary increase policies on it. And since it is not that easy to enter ISI journals, very accurately the ones that are (still) easy to enter are very fast identified by some researchers (who actually in many cases do not do any research anymore, but rather search for ways to publish their work in as many articles in as high rated journals as possible),

and the manuscripts are submitted there. Such journals have names such as "Scientific Research and Essays" (based in Lagos, Nigeria) and publish a colourful collection of articles. Very few people read them, very few people cite them, and publishing there does not at all advance any scientific field.

The number of papers submitted there increases, and – since working as a reviewer for a scientific journal is not thanked neither paid, it is increasingly complicated for the journal to find reviewers, in the exact field of the paper or in a (perhaps, if you are lucky) remotely connected one.

Emails with request to act as reviewer are sent out as mass emails by the editors, without addressing the potential reviewer by name. The future of the journal was doomed, it already lost its impact factor; it is not an ISI journal anymore. But new ones will come up on the horizon. Other ornaments in science are the number of research projects (which in fact limit your thinking to just thinking in milestones and deliverables, and to short time frames not exceeding the end of your project). We have a major problem in dealing with over information, in structuring knowledge and in scientific publishing and accessing human knowledge and we need to address this problem, if we want things to move forward (Gebeshuber, Gruber and Drack 2009, Gebeshuber and Majlis 2010). This is increasingly getting important with our planet approaching a tipping point.

### 3.1. Stages

Loos: "Wenn der mensch geboren wird, sind seine sinneseindrücke gleich denen eines neugeborenen hundes. Seine kindheit durchläuft alle wandlungen, die der geschichte der menschheit entsprechen."

Translation: "And when a human being is born, his sense impressions are like a new-born dog's. In childhood he goes through all changes corresponding to the stages in the development of humanity." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: What comes to the mind of the scientist in the team of authors is the cycle of life. Development always goes from the primitive to the complex to the simple.

The stages in the development of humanity go from primitive societies to our current complex technosophical society to a refined simple future society. Traditional architecture is not sustainable, in the sense that, e.g., certain trees were used too excessively and are not available anymore (Gruber 2011). In a small primitive society without technology, architecture

might not be sustainable – however due to the small size of such systems the damages may be just local and life can adapt to them. Sustainability is increasingly a goal in the current complex technosocial society. Sustainable architecture and design is necessary for survival in the refined, simple society we aim for.

### 3.2. The Humble Beginnings of Art

Loos: “Der drang, sein gesicht und alles, was einem erreichbar ist, zu ornamentieren, ist der uranfang der bildenden kunst. Es ist das lallen der malerei. Alle kunst ist erotisch.”

Translation: “The urge to decorate one’s face and anything else within reach is the origin of the fine arts. It is the childish babble of painting. But all art is erotic.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Nothing is perfect from the very beginning. You have to start somewhere, and in architecture and design, we are at the moment in a transition phase. Sustainability is increasingly important in architecture and design (a search on amazon.com for ‘sustainability in architecture’ yields 1475 results, status June 10, 2012), and enters fields of science, engineering and the art where nobody would have thought it would ever arrive. Vivienne Westwood for example, the British fashion designer, just recently published a manifesto calling for sustainability.

### 3.3. Evolution

Loos: “Ich habe folgende erkenntnis gefunden und der welt geschenkt: Evolution der kultur ist gleichbedeutend mit dem entfernen des ornamentes aus dem gebrauchsgegenstande.”

Translation: “I made the following discovery, which I passed on to the world: the evolution of culture is synonymous with the removal of ornamentation from objects of everyday use.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Reduction to the necessary - key function, all other is not important. Current materials used in architecture and design are changing from being monofunctional to being multifunctional. The exquisite relationship between structure and function as can be seen in living nature and in ecosystems is amazing. Structure and function cannot, in most cases, be separated. The ornament, the artificial add-on to the

structure, will become obsolete.

The beauty will be inherent in the functional material (e.g., structure – function – shiller – colour relationship in butterfly wings or orchids, Kinoshita 2008, Gebeshuber and Lee 2012).

### 3.4. Beyond

Loos: “Wir haben das ornament überwunden, wir haben uns zur ornamentlosigkeit durchgerungen.”

Translation: “We have gone beyond ornament, we have achieved plain, undecorated simplicity.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Simplicity is the ultimate goal. Perfectly simple systems have integrated functionality, are easy to use, beautiful to watch, wonderful to live in, biodegradable and non-toxic. The designs and architecture of the future does not need to show off with itty-bitty add-ons, it is intrinsically of highest quality, functionality, beauty and sustainability.

### 3.5. There is Hope

Loos: “Der ungeheure schaden und die verwüstungen, die die neuerweckung des ornamentes in der ästhetischen entwicklung anrichtet, könnten leicht verschmerzt werden, denn niemand, auch keine staatsgewalt, kann die evolution der menschheit aufhalten.”

Translation: “It is easy to reconcile ourselves to the great damage and depredations the revival of ornament had done to our aesthetic development, since no one and nothing, not even the power of the state, can hold up the evolution of mankind.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: There is hope. It will take some time, but quality always wins.

### 3.6. Sustainability

Loos: “Der wechsel der ornamente hat eine frühzeitige entwertung des arbeitsproduktes zur folge. Die zeit des arbeiters, das verwertete material sind kapitalien, die verschwendet werden. Ich habe den satz aufgestellt: Die form eines gegenstandes halte so lange, das heißt, sie sei so lange

erträglich, solange der gegenstand physisch hält. Ich will das zu erklären suchen: ein anzug wird seine form häufiger wechseln als ein wertvoller pelz. Die balltoilette der frau, nur für eine nacht bestimmt, wird ihre form rascher wechseln als ein schreibtsch. Wehe aber, wenn man den schreibtsch so rasch wechseln muß wie eine balltoilette, weil einem die alte form unerträglich geworden ist, dann hat man das für den schreibtsch verwendete geld verloren."

Translation: "The changing fashion in ornament results in a premature devaluation of the product of the worker's labor; his time and the materials used are wasted capital. I have formulated the following principle: The form of an object should last, that is, we should find it tolerable as long as the object itself lasts. I will explain: A suit will change its style more often than a valuable fur. A woman's ball outfit, intended for one night alone, will change its style more quickly than a desk. Woe betide us, however, if we have to change a desk as quickly as a ball outfit because we can no longer stand the old style. Then we will have wasted the money we paid for the desk." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Here, Loos establishes a direct link to sustainability. No interpretation or brainstorming is needed. He talks about premature devaluation, useless lost work and waste capital, and one can add, regarding science, architecture and design, respect for the ecosphere, respect for all the organisms with whom we share this planet – and for the ones to come in the near and distant future.

### 3.7. Quality

Loos: "Wenn alle gegenstände ästhetisch so lange halten würden, wie sie es physisch tun, könnte der konsument einen preis dafür entrichten, der es dem arbeiter ermöglichen würde, mehr geld zu verdienen und weniger lang arbeiten zu müssen. Für einen gegenstand, bei dem ich sicher bin, daß ich ihn voll ausnützen und aufbrauchen kann, zahle ich gern viermal soviel wie für einen in form oder material minderwertigen. Ich zahle für meine stiefel gern vierzig kronen, obwohl ich in einem anderen geschäft stiefel um zehn kronen bekommen würde. Aber in jenen gewerben, die unter der tyrannei der ornamentiker schmachten, wird gute oder schlechte arbeit nicht gewertet. Die arbeit leidet, weil niemand gewillt ist, ihren wahren wert zu bezahlen."

Translation: "If all objects would last as long in aesthetic terms as they last physically, the consumer would be able to pay a price for them that would allow the worker to earn more money and work shorter hours. For an object

from which I am convinced I will get full use until it is worn out I am quite happy to pay four times the price of another I could buy. I am happy to pay forty crowns for my shoes, even though there are shoes for ten in another shop. But in those trades that languish under the yoke of the ornamental artist, no value is put on good or bad workmanship. Work suffers because no one is willing to pay for it at its true value." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: More money and less work for the producer of high quality products – this should be the aim. In science, in architecture, in design. We are currently at a stage where machines could take over a large proportion of our work. But instead of working shorter hours, in many professions people are working longer and longer hours, and often even define their value as 'work force' depending on the amount of overtime they are doing. In a sustainable society, the balance between life and work becomes obsolete, as work is an integrated and fulfilling part of a high quality life. Extra time can be spent with kids, for pleasure, for further education, for travel, for community work, etc. – there is no need to fill eight hours per person per day with useless jobs.

### **3.8. Golden Waste**

Loos: "Aber das werfen mit goldstücken statt mit kieselsteinen, das anzünden einer zigarette mit einer banknote, das pulverisieren und trinken einer perle wirkt unästhetisch."

Translation: "But throwing coins instead of stones, lighting a cigar with a bank note, crushing up and drinking a pearl, I find unaesthetic." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: There is no point in overdoing things.

Sustainability has at the moment very positive connotation. In this respect it meets with biomimetics. However, sustainability is usually not associated with aesthetics, with fun and joy.

### **3.9.A Bright Future**

Loos: "Wir haben die kunst, die das ornament abgelöst hat. ... Ornamentlosigkeit ist ein zeichen geistiger kraft."

Translation: "We have the art that has superseded ornament. ... Lack of ornamentation is a sign of intellectual strength." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: We need intellectual strength in our current times. We need sustainability. For the future of us and all life on Earth.

#### **4.Sustainable Biomimetics in Biornametics**

The art-based research PEEK project 'Biornametics - Architecture defined by natural patterns' (Gebeshuber, Gruber and Imhof 2012) explored a new methodology to interconnect scientific evidence with creative design in the field of architecture (Fig. 1). It took on the history of one of the composed parts of this word, 'ornament' referring to Adolf Loos, and extended into another, 'biomimetics'. The 'New Ornament' was introduced as an emerging contemporary design practice based on digital techniques that assembled from controlling programs and codes, less concerned with serial rationality but with algorithmic, digital operations and connecting the processes of planning and production. Role models from nature, static and dynamic patterns (e.g. growth principles, movement patterns, adaptation and differentiation as key for emergence of patterns etc.) were investigated and the findings applied to design strategies. The emergence of patterns in nature at all scales of existence of organisms as one of the most important signs of life - order - is not arbitrary, but highly interconnected with boundary conditions, functional requirements, systems requirements, material and structure. The main objectives of the project were the exploration of aesthetic and functional interpretation for a new architecture together with the utilisation of new manufacturing technologies, and elaboration of the biomimetic design method and the "New Ornament" (Imhof et al 2011).

#### **4.1.Intersections between the sciences and the design industry**

Increasingly, scientists and designers are working together. The Austrian science fund introduced a new funding scheme called PEEK that concentrates on art-based research. In the framework of such projects, scientists and artists are collaborating. This approach is very interesting since it allows addressing current aspects in the arts, architecture and design from fresh, new points of view. PEEK is now (2012) in its third round, and it is highly recommended by the authors that less concentration is put on method, immediate outcome and approach, and more on interdisciplinarity, learning from each other, accepting one's pace, slowing down and establishing a creative, joyful atmosphere.

#### **4.2.The relation between sustainability and biomimetics**

Since biomimetics is a design method, there is no value attached to it. So

biomimetics does not come with sustainability. Biomimetics is not per se green.

**FICUS BENGHALENSIS**, Banyan tree

18

ROLEMODEL DESCRIPTION

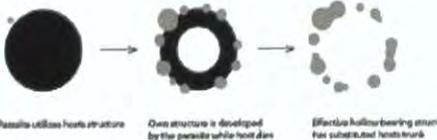


**TOPIC**  
2 - shape and growth; 3 - adaptation and reorganisation

**KEYWORDS / FEATURES**  
roots, desalination, structure

**APPLICATION IDEAS**  
renovation of old buildings; parasitic structures; interweaving of two systems; generative structures; circulation system around centre cone; added layering in architecture

**SYSTEM DIAGRAM:**



dimension 3D	+
speed/timescale	+
scale [m]	low
scale [m]	spc
scalability	
geometry	+
function	+
structural performance	
structure	+
material (chemistry)	0
reactivity	
input serving	+
output	-
adaptivity	++
aesthetics	
pattern repetition	++
colour	-
colour change	-
symmetry	-
elegance	0
cool	++
copy	++
information communication	+
complexity*	0
growth	+
motion	+
innovative potential	+
compatibility	+
availability of information	0
scalability	
computation (computer/brain)	+
technological transfer	-

EVALUATION CRITERIA

BIORNAMETICS

Regulation	
-1/0/1/2/3	
-2/1/0/1/2	
-3/2/1/0/1/2	
-4/3/2/1/0/1/2	

Fig. 1 Biornametics Rolemodel #18 Data Sheet: Ficus benghalensis. The datasheets are organised in two sheets per rolemodel, giving an image, the Latin name, the area of defined research, an abstract about the features which seem interesting, references, first application ideas and a functional diagram of the feature to be explored in the further process.

“... the increasing popularity of biomimetics is also due to a common misunderstanding of biomimetic technologies being directly linked to sustainability and thus ‘greener’ than any other innovation method. It is beyond controversy that the discussion of nature and natural technologies delivers an increased knowledge and consciousness about ecological interconnections, but as researchers have argued again and again, biomimetics as a sole innovation tool can also deliver unsustainable products and is not a panacea for all global problems. The intention to design environmentally responsible and sustainable products is independent of this design method. The values according to which applications are designed come from outside referring to societal and cultural norms. This will not change in the future, which means biomimetics will still be an innovation method, characterized by the strategic information transfer, independent of a value system.” (Gebeshuber, Gruber and Drack 2009).

One can do highly successful biomimetics that is not sustainable at all. Sustainability was of no concern in the Biornametics project, and in fact, just when we discussed this point with Markus Milwich of ITV Denkendorf, who was invited to speak about biomimetic product innovation in the field of textiles and fibres in his talk 'Advanced Textile Technologies for Bioinspired Constructions' it became clear to the students that taking the best ideas out of nature without including the interdependencies, the sustainability, the complexity, can result in products that are much more unsustainable than anything that can be produced without biomimetics basis.

#### **4.3. Biomimetic and sustainable futuristic approaches and applications in architecture and design**

The approach taken in the PEEK project was not intended to include sustainability. However, given the high importance and increasing relevance of sustainability, any follow up project should definitely include this concept, even more, make it one of the base concepts in the approaches. Sustainability can easily be introduced as a design requirement, regardless of the innovation method taken. In the Biornametics project it was clear from the beginning that the frame of the project does not allow an extensive investigation on sustainability aspects, but in order to translate some of the key issues found in nature's role models to architectural application there is a hope in the sustainability of the developed solutions and databases for further use (Imhof, Gruber and Hoheneder 2012).

#### **5. Summary and Conclusions**

This paper is dealing with the state of the planet, Loos's important article "Ornament and Crime" and the art-based science project Biornametics. All three sections of the paper touch upon sustainability: In "Setting the Stage: The State of the Planet" David Attenborough's BBC series is presented in a condensed way along with references to primary scientific literature. This series highlights the human influence on the ecosphere, and its contribution to the 6th mass extinction of species. In "Aspects of Sustainability in A. Loos 'Ornament and Crime'" the authors present quotes from Loos's highly influential article (in the German original and an English translation), and establish a connection to sustainability in science, architecture and design. "Sustainable Biomimetics in Biornametics" is treated with in the third section. Art-based science projects such as the PEEK projects initiative introduced by the Austrian Science Fund in 2009 offer a unique possibility of transdisciplinary treatment of art-based research. This type of projects turned out to be highly successful, and the PEEK program in increasingly being internationalized.

Sustainability is buzzword nowadays (a Google search on “conference sustainability” yields nearly 98 million results), and is used in various, often highly different, definitions (Adams 2006). For effective change for the better we need to collaborate, we need to establish common visions and goals and we need to jointly work to address them. Addressing 14 of the 15 major challenges (Glenn, Gordon and Florescu 2011) might not be enough - ignoring one of them might result in serious trouble. Architects and designers can contribute their share to sustainability. We are spending nearly all of our time in built environments - continuous exposure to sustainability, consciousness and knowledge about the fragility and importance of our ecosphere would pave the way for a new society, for a society who - in Loos’s words - has intellectual strength and the ability of aesthetic development. Art-based research projects such as the Biornametics project can be the initial ignition to embed sustainability in the avantgarde, and successively, in the general public. Exploration of aesthetic and functional interpretation for a new sustainable architecture, contributing to improving the state of the planet, is indeed possible.

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## **SUSTAINABILITY IN SCIENCE, ARCHITECTURE AND DESIGN**

### **Lessons from Attenborough, Loos and Biornametics**

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#### **ABSTRACT:**

*Biomimetics is per se not sustainable. It is a design method, and as such, it is free from values. However, when we are learning from nature for our engineering and artistic endeavours, why should we just be constrained to patterns, structures, materials or processes – why not transfer the most amazing property of life itself – sustainability?! This paper is dealing with sustainability on three interdisciplinary levels: first, to set the stage, the state of the planet is described. Earth's biosphere is approaching a critical state shift. We humans are currently causing a 6<sup>th</sup> mass extinction. In the 5<sup>th</sup>, 55 millions of years ago, 80% of all species died out. Second, Adolf Loos's famous 1908 article "Ornament and Crime" is critically dealt with regarding its inspirational potential to sustainability. Loos builds the bridge to the third level: Biornametics, architecture defined by natural patterns, a new methodology that interconnects scientific evidence with creative design in the field of architecture. It takes on the history of one of the composed parts of this word "ornament" referring to Loos and extends into another, "biomimetics", the strategic search for nature's solutions in order to gain innovation. The emergence of patterns in nature at all scales of existence of organisms as one of the most important signs of life – order – is not arbitrary, but highly interconnected with boundary conditions, functional requirements, systems requirements, material and structure. In bringing all these three levels together the authors show that the exploration of aesthetic and functional interpretation for a new sustainable architecture, contributing to improving the state of the planet, is indeed possible.*

**Conference theme:** This keynote address aims at bridging all the conference themes.

#### **Keywords:**

architecture, biomimetics, biornametics, ornament, science, sustainability, the state of the planet, tipping point

### **1. Introduction**

The State of the World 2010 report by the Worldwatch Institute is all about sustainability (Worldwatch Institute 2010). The review in "Publishers Weekly" speaks for itself:

*"In this year's volume, the D.C.-based Worldwatch Institute think-tank considers, in several dozen pieces, how "cultures of consumption" can be transformed into "cultures of sustainability." Many ideas take inspiration from diverse traditions: religions can be called upon to embrace their own deepest values and renounce materialism, while establishing new holidays, rituals and taboos incorporating strategies for sustainability (Earth Day, "Green funerals," new days of fasting, etc.); practices honoring elders as transmitters of ancient wisdom can be spread beyond regions where they still thrive (Africa, India, etc.); thousand-year-old Asian farming methods can be revived. Ideas for restructuring education include replacing the "Three Rs" with the "Seven Rs" ("reduce, reuse, recycle, respect, reflect, repair, and responsibility") and emphasizing "environmental education" in higher learning. The largest-scale changes include shifting societal goals from "maximizing growth of the*

*market economy to maximizing sustainable human well being”; ensuring that the burden of reduced production falls on the wealthiest, not the poorest; and building sustainable cities like Vauban, a 5,000-household German community that uses 100 percent renewable energy. Though many solutions in this visionary volume require a pie-in-the-sky “whole Earth community” legal system prioritizing “the right to life” over “the right to conduct business,” it should give leaders and laypeople much to consider.”* (Copyright © Reed Business Information, a division of Reed Elsevier Inc., <http://www.amazon.com/State-World-2010-Transforming-Sustainability/dp/039333726X/>, last accessed June 9, 2012).

This article is undertaking the endeavour to bridge the current state of the planet with possible sustainability aspects in Adolf Loos’s article “Ornament and Crime” and Biornametics, an interdisciplinary design approach that has recently been developed at the University of Applied Arts in Vienna, Austria in the framework of an art-based research project, bringing together architects, designers, artists, mechanical engineers and physicists. Each of these three aspects is introduced and treated in due detail, until in the final section, the three strings are interwoven, resulting in a picture full of hope: we can make the world a better place by achieving sustainable biomimetic architecture.

Biomimetics is the strategic search for nature’s solutions in order to gain innovation. Efficiency and intelligence are intrinsic to ‘design’ in nature. The hypothesis underlying this innovation method is that living nature has evolved in a process of continuing adaptation to a complex changing environment, and that the exploitation of highly optimised solutions is likely to deliver innovations that provide more intelligence and better efficiency than our standard methods.

With biomimetics we use living nature as our teacher, and with today’s technology we are ready to think, work and act in inter- and transdisciplinary ways. This will pave our way towards sustainability, for the sake not only of humans but the whole biosphere.

## **2. Setting the Stage: The State of the Planet**

Our planet is not in a good shape. In three programmes called “State of the Planet”, presented on BBC by David Attenborough at the beginning of the new millennium, the situation is explained in alarming words (Attenborough and Broome 2000). In the following the authors of this entry (who come from architecture and physics) present a condensed version of the themes treated in these programmes, along with references to primary scientific literature.

Increased population and industrial activities might very well have brought us on the verge of yet another mass extinction of species (Barnosky *et al* 2011, Rogers and Laffoley 2011) and might anytime result in an unfortunate state shift in the Earth’s biosphere (Barnosky *et al* 2012). This will not be the first mass extinction: it will be the 6<sup>th</sup>. But – it will be the one that is caused by human activity. If we want to ensure quality of life for all people on Earth, and for the ones following us, we need to ensure it sustainably.

The scale of the damage to the natural environment is enormous. Life can adapt (and has always done so) to local damage. But what about the global damage we are currently doing on a planetary scale? We are limited in space (we just have one planet), we are limited in resources, and the Earth has a maximum capacity to bear life.

Some numbers illustrate the dramatic situation: The Australian theoretical ecologist Sir Robert May, past president of the Royal Society, estimates that scientists have identified, described and named about 1.5 million species on Earth. The American oceanographer Sylvia A. Earle, who was chief scientist for the U.S. National Oceanic and Atmospheric Administration, says

that coral reefs harbour biodiversity larger than the tropical rainforests, and that only 5 percent of the oceans have already been explored.

Biologists have always appreciated the interconnectedness of nature, and now, slowly, also scientists from other disciplines and the general public have gained awareness of this fact. Due to the complexity of the biosphere the impact of extinction of so many species can not at all be pre-estimated.

The Pulitzer Prize winner and ant specialist Edward O. Wilson (ranked by Time Magazine as one of the 25 most influential people on the planet) says that there is an estimate of a minimum of 5 million and a maximum of 100 million of species on this planet (Wilson 1994, 143). The threat to them by human activity can only scarcely be estimated. At the moment we have an extinction rate that is elevated 100 to 1000 fold compared to the one before humans entered the scene (Lawton and May 1995).

The palaeontologists Peter D. Ward and Charles R. Marshall, director of the University of California Museum of Palaeontology, say that the meteor impact in Mexico 55 millions of years ago wiped out 60-70% of the world's species (Marshall and Ward 1996, Pope *et al* 1998). This meteor was just about 10 miles wide. Being now on the verge of the next mass extinction we must state that human impact on the planet equals a massive meteor impact.

The concept of keystone species, introduced by Paine in 1969 (Paine 1969) even worsens the prospects. When the number of individuals of a so-called keystone species decreases, huge effects on the whole ecosystem are the result. As species do not exist in isolation a major crisis may occur if an important species disappears. Which species are keystone species is hard to tell, hard to calculate and hard to predict – when it comes to complex, interdependent systems, we are still very much at the beginning of scientific understanding.

One famous example for a keystone species are sea otters in kelp beds (Estes and Palmisano 1974, Duggins 1980): sea otters live in or close to kelp forests which are home to many other animals, including sea urchins. When the otters were nearly extinct because they were hunted too much for their furs, much less otters were eating sea urchins. So the urchins were reproducing much faster, and taking over the ecosystem by excessively feeding on the kelp, especially its insertions into the seabed. As the kelp was gone so were all the species that depended on it, including many fish and shrimp species that had used the kelp forests as breeding grounds. Species are doing a lot for the environment that is important for humans. They are creating the soil, the water, the air – for free.

There are five human activities that yield the current mass extinction. We are damaging life's diversity in 5 ways: Overharvesting of animals and plants, introduction of alien species, destruction of habitats, habitat fragmentation and pollution.

We have to think and brainstorm where we can contribute with sustainable architecture, with sustainable design, to the preservation of life's diversity.

50 000 years ago we had big herds of big animals on all continents apart from Antarctica. Even on the area of current Los Angeles camels, lions, cheetahs and elephants were living (says Pulitzer Prize winner Jared Diamond, interdisciplinary scientist and author). Is it a coincidence that these big herds disappeared when humans started to spread out there? Sir John H. Lawton, British ecologist, chair of the Royal Commission on Environmental Pollution and former head of Natural Environment Research Council, says that humans are switching predators - making us so dangerous for life's diversity.

### **2.1. Overharvesting of Animals and Plants**

Overharvesting inevitably affects all other species that interact with the overharvested species or depend on them. We can only harvest something sustainably if it regrows faster than we cut it down/catch it/kill it/harvest it. At the moment, tropical trees are cut down ten times faster than they can regrow (Longman and Wilson 1998). Also concerning the

oceans, we are very fast approaching the limit: 70% of the fish species are removed at or above the rate at which they can reproduce. Sylvia Earle says that we are getting to good, with our acoustic methods, we can locate each and every tuna in the sea; we take too much out of the seas.

To give an idea about the impact of people on the planet: Each year half of the plant growth on Earth is used for just one species – us!

## **2.2. Introduction of Alien Species**

One example for the effects of the introduction of plants and animals to places where they have never lived before are the lowlands of Hawaii – there is no single native birds species anymore there. All birds there are introduced, and there is nearly any native population of indigenous birds left. Most that are left are isolated on the mountaintops. Another example is Hawaiian snails –many of them are already extinct. Rats or introduced alien snail species killed them.

Rhododendron for example is an invasive species that lives in symbiosis with a root fungus that poisons the earth, and does not allow any other plants to live there - while the rhododendron is living there, and even up to seven years after is has been cut down! In the Snowdonia National Park in Wales this is a huge problem (see, e.g., Dehnen-Schmutz and Williamson 2006).

## **2.3. Destruction of Habitat**

The Anasazi Indians in Pueblo Bonito where once a thriving and rich community. Now, their land is a desert, all the people are gone, the water table is so low that no crops can be grown anymore. The Anasazi were cutting down all trees in their region, changing the landscape with long lasting effects (for more details on this collapsed society, see Diamond 2005, 136-156). Finally, the packrat lead to the collapse in Chaco Canyon (Diamond 2005, 145-147).

The destruction of habitats is doing more damage to biodiversity around the world than any other human activity.

Reading all this, and thinking about it, one might start to ask if we, the human species, are deliberately destructive. Edward O. Wilson indeed says: “We are evil.” The effect of the modern industrial human behaviour on the rest of life is enormous. We are destroying the environment very efficiently at the present time. According to Wilson, we conquer wilderness and we utilise wilderness, and we expand our population to gain security, to gain control and to alter. For millions of years this went well, with no major harm done. However, then we developed modern industrial capacity. We developed the techno-scientific capacity to eliminate entire habitats quickly and efficiently. We are destroying the very foundation in the environment on which humanity was built.

## **2.4. Habitat Fragmentation**

The conservation biologist Thomas E. Lovejoy, the one who introduced the term “biological diversity” in 1980 (!) (Lovejoy 1980), states that one road is enough to bisect a rainforest. The effects of habitat fragmentation and habitat loss are very well summarized in Fahrig 2003. She states that habitat loss is always detrimental for biodiversity, whereas with fragmentation, this is not necessarily the case (Fahrig 2003).

## **2.5. Air Pollution, Global Warming and Climate Change**

Global warming and climate change pose major challenges to life on Earth. Actually, sustainability and climate change represent the first global challenge (of 15) identified by the UN Millennium Project in their annual State of the Future Report (Glenn, Gordon and Florescu 2011). Engineers now start to actively address climate change (see, e.g., the Special Section on

Engineering in a Changing Climate 2010, i-ii and 505-580). Nobel Prize winner Stephen H. Schneider from Stanford University liked to state that change in itself is not necessarily destructive when it happens slowly. He was talking about our current biological crisis and kept on stressing the importance of education, awareness and sensitivity. The great challenge of the next century according to him can be phrased like this: How to provide a good living standard to an ever growing number of human beings without inflicting grave impoverishments on the planet? How can a change in our behaviour prevent a great loss of species over the next century? We do have the ability to make a difference!

## **2.6. The Importance of Biodiversity/Summary**

Over half of the species on Earth will become seriously endangered or extinct over the next 100 years (Barnosky *et al* 2011, Rogers and Laffoley 2011). We must find ways of reducing the pressures that we are putting on the planet.

Walter J. Lusigi, retired Senior Advisor with the Global Environment Facility Secretariat, says that it is not enough to conserve the species. We have to conserve the species plus the environment. The conservationist John Hanks established in Africa the Peace Parks Initiative, Trans-Frontier Conservation Areas providing habitat for wildlife across borders.

Biological diversity is not just a bunch of conservationists saying “We love these animals.” It is about quality of life, it is about human survival. The commercial value of a range of species can make a huge difference for local communities living in marginal areas. Protected areas are important. But we need to develop methods to live with nature, not separating humans from nature.

In this regard, the 3D corporate tourism method (Gebeshuber and Majlis 2011), a concept for innovation in nanomaterials engineering, is of importance: Scientists from around the world are visiting virgin rainforest and are doing biomimetics there. They discover, develop and design new approaches inspired by nature, with the help of local communities and scientists. They give value to the forest itself, and for them, the virgin rainforest is a treasure box, full with unconventional, interesting solutions – and sustainable. And not just for them – via the transfer to engineering and the arts this treasure box is of benefit for the whole society.

We have 8 million commercial flights every year (status: June 2011).

Sir John H. Lawton says that it is in the interest of rich developed nations to help developing nations to pay for the protection of forests, to pay for the protection of wild life (see, e.g., Edwards and Abivardi 1998). Armanda Vincent from the Fisheries Centre at the University of British Columbia in Canada for example, the initiator of Project Seahorse, does exactly this: she and her team pay indigenous people for bringing her seahorses (which are subsequently sold to the market, mainly for traditional Chinese medicine), but the collecting is continuously monitored and care is taken that no area is overfished (Ban and Vincent 2009). Stephen H. Schneider says that although coral reefs are just 1% of the ocean, they are home to 25% of the fish. One solution to global warming is the use of more sustainable energy sources, not burning past fossil fuels. And fewer people who consume less energy and have less extravagant patterns of consumption. We currently experience a major increase in the human population: 100 years ago, we had 2 billion people. In 2012 we exceeded 7 billion (US Census Bureau 2012), and this number is continuously rising. How to bring population growth and resources into balance is the third of the 15 major challenges of humankind as identified in the 2010 State of the Future Report by the UN Millennium Project, a project that was commissioned by the United Nations Secretary-General in 2002 to develop a concrete action plan for the world to achieve the Millennium Development Goals and to reverse the grinding poverty, hunger and disease affecting billions of people (Glenn, Gordon and Florescu 2010).

We need to develop ways to minimize the damage. How many species can we afford to

lose in this immense increase in human population without seriously compromising the future? We need strategies how to scale down our excesses in consumption.

We have to learn a new ethics method that allows us to care as much about the Brazilian rainforest as about our own local reserve. And we need to think beyond just a few years or just one generation: What do we want to leave to future generations? Which kind of world? The future of life on Earth depends on our ability to take action. Many individuals are doing all they can, but real success can only come if there is a challenge in our societies and our economics and in our politics.

### **3. Aspects of Sustainability in A. Loos “Ornament and Crime”**

Adolf Loos (1870-1933) wrote his famous and highly influential essay “Ornament and Crime” in 1908 (Loos 1997). Loos was a Viennese architect, a man of high taste and refined intellect. A pioneer of modern architecture, he had a radical, innovative outlook on life. Reading his essay with regards to architecture, sustainability and design stimulates the mind, and directs it into new areas. Below, we summarize the thoughts that came to our minds when reading “Ornament and Crime”. It might be that the conclusions we draw from his words are not at all his own intentions. It is also not the intention here carry out an analysis in a historical context. The intention here is to have a stimulus from a famous piece, and let the mind wander to come up with new connections, ideas and possible applications regarding sustainability in science, in architecture and in design. This section introduces intriguing sentences (in the original German original version, and in the English translation, from <http://technical-english.wikidot.com/text-1-2>) and the ideas stemming from them.

The initial thoughts of the physicist in our author collective after having read Loos’s classical work for the first time, and after just having watched Attenbourough’s “State of the Planet” BBC Series, was not concerned with sustainability in architecture or design, but with something that might be termed “sustainability in science”. Today, scientists are expected to write a lot. Advancement in science, the position in the scientific hierarchy, promotions, social standing, etc. are valued according to the output of the scientists (Pendlebury 1991). Science culture is increasingly quantity driven (Hamilton 1990). Many of the plenitude of scientific papers published aren’t even read or discussed (Hamilton 1991). They are not placed in journals with a certain readership in mind, but in journals with a certain “impact factor”, a number, in mind. Numbers are the ornament of our time (sic!). We decorate our science with numbers, and the problem is, these numbers are, just as the ornaments of Loos, not sustainable. You get what you measure. If you decide to count ‘Scopus papers’ (Scopus is a bibliographic database owned by Elsevier that covers titles from thousands of international publishers, including 18 500 peer-reviewed journals – status May 2012, and a ‘Scopus paper’ is a paper that is listed in Scopus – the more Scopus listed papers you have, the higher your esteem in certain universities and research institutions), people try to publish papers that are listed in Scopus. If you then switch to ISI (Institute for Scientific Information, now belonging to the Healthcare & Science business of the multi-billion dollar Thomson Reuters Corporation, listing over 16 800 journals, status June 9, 2012) people are increasingly publishing in ISI journals, especially if universities base promotion, advancement and salary increase policies on it. And since it is not that easy to enter ISI journals, very accurately the ones that are (still) easy to enter are very fast identified by some researchers (who actually in many cases do not do any research anymore, but rather search for ways to publish their work in as many articles in as high rated journals as possible), and the manuscripts are submitted there. Such journals have names such as “Scientific Research and Essays” (based in Lagos, Nigeria) and publish a

colourful collection of articles. Very few people read them, very few people cite them, and publishing there does not at all advance any scientific field.

The number of papers submitted there increases, and – since working as a reviewer for a scientific journal is not thanked neither paid, it is increasingly complicated for the journal to find reviewers, in the exact field of the paper or in a (perhaps, if you are lucky) remotely connected one.

Emails with request to act as reviewer are sent out as mass emails by the editors, without addressing the potential reviewer by name. The future of the journal was doomed, it already lost its impact factor; it is not an ISI journal anymore. But new ones will come up on the horizon. Other ornaments in science are the number of research projects (which in fact limit your thinking to just thinking in milestones and deliverables, and to short time frames not exceeding the end of your project). We have a major problem in dealing with over information, in structuring knowledge and in scientific publishing and accessing human knowledge and we need to address this problem, if we want things to move forward (Gebeshuber, Gruber and Drack 2009, Gebeshuber and Majlis 2010). This is increasingly getting important with our planet approaching a tipping point.

### **3.1. Stages**

Loos: *“Wenn der mensch geboren wird, sind seine sinneseindrücke gleich denen eines neugeborenen hundes. Seine kindheit durchläuft alle wandlungen, die der geschichte der menschheit entsprechen.”*

Translation: “And when a human being is born, his sense impressions are like a new-born dog’s. In childhood he goes through all changes corresponding to the stages in the development of humanity.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: What comes to the mind of the scientist in the team of authors is the cycle of life. Development always goes from the primitive to the complex to the simple.

The stages in the development of humanity go from primitive societies to our current complex technosophical society to a refined simple future society. Traditional architecture is not sustainable, in the sense that, e.g., certain trees were used too excessively and are not available anymore (Gruber 2011). In a small primitive society without technology, architecture might not be sustainable – however due to the small size of such systems the damages may be just local and life can adapt to them. Sustainability is increasingly a goal in the current complex technosophical society. Sustainable architecture and design is necessary for survival in the refined, simple society we aim for.

### **3.2. The Humble Beginnings of Art**

Loos: *“Der drang, sein gesicht und alles, was einem erreichbar ist, zu ornamentieren, ist der uranfang der bildenden kunst. Es ist das lallen der malerei. Alle kunst ist erotisch.”*

Translation: “The urge to decorate one’s face and anything else within reach is the origin of the fine arts. It is the childish babble of painting. But all art is erotic.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Nothing is perfect from the very beginning. You have to start somewhere, and in architecture and design, we are at the moment in a transition phase. Sustainability is increasingly important in architecture and design (a search on amazon.com for ‘sustainability in architecture’ yields 1475 results, status June 10, 2012), and enters fields of science, engineering and the art where nobody would have thought it would ever arrive. Vivienne Westwood for example, the British fashion designer, just recently published a manifesto calling for sustainability.

### **3.3. Evolution**

*Loos: "Ich habe folgende erkenntnis gefunden und der welt geschenkt: Evolution der kultur ist gleichbedeutend mit dem entfernen des ornamentes aus dem gebrauchsgegenstande."*

Translation: "I made the following discovery, which I passed on to the world: the evolution of culture is synonymous with the removal of ornamentation from objects of everyday use." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Reduction to the necessary - key function, all other is not important. Current materials used in architecture and design are changing from being monofunctional to being multifunctional.

The exquisite relationship between structure and function as can be seen in living nature and in ecosystems is amazing. Structure and function cannot, in most cases, be separated. The ornament, the artificial add-on to the structure, will become obsolete.

The beauty will be inherent in the functional material (e.g., structure – function – shiller – colour relationship in butterfly wings or orchids, Kinoshita 2008, Gebeshuber and Lee 2012).

### **3.4. Beyond**

*Loos: "Wir haben das ornament überwunden, wir haben uns zur ornamentlosigkeit durchgerungen."*

Translation: "We have gone beyond ornament, we have achieved plain, undecorated simplicity." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Simplicity is the ultimate goal. Perfectly simple systems have integrated functionality, are easy to use, beautiful to watch, wonderful to live in, biodegradable and non-toxic. The designs and architecture of the future does not need to show off with itty-bitty add-ons, it is intrinsically of highest quality, functionality, beauty and sustainability.

### **3.5. There is Hope**

*Loos: "Der ungeheure schaden und die verwüstungen, die die neuerweckung des ornamentes in der ästhetischen entwicklung anrichtet, könnten leicht verschmerzt werden, denn niemand, auch keine staatsgewalt, kann die evolution der menschheit aufhalten."*

Translation: "It is easy to reconcile ourselves to the great damage and depredations the revival of ornament had done to our aesthetic development, since no one and nothing, not even the power of the state, can hold up the evolution of mankind." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: There is hope. It will take some time, but quality always wins.

### **3.6. Sustainability**

*Loos: "Der wechsel der ornamente hat eine frühzeitige entwertung des arbeitsproduktes zur folge. Die zeit des arbeiters, das verwertete material sind kapitalien, die verschwendet werden. Ich habe den satz aufgestellt: Die form eines gegenstandes halte so lange, das heißt, sie sei so lange erträglich, solange der gegenstand physisch hält. Ich will das zu erklären suchen: ein anzug wird seine form häufiger wechseln als ein wertvoller pelz. Die balltoilette der frau, nur für eine nacht bestimmt, wird ihre form rascher wechseln als ein schreibtisch. Wehe aber, wenn man den schreibtisch so rasch wechseln muß wie eine*

*balltoilette, weil einem die alte form unerträglich geworden ist, dann hat man das für den schreibtisch verwendete geld verloren.*”

Translation: “The changing fashion in ornament results in a premature devaluation of the product of the worker’s labor; his time and the materials used are wasted capital. I have formulated the following principle: The form of an object should last, that is, we should find it tolerable as long as the object itself lasts. I will explain: A suit will change its style more often than a valuable fur. A woman’s ball outfit, intended for one night alone, will change its style more quickly than a desk. Woe betide us, however, if we have to change a desk as quickly as a ball outfit because we can no longer stand the old style. Then we will have wasted the money we paid for the desk.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: Here, Loos establishes a direct link to sustainability. No interpretation or brainstorming is needed. He talks about premature devaluation, useless lost work and waste capital, and one can add, regarding science, architecture and design, respect for the ecosphere, respect for all the organisms with whom we share this planet – and for the ones to come in the near and distant future.

### 3.7. Quality

*Loos: “Wenn alle gegenstände ästhetisch so lange halten würden, wie sie es physisch tun, könnte der konsument einen preis dafür entrichten, der es dem arbeiter ermöglichen würde, mehr geld zu verdienen und weniger lang arbeiten zu müssen. Für einen gegenstand, bei dem ich sicher bin, daß ich ihn voll ausnützen und aufbrauchen kann, zahle ich gern viermal soviel wie für einen in form oder material minderwertigen. Ich zahle für meine stiefel gern vierzig kronen, obwohl ich in einem anderen geschäft stiefel um zehn kronen bekommen würde. Aber in jenen gewerben, die unter der tyrannei der ornamentiker schmachten, wird gute oder schlechte arbeit nicht gewertet. Die arbeit leidet, weil niemand gewillt ist, ihren wahren wert zu bezahlen.*”

Translation: “If all objects would last as long in aesthetic terms as they last physically, the consumer would be able to pay a price for them that would allow the worker to earn more money and work shorter hours. For an object from which I am convinced I will get full use until it is worn out I am quite happy to pay four times the price of another I could buy. I am happy to pay forty crowns for my shoes, even though there are shoes for ten in another shop. But in those trades that languish under the yoke of the ornamental artist, no value is put on good or bad workmanship. Work suffers because no one is willing to pay for it at its true value.” (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: More money and less work for the producer of high quality products – this should be the aim. In science, in architecture, in design. We are currently at a stage where machines could take over a large proportion of our work. But instead of working shorter hours, in many professions people are working longer and longer hours, and often even define their value as ‘work force’ depending on the amount of overtime they are doing. In a sustainable society, the balance between life and work becomes obsolete, as work is an integrated and fulfilling part of a high quality life. Extra time can be spent with kids, for pleasure, for further education, for travel, for community work, etc. – there is no need to fill eight hours per person per day with useless jobs.

### 3.8. Golden Waste

*Loos: “Aber das werfen mit goldstücken statt mit kieselsteinen, das anzünden einer zigarette mit einer banknote, das pulverisieren und trinken einer perle wirkt unästhetisch.*”

Translation: “But throwing coins instead of stones, lighting a cigar with a bank note, crushing up and drinking a pearl, I find unaesthetic.” (<http://technical-english.wikidot.com/text-1-2>,

accessed June 10, 2012)

Inspiration regarding sustainability: There is no point in overdoing things. Sustainability has at the moment very positive connotation. In this respect it meets with biomimetics. However, sustainability is usually not associated with aesthetics, with fun and joy.

### **3.9. A Bright Future**

*Loos: "Wir haben die kunst, die das ornament abgelöst hat. ...*

*Ornamentlosigkeit ist ein zeichen geistiger kraft."*

Translation: "We have the art that has superseded ornament. ...

Lack of ornamentation is a sign of intellectual strength." (<http://technical-english.wikidot.com/text-1-2>, accessed June 10, 2012)

Inspiration regarding sustainability: We need intellectual strength in our current times. We need sustainability. For the future of us and all life on Earth.

## **4. Sustainable Biomimetics in Biornametics**

The art-based research PEEK project 'Biornametics - Architecture defined by natural patterns' (Gebeshuber, Gruber and Imhof 2012) explored a new methodology to interconnect scientific evidence with creative design in the field of architecture (Fig. 1). It took on the history of one of the composed parts of this word, 'ornament' referring to Adolf Loos, and extended into another, 'biomimetics'. The 'New Ornament' was introduced as an emerging contemporary design practice based on digital techniques that assembled from controlling programs and codes, less concerned with serial rationality but with algorithmic, digital operations and connecting the processes of planning and production. Role models from nature, static and dynamic patterns (e.g. growth principles, movement patterns, adaptation and differentiation as key for emergence of patterns etc.) were investigated and the findings applied to design strategies. The emergence of patterns in nature at all scales of existence of organisms as one of the most important signs of life - order - is not arbitrary, but highly interconnected with boundary conditions, functional requirements, systems requirements, material and structure. The main objectives of the project were the exploration of aesthetic and functional interpretation for a new architecture together with the utilisation of new manufacturing technologies, and elaboration of the biomimetic design method and the "New Ornament" (Imhof *et al* 2011).

### **4.1. Intersections between the sciences and the design industry**

Increasingly, scientists and designers are working together. The Austrian science fund introduced a new funding scheme called PEEK that concentrates on art-based research. In the framework of such projects, scientists and artists are collaborating. This approach is very interesting since it allows addressing current aspects in the arts, architecture and design from fresh, new points of view. PEEK is now (2012) in its third round, and it is highly recommended by the authors that less concentration is put on method, immediate outcome and approach, and more on interdisciplinarity, learning from each other, accepting one's pace, slowing down and establishing a creative, joyful atmosphere.

### **4.2. The relation between sustainability and biomimetics**

Since biomimetics is a design method, there is no value attached to it. So biomimetics does not come with sustainability. Biomimetics is not *per se* green.

*"... the increasing popularity of biomimetics is also due to a common misunderstanding of biomimetic technologies being directly linked to sustainability and thus 'greener' than any*

other innovation method. It is beyond controversy that the discussion of nature and natural technologies delivers an increased knowledge and consciousness about ecological interconnections, but as researchers have argued again and again, biomimetics as a sole innovation tool can also deliver unsustainable products and is not a panacea for all global problems. The intention to design environmentally responsible and sustainable products is independent of this design method. The values according to which applications are designed come from outside referring to societal and cultural norms. This will not change in the future, which means biomimetics will still be an innovation method, characterized by the strategic information transfer, independent of a value system.” (Gebeshuber, Gruber and Drack 2009).

One can do highly successful biomimetics that is not sustainable at all. Sustainability was of no concern in the Biornametics project, and in fact, just when we discussed this point with Markus Milwich of ITV Denkendorf, who was invited to speak about biomimetic product innovation in the field of textiles and fibres in his talk ‘Advanced Textile Technologies for Bioinspired Constructions’ it became clear to the students that taking the best ideas out of nature without including the interdependencies, the sustainability, the complexity, can result in products that are much more unsustainable than anything that can be produced without biomimetics basis.

**FICUS BENGHALENSIS**, Banyan tree 18

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ROLEMODEL DESCRIPTION

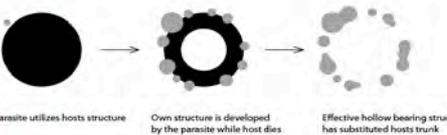


**TOPIC**  
2 - shape and growth; 3 - adaptation and reorganisation

**KEYWORDS / FEATURES**  
roots, desalination, structure

**APPLICATION IDEAS**  
renovation of old buildings; parasitic structures; interweaving of two systems; generative structures; circulation system around centre core; added layering in architecture

**SYSTEM DIAGRAM:**



Parasite utilizes hosts structure → Own structure is developed by the parasite while host dies → Effective hollow bearing structure has substituted hosts trunk

BIORNAMETICS

**FICUS BENGHALENSIS**, Banyan tree 18

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dimension 3D	+
speed/timescale	+
scale [m]	low
scaleability	+
geometry	+
function	+
<b>structural performance</b>	
structure	+
material (chemistry)	0
<b>reactivity</b>	
input sensing	+
output	++
<b>adaptivity</b>	++
<b>aesthetics</b>	
pattern repetition	+
colour	-
colour change	-
symmetry	-
elegance	0
cool	++
story	story
<b>information communication</b>	+
complexity*	0
growth	+
motion	-
innovative potential	+
compatibility	+
availability of information	0
<b>transferability</b>	
simulation (computerbased)	+
technological transfer	-

EVALUATION CRITERIA

evaluation
→ high/yes
→ 0/neutral
→ low/no
→ no/empty

BIORNAMETICS

**Fig. 1 Biornametics Rolemodel #18 Data Sheet: *Ficus benghalensis*.**

The datasheets are organised in two sheets per rolemodel, giving an image, the Latin name, the area of defined research, an abstract about the features which seem interesting, references, first application ideas and a functional diagram of the feature to be explored in the further process.

### 4.3. Biomimetic and sustainable futuristic approaches and applications in architecture and design

The approach taken in the PEEK project was not intended to include sustainability. However, given the high importance and increasing relevance of sustainability, any follow up project should definitely include this concept, even more, make it one of the base concepts in the approaches. Sustainability can easily be introduced as a design requirement,

regardless of the innovation method taken. In the Biornametics project it was clear from the beginning that the frame of the project does not allow an extensive investigation on sustainability aspects, but in order to translate some of the key issues found in nature's role models to architectural application there is a hope in the sustainability of the developed solutions and databases for further use (Imhof, Gruber and Hoheneder 2012).

## **5. Summary and Conclusions**

This paper is dealing with the state of the planet, Loos's important article "Ornament and Crime" and the art-based science project Biornametics. All three sections of the paper touch upon sustainability: In "Setting the Stage: The State of the Planet" David Attenborough's BBC series is presented in a condensed way along with references to primary scientific literature. This series highlights the human influence on the ecosphere, and its contribution to the 6<sup>th</sup> mass extinction of species. In "Aspects of Sustainability in A. Loos 'Ornament and Crime'" the authors present quotes from Loos's highly influential article (in the German original and an English translation), and establish a connection to sustainability in science, architecture and design. "Sustainable Biomimetics in Biornametics" is treated with in the third section. Art-based science projects such as the PEEK projects initiative introduced by the Austrian Science Fund in 2009 offer a unique possibility of transdisciplinary treatment of art-based research. This type of projects turned out to be highly successful, and the PEEK program in increasingly being internationalized.

Sustainability is buzzword nowadays (a Google search on "conference sustainability" yields nearly 98 million results), and is used in various, often highly different, definitions (Adams 2006). For effective change for the better we need to collaborate, we need to establish common visions and goals and we need to jointly work to address them. Addressing 14 of the 15 major challenges (Glenn, Gordon and Florescu 2011) might not be enough - ignoring one of them might result in serious trouble. Architects and designers can contribute their share to sustainability. We are spending nearly all of our time in built environments - continuous exposure to sustainability, consciousness and knowledge about the fragility and importance of our ecosphere would pave the way for a new society, for a society who - in Loos's words - has intellectual strength and the ability of aesthetic development. Art-based research projects such as the Biornametics project can be the initial ignition to embed sustainability in the avantgarde, and successively, in the general public. Exploration of aesthetic and functional interpretation for a new sustainable architecture, contributing to improving the state of the planet, is indeed possible.

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