Towards a new type of science for successfully addressing the global challenges for humankind

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ABSTRACT.

Most current scientists are specialists who know a lot about a tiny area of their field. They tend to publish of their research results in papers and books that are solely accessible for their close peers, in terms of concepts, ideas, language, goals and approaches. This approach used to be highly successful in the past, and led to the thriving of the Western approach to science. However, this approach also contributed to the fragmented scientific world as we currently have it. Humankind is now facing major global challenges; successful addressing of these global challenges calls for a new type of science. We need generalists with a broader view, people with the talent to see structures and connections, trends and the emergence of solutions. Science in South-East Asia used to be different from the Western approach. An integrated worldview and a deep understanding (and appreciation) of natural phenomena paved the way for the Eastern holistic approach. Based on the specific example of biomimetics, which is an emerging new field that deals with the abstraction of good design from living nature for human applications in science, technology and the arts, the authors introduce a concept concerned with a new type of scientist, whose world view combines the inherent wisdom in South-East Asia with the Western approach to science, based on an education that concentrates on understanding instead of learning by heart. Such people would be apt to develop new tools and applications for a better future for humanity, successfully address global challenges and contribute to a tree of knowledge that is accessible for all.

Keywords: biomimetics, creativity, engineering, global challenges, interdisciplinarity, rainforest, scientific expeditions, South-East Asia, sustainability, tree of knowledge

1. Introduction

South-East Asia is a region blessed with an amazing nature and talented people. This makes it an ideal environment for biomimetics research that is indeed facing a dual challenge: it has to learn from the natural environment and the requirements of people alike. The art is to build a bridge between the clever solutions jungle life has developed over millions of years in its struggle for survival and the problems human engineers are facing in their struggle to develop new tools and applications. Here nature proves to be the greatest teacher. Frequent scientific expeditions to the deep rainforest teach about sustainability, about elaborate materials, structures and processes. This is supported by the open mindedness, the positive attitude and the respect of people in South-East Asia towards nature that are a solid base for a more profound understanding of nature's creativity.

Most scientists of our time are still specialists; they are very good in a tiny little area of their field. With the huge quantitative output of the science industry and interdependencies getting increasingly complex, a new type of scientist is needed to connect, evaluate and ultimately understand the complex issues modern science and technology are facing. To progress further, biomimetics requires interdisciplinary scientists, with a good general understanding of large-scale connections and structures, developments and trends, concepts and ideas. The successful addressing of global challenges needs people who can deal with interconnectedness and interdependence, across fields, across levels of education, across cultures.

Albert Einstein once said "We can't solve problems by using the same kind of thinking we used when we created them." Climate change, the increasing rich-poor gap, health issues arising from increasingly resistant microorganisms, transnational organized crime and global ethics are just some examples of global challenges that require a more comprehensive approach and that cannot be addressed by individual researchers who publish their valuable findings in isolated journals.

The inherent wisdom in South-East Asia has an amazing potential; a successful combination with the Western approach to science might yield scientists and teachers who will focus on understanding, not on learning by heart. They will inspire their students to become more creative, and therefore provide them with the best basis to become the motors of change towards a better future for humanity.

The interaction between separate fields and mindsets has the potential to be mutually beneficial but will also need lots of efforts to overcome cultures differences and communication problems. The outcome of this process could be a new type of scientist who will have a deep understanding of the world around us, who has the resourcefulness to find new ways in arts, science and engineering and who develops a different approach to communicate the wonders of science and nature - contributing to a tree of knowledge that is accessible for all.

2. The Global Challenges

In 2005 Jared Diamond published his book 'Collapse: How societies choose to fail or succeed' [1]. In this work, Diamond identifies four major issues that lead to the collapse of societies. The first issue comprises destruction and loss of natural resources (e.g., destruction of natural habitats, aquacultures, biodiversity loss, erosion and soil damage), the second ceilings on natural resources (e.g., fossil fuels, water, photosynthesis ceiling), the third harmful things that we produce and move around (e.g., toxic man-made chemicals, alien species, ozone hole) and the fourth comprise population issues (e.g., population growth, impact of population on the environment).

Fifteen global challenges are annually identified by the Millennium Project, a major undertaking that has started in 1996 and that incorporates organizations of the United Nations, governments, corporations, non-governmental organizations, universities and individuals from more than 50 countries from around the world. These challenges are interconnected and interdependent, and successful addressing of all of them is needed if we were to succeed – ignoring one of them might result in detrimental effects on all the others.

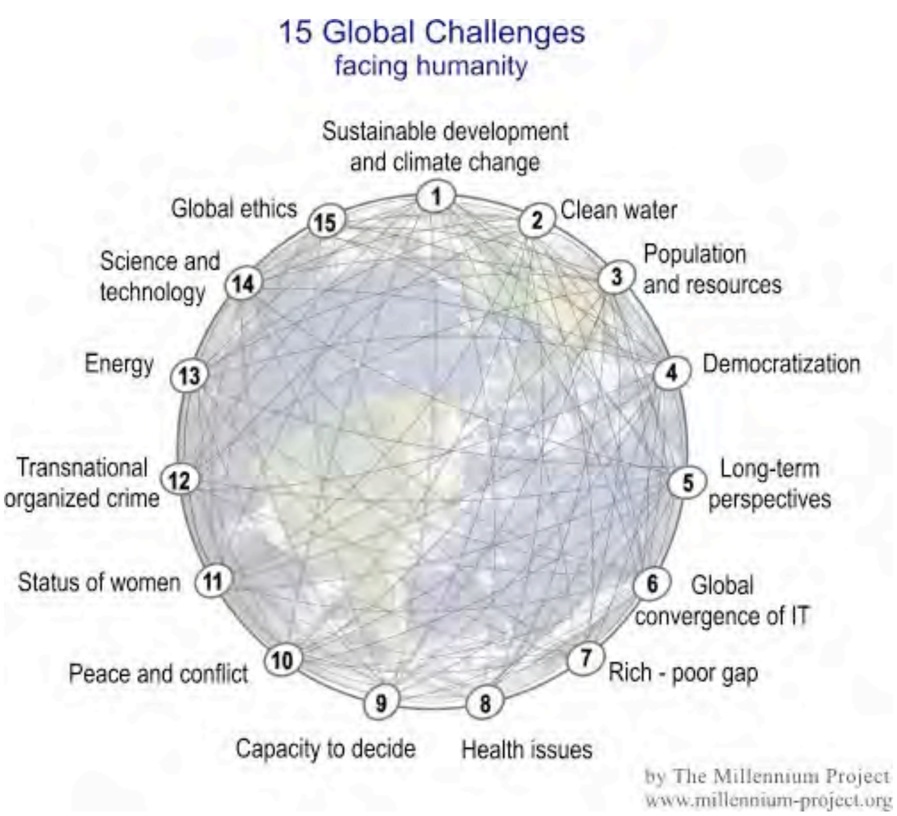

Figure 1: 15 Global Challenges facing humanity as identified by the Millennium Project. Source: http://www.millennium-project.org/millennium/images/15-GC.jpg (last accessed October 5, 2011)

The Millennium Project comprises the work of 2500 futurists, scholars, decision makers and business planners from over 50 countries. The project has nodes in 30 countries. It publishes the annual State of the Future Report (SOF) [2]. The SOF identifies and deals in detail with the fifteen major global challenges for humanity (Fig. 1), and provides an action plan for the world.

The fifteen Global Challenges identified by the Millennium Project are:

1. How can sustainable development be achieved for all while addressing global climate change?
2. How can everyone have sufficient clean water without conflict?
3. How can population growth and resources be brought into balance?
4. How can genuine democracy emerge from authoritarian regimes?
5. How can policymaking be made more sensitive to global long-term perspectives?
6. How can the global convergence of information and communications technologies work for everyone?
7. How can ethical market economies be encouraged to help reduce the gap between rich and poor?
8. How can the threat of new and reemerging diseases and immune micro-organisms be reduced?
9. How can the capacity to decide be improved as the nature of work and institutions change?
10. How can shared values and new security strategies reduce ethnic conflicts, terrorism, and the use of weapons of mass destruction?
11. How can the changing status of women help improve the human condition?
12. How can transnational organized crime networks be stopped from becoming more powerful and sophisticated global enterprises?
13. How can growing energy demands be met safely and efficiently?
14. How can scientific and technological breakthroughs be accelerated to improve the human condition?
15. How can ethical considerations become more routinely incorporated into global decisions?

3. Biomimetics

Otto H. Schmitt coined the word 'biomimetics' in the 1980s [3]. Biomimetics denotes a method in science, engineering and the arts that gains inspiration from nature [4]. Nature is not blindly copied, but the basic principles are identified and transferred to science, engineering or the arts. One very successful example for biomimetics and in fact the work that forms the basis of the current highly positive connotation of biomimetics in the general public is technological applications inspired by the self-cleaning property of the lotus leaf. Minuscule wax structures on the leaf surface yield a high contact angle for water droplets, which subsequently, if the surface is just slightly tilted, roll off, taking impurities with them [5]. Buddhists admire the purity of the lotus, and it is one of their sacred plants. Inspired by the surface structure of the lotus leaf, currently, various self-cleaning surface coatings and paints are on the market, and millions of liters of the facade paint Lotusan® by the STO company have been used in the recent years.

Biological materials are sophisticated, have a high degree of miniaturization and hierarchical organization, are resistant and adaptive. Their hydrodynamic, aerodynamic, wetting and adhesive properties are remarkable. Biomimetic principle transfer to engineering paves the way for more reliable, efficient and environment-respecting materials [6].

However, biomimetics is not inherently green (i.e., minimized environmental footprint) or sustainable (i.e., optimized use of available resources): "*… 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*." [7]. It is simply a method, and as such it is not connected with any value. Not surprisingly, some biomimetic materials are way less sustainable than their commonly produced counterparts – this comes from the fact that in biology, sustainability emerges for the whole system, and not necessarily its single subsystems (or 'strategies') are sustainable. If we extract a principle of such a subsystem, and apply it to our technology, the result might even be dangerous. And exactly such approaches have contributed to the current status of the world: we often apply research results in science and engineering, without thinking about the wider consequences.

Sustainable biomimetic work can contribute to address the global challenges. However, it is necessary to establish a common language across fields and levels of education, a language in which descriptions at different level of detail are more compatible.

The technological and societal potential of biomimetics was treated by Stachelberger, Gruber and Gebeshuber in 2011 [8]. There is no guarantee that a technical solution based on biomimetics will be eco-friendly. However, biomimetics as an interdisciplinary scientific subject is thought to contribute to some extent to sustainable innovation [9] and the sustainability of the final product can be implemented in the design rules for biomimetic work [10]. Emergence as one the key properties in biology can be put into relation with sustainable innovation, via a bridge of necessity to go well beyond the frontiers of classical disciplines, thought patterns and organizational structures. In order to introduce innovation principles into societal practice there is need for ingenious and well-educated people as well as a proactive environment. And these people will be the motors of the successfully addressing of the Global Challenges for humankind.

The 3D corporate tourism concept introduced by Gebeshuber and Majlis in 2011 [11] introduced a novel way to foster and promote innovative thinking in the sciences. This concept considers the need for synergy and collaboration between research fields and cultural background rather than segmentation and isolation: Supported by specially trained biologists, research and development engineers as well as designers apply biomimetics in an environment with high inspirational potential and discover, develop and design materials, structures and processes inspired by nature. The three main pillars of this approach are *discover*, *develop* and *design* – the integrated concept is therefore termed "3D Corporate Tourism" (Fig. 2). This concept can be translated to one that helps addressing global challenges.

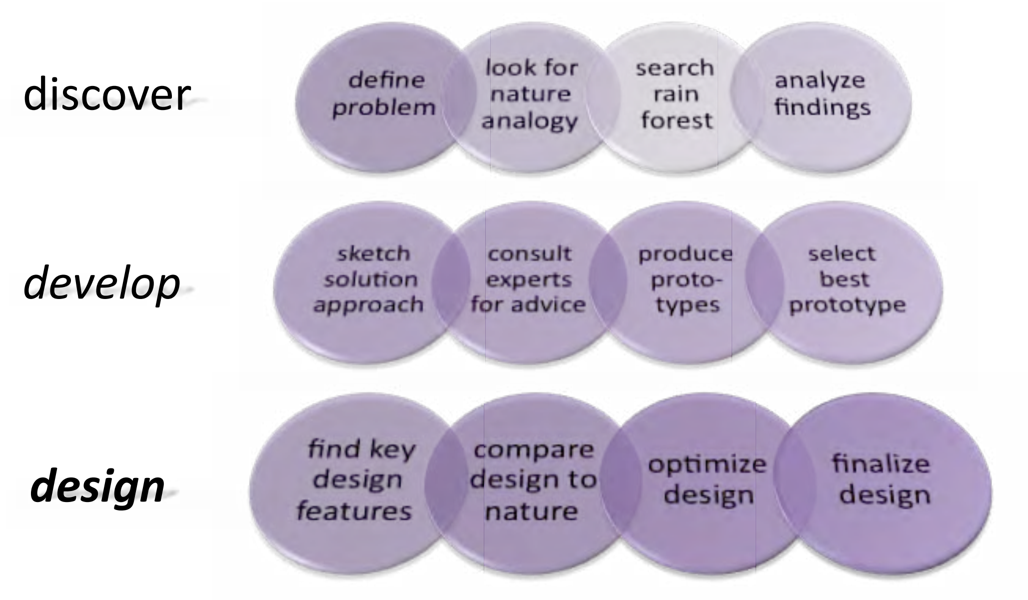

Figure 2: Details of the three main pillars of the '3D Corporate Tourism' concept

Inspiring materials, structures and processes are omnipresent in the rainforest. One feasibility study for '3D Corporate Tourism' was an expedition to Fraser Hill (Malaysia) headed by Prof. Jumaat Adam (UKM Biology Department) in February 2010 with biologists and engineers from Universiti Kebangsaan Malaysia and two Austrian tissue engineers performing industrial training at the UKM Institute of Microengineering and Nanoelectronics. The group (15 people) focused on getting to know the rainforest, learning to speak each other's languages and structure-function relationships in nature (e.g., nanostructures in butterfly and moth wings as well as in ferns that lead to structural colours, hierarchical symmetries in nature, spider eye nanoscale reflectors). Interesting samples were identified, investigated on-site and taken to UKM and Austria for further investigation (due to current lack of nanotechnological instrumentation at the research station). Friendships and collaborative networks across fields, cultures and continents were the first results, various academic papers are currently in preparation, and a report on the expedition appeared in the KL Post, the Journal of the German Speaking Society of Malaysia [12]. In this way, collaborations between local scientists and engineers with the international clientele are initiated, bidirectional knowledge transfer takes place and new knowledge is generated.

The high species variety in the rainforest, with nature's 'best practices' everywhere aids to relate structure with function in natural materials, structures and processes and helps to increase awareness about the natural resources surrounding us. With the concept of '3D Corporate Tourism' the potential of the virgin rainforests is used in a sustainable way, without exploiting the natural resources or removing anything else from the jungle apart from ideas.

3. A New Type of Science

3.1 Towards the Topic

The goal for the new type of science should be the construction of a knowledge tree that is open for all, which allows communication amongst fields, from specialists to generalists, from pupils to highly trained professors, from the social scientist to the artist and the person doing string theory [13]. With the power of the Internet, of links and huge databases, cross–linking and the establishment of connections of the huge current body of knowledge can be envisaged.

They key issue to such a tree is the people who are building the tree. Two different types of researchers are needed: specialists who dig deeper and deeper into their respective fields, and contribute ever-increasing detailed information (information retrieval – towards knowledge) and generalists, who provide detailed understanding of the basic construction of the tree, of its major branches and growth directions, of its base and of its outreach (knowledge processing – towards understanding). In the construction of the tree of knowledge holistic thinking and linear thinking meet, the essentials of the Eastern and Western approaches to science yield a new way to combine and construct knowledge.

The three tasks in this respect are:

1. Determine position of own research in context with state-of-the-art (→ where)
2. Discover a goal (missing information) that needs to researched (→ Where to)
3. Define the delta to existing knowledge (→ How)

3.2 Towards the Colleagues (Across Cultures and Fields)

The worldview of the new type of scientist combines the inherent wisdom in South-East Asia (cf. Soekarno-Hatta International Airport, Indonesia, Fig. 3) with the linear Western approach (cf. Franz Josef Strauss Airport, Germany, Fig. 3), and (s)he does this based on an education that concentrates on understanding instead of learning by heart.

The colleagues are to be reached on three levels:

1. Across scientific fields
2. Across social communites
3. Across global cultures

3.3 Towards the Public

The general public funds a major share of current research. However, accessing research results is increasingly complicated, since less and less research is published in the public domain in a way that is understandable for the public. Furthermore, various applications of research directly influence the lives of the public, e.g., genetical engineering, energy conversion in nuclear power plants, education systems, pharmaceuticals.

In the new type of science, this would change because the following three steps that are essential in the process of science outreach would be followed:

1. Build a knowledge structure of interconnected data that contains comprehensive information from general knowledge to state-of-the-art research
2. Elimination of over information (reduction of redundant and/or unnecessary information)
3. Establish a system of variable depth of details on the different subjects to provide and equal content of understanding to different levels of education and background knowledge

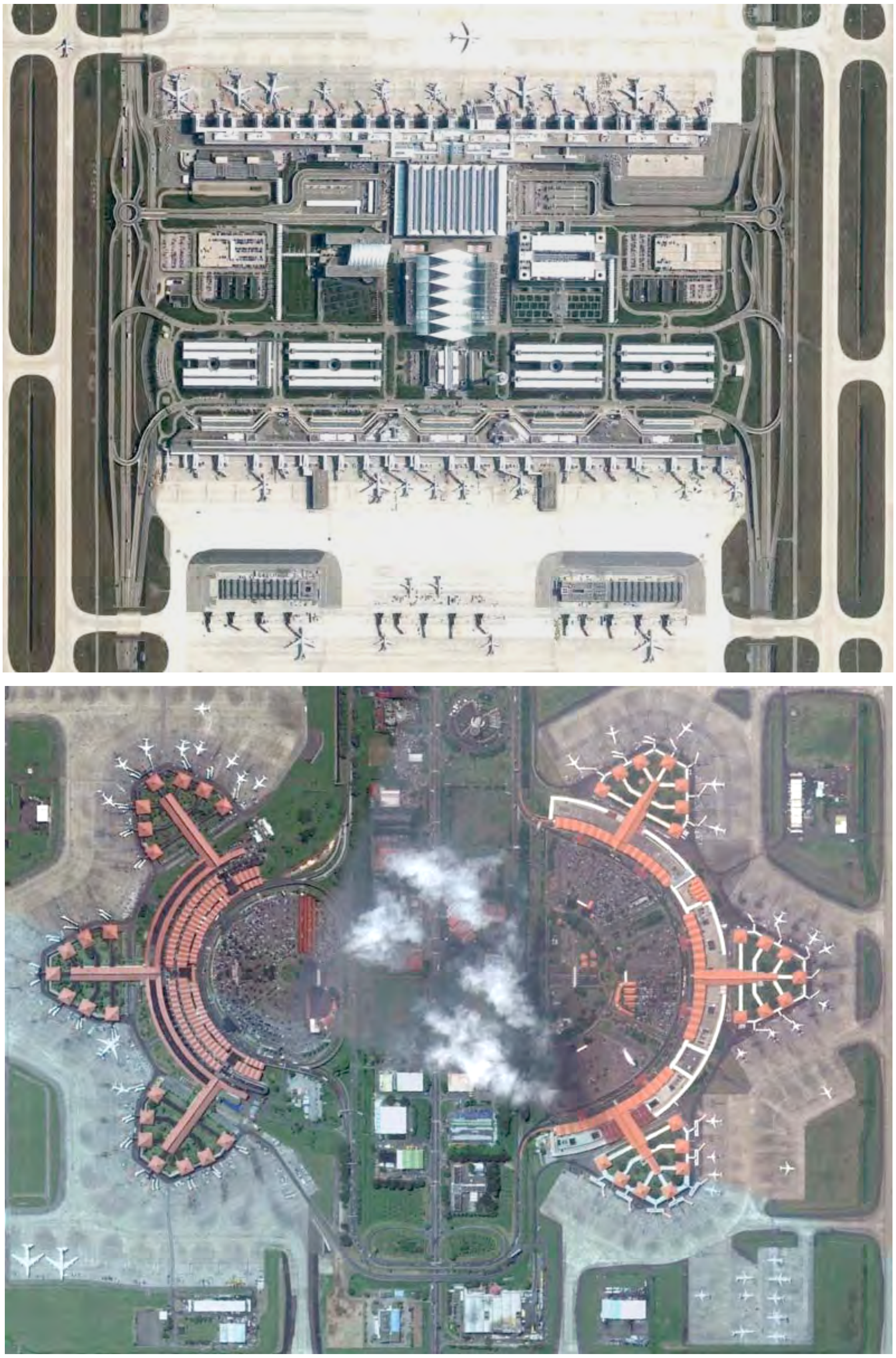

Figure 3: Details of the airports in Munich, Germany (top) and Jakarta, Indonesia (bottom) exemplifying the linear vs. integrated approach in Western and Eastern cultures.

4. Summary, Conclusions and Outlook

Successful addressing of the global challenges for humankind needs people with a deep understanding of complex scenarios and with the talent to see connections, trends and developments. Apart from geniuses (who would be present in any society and any schooling system) such people with holistic approach can only come out of schools in which the focus is on understanding rather than on learning by heart. Biomimetics and the 3D tourism approach show that transdisciplinary and cross-cultural approaches can be highly successful in generating completely new approaches, ideas and ways – this is exactly what is needed for addressing the global challenges.

As a first step and proof of concept, an undergraduate project is envisaged at a South-East Asian university. Students of various fields (e.g., environmental sciences, biology, chemistry, engineering) shall think what they, as generalists or as specialists, would like to contribute to the tree of knowledge addressing the global challenges for humankind. The environmental scientist would provide the big picture, understanding of the concepts and the broader approach, whereas for example the chemist would come up with novel ways to utilize waste materials (inspired by knowledge she got from the biologist about food chains) or the engineer would provide novel energy harvesting methods regarding waste energy of cars. Literature search and scientific expeditions to areas with high species abundance and complex relationships between the single actors (e.g. virgin South-East Asian rainforest) shall help generate new ideas and concepts and validate their applicability throughout educational levels and scientific fields at public science events, for kids and adults. In this way, also the public would be made aware of this undertaking, people interested in the global challenges would help constructing the branches of the tree of knowledge that are of specific relevance to them, the students would gain invaluable experience, and first versions of an expert system for use in addressing the global challenges would be programmed.

Realizing the tree of knowledge will show the uselessness of learning by heart and the importance of understanding, contributing to a new type of scientist with deeply embedded responsibility for our joint future – and the talents to safeguard humanity.

5. Acknowledgment

The National University of Malaysia funded part of this work with its leading-edge research project scheme ‘Arus Perdana’ [UKM-AP-NBT-16-2010] and the Austrian Society for the Advancement of Plant Sciences funded part of this work via the Biomimetics Pilot Project ‘BioScreen’. F. Aumayr, H. Störi and G. Badurek (Vienna University of Technology) are acknowledged for enabling ICG years of research in the inspiring environment in Malaysia.

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